Educational Exhibit Posters

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Advances in Lumbosacral Transitional Vertebrae on MRI: Developing an Algorithm for Consistent and Accurate Vertebral Numbering

A Podolsky1, C Li1, A Sohn1, M Spearman1, M Goldberg1, W CHANG2
1Allegheny Health Network, Pittsburgh, PA, 2ALLEGHENY HEALTH NETWORK, PITTSBURGH, PA

Purpose
While transitional vertebrae are typically easy to recognize, even when transitional anatomy is identified, the vertebrae have been shown to be incorrectly labeled in up to 60% of cases. Many parameters have been described to help radiologists correctly number transitional vertebrae, especially when total spine imaging is not available, however, a standard approach to ensure consistent and correct labeling is still lacking. We discuss a number of techniques to assist in consistent and accurate vertebral numbering on lumbar spine MRI and potentially develop machine learning algorithms for automated spine labeling.

Materials and Methods
1) Understand the clinical importance of identifying transitional anatomy, specifically with regards to patients undergoing spine surgery. 2) Identify imaging parameters for accurate and consistent numbering of transitional vertebrae on lumbar spine MRI. 3) Develop an algorithm that can be used for accurate, concordant and automated vertebral numbering, including the use of artificial intelligence.

Results
This educational exhibit will illustrate the prevalence, types, imaging features and clinical implications of lumbosacral transitional vertebrae, specifically with regard to identifying and labeling the vertebrae on lumbar spine MRI. A set of specific imaging parameters that can be used to create an algorithm for accurate and consistent vertebral numbering will be provided. The parameters discussed include: - S1 vertebral body shape - L5 Nerve root morphology - Lumbosacral/S1 branch angle - Iliolumbar ligament - T12 rib and rib anomalies - Whole spine MRI images

Conclusions
The proper recognition and subsequent labeling of lumbosacral transitional vertebrae is extremely important, especially in patients who will be undergoing spine surgery. Unfortunately, even when transitional vertebrae are seen, they were incorrectly labeled a large percentage of the time, with numerous reports of surgery being performed at the incorrect spinal level. Utilizing a standard approach, incorporating specific reliable parameters seen on lumbar spine MRI, accurate and concordant spine labeling can be achieved in the future. Furthermore, these parameters can be coupled with machine learning to eventually provide automated vertebral numbering.
1440

Angioarchitecture and Imaging Features of Intracranial Arteriovenous Shunts

A Efendizade¹, K Hewitt¹, D Cohen-Addad¹, Z Chaudhry¹, D Bell¹
¹SUNY Downstate Medical Center, Brooklyn, NY

Purpose
Describe variations of intracranial arteriovenous shunts, pathophysiology, anatomy, and grading as they relate to management and clinical course. We present illustrations with radiographic correlates to differentiate these shunts. This will aid the interpreter in formulating appropriate differentials and follow-up recommendations.

Materials and Methods
- Depict pathologic and architectural differences between AV malformations, dural AV Fistulas, and Carotid-Cavernous Fistulas
- Outline various grading schema as they pertain to shunt type
- Review non-invasive imaging findings of AV shunts with comparison to DSA
- Describe how imaging findings inform critical management decisions and clinical course

Results
- There is often confusion with regard to the nomenclature and functional significance of various arteriovenous shunts (AVM, AVF, dural vs pial, cavernous, VGAM, DSM) early in neuroanatomic education
- Intracranial Arteriovenous shunts are defined by their angioarchitecture and broadly differentiated by feeding arteries, presence of a nidus, and location
- Several grading systems (Spetzler-Martin/Endovascular, Borden/Cognard, and Barrow) have been proposed to inform clinicians if and when to intervene, as well as what to expect with and without intervention
- Digital Subtraction Angiography is the gold standard for diagnosing and elucidating the angioarchitecture as well as functional significance of an AV shunt
- Although vascular anomalies can be recognized on classical CT angiography and various MR pulse sequences, time-resolved CT/MR angiography and unique non-contrast MR pulse sequences (including arterial spin-labeling and susceptibility-weighted imaging) have been developed that can differentiate the type of AV shunt and to a lesser degree characterize arterial and venous drainage pathways
Conclusions
Differentiating intracranial AV shunts can be challenging. Even with improvements in non-invasive imaging, the reduced temporal resolution remains an obstacle in accurate diagnosis. Thus, a solid understanding of the pathologic and radiographic angioarchitecture of AV shunts is critical to accurate interpretation of these lesions. In conjunction with the appropriate grading scheme, this knowledge aids in developing the optimal management strategy.

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2656

Beyond TORCHS infections: LCMV and the neonatal brain

A Femi-Abodunde¹, K Budd¹, V Jewells²
Purpose
Lymphocytic choriomeningitis virus (LCMV) is a rodent born arenavirus which has profound impact on the developing neonatal brain. This exhibit will describe the cases encountered in our institution over the past decade.

Materials and Methods
The primary goal of this exhibit is to describe key imaging findings across all modalities some of which include microcephaly, ventriculomegaly, periventricular calcifications, and lissencephaly. This presentation will also review the differential diagnosis for LCMV and discuss distinguishing features or lack thereof from other TORCH infections as well as highlight crucial aspects of the clinical history and histopathology, which aid in its diagnosis.

Results
The primary goal of this exhibit is to describe key imaging findings across all modalities some of which include microcephaly, ventriculomegaly periventricular calcifications, and lissencephaly. This presentation will also review the differential diagnosis for LCMV highlighting crucial imaging findings, together with clinical history and histopathology discussing distinguishing features or lack thereof from other TORCH infections.

Conclusions
There is a broad differential when approaching congenital infections. Multimodality imaging features in tandem with clinical history, and adjunct testing are helpful in diagnosing congenital LCMV, a disease of increasing prevalence in the US.

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2640

Carotid bulb lesions: reviewing imaging patterns and differential diagnoses

A Alves Fonseca¹, D Guimarães², I Padilha³, F SCORTEGAGNA³, F Pacheco³, L Morais⁴, R Hoffmann Nunes³, A da Rocha⁵
¹Irmandade da Santa Casa de Misericórdia de São Paulo and DASA, Sao Paulo, SP, ²DASA, São Paulo, CA, ³Irmandade da Santa Casa de Misericórdia de São Paulo and DASA, São Paulo, SP, ⁴DASA, São Paulo, SP, ⁵Santa Casa de Misericórdia de São Paulo and DASA, São Paulo, WA

Purpose
The carotid arteries are major blood vessels in the neck that supply blood to the brain, neck, and face. The carotid bulb is a widening of a carotid artery at its main branch point. Our purpose is to review and discuss disorders that affect the carotid bulb, focusing on image patterns and exemplify mimicking disorders in order to scrutinize a practical approach for the differential diagnosis.

Materials and Methods
After reviewing our institution teaching files, we selected cases demonstrating disorders that affect the carotid bulb, including carotid artery stenosis (due to cholesterol plaque buildup or atherosclerosis), vasculitis, carotid web, transient perivascular inflammation of
the carotid artery (TIPIC) syndrome, carotid artery dissection, among others. Furthermore, the main pitfalls were exemplified, such as the flow void artifact, as well as the risk of intracranial complications.

Results
The diagnostic modalities that are used to image the carotid artery diseases are digital subtraction angiography, duplex ultrasound, computed tomography angiography, magnetic resonance angiography, and MR vessel-wall imaging. Each technique has its own strengths and drawbacks. We review the radiologic features and the use of these methods of each carotid pathology, identifying their advantages and disadvantages.

Conclusions
The differential diagnosis of disorders that affect the carotid bulb requires an understanding of involvement patterns and its main pitfalls in order to prevent misinterpretation. This approach aims to allow an imaging pattern recognition approach and takes into account clinical information.
Clinically Important Variant Anatomy of the Basilar Artery: A Pictorial and Educational Neuroimaging Review

D Wolman1, K McCullagh2, N Telischak2, J Heit3, T MASSOUD4
2Stanford University Hospital, Stanford, CA, 3Stanford University School of Medicine, Stanford, CA, 3Stanford University, Stanford, CA, 4STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
Anatomic variants of the basilar artery (BA) and its branches are common, and have important implications for cerebrovascular hemodynamics, risks of aneurysm formation or posterior circulation ischemic stroke, endovascular and surgical planning, and associations with embryologic malformations such as midline craniofacial anomalies. We review the neuroimaging findings and clinical relevance of numerous common and uncommon variants of the BA. Neuroradiologists should be familiar with these arterial variants and their important clinical implications during routine evaluation of CT and MR angiographic examinations, procedural planning, and to avoid misdiagnosis of posterior circulation arterial pathologies.

Materials and Methods
We provide a comprehensive review of the neuroimaging findings of both normal and variant anatomy of the BA system, with a description of the developmental and pathologic relevance of each variant.

Results
Following a description of the normal anatomy of the BA and its branches, we review the neuroimaging appearances of four of the five persistent fetal carotidobasilar anastomoses: (1) persistent trigeminal artery; (2) hypoglossal artery; (3) proatlantal segmental artery; and (4) transclival artery, with notation of the developmental, clinical, and hemodynamic significance of each variant. To date there has been no convincing angiographic evidence of the fifth anastomosis, the otic artery. We then describe variations in BA fusion, including segmental or complete basilar duplications and associated developmental anomalies, and BA fenestrations and associated aneurysms. We demonstrate and schematize variations in the BA termination, including nonfurcation, bifurcation, trifurcation, quadrifurcation, and pentalunation of the basilar apex. We describe the rare origination of clinically significant arteries from the BA apex, including the middle meningeal artery and the ophthalmic artery. Finally, we also display many other anatomically interesting variants, and morphometric ranges for the BA and its branches.

Conclusions
Anatomic variants of the BA belie developmental anomalies in cerebrovascular formation and may be associated with a range of vascular pathologies, including the induction of altered hemodynamics and subsequent posterior circulation stroke or aneurysm formation. Knowledge of these clinically relevant variants is important for neuroradiologists, neurointerventionalists, and neurosurgeons during endovascular and surgical procedural planning.

2318

Cranial Nerve Pathways; A Three-Dimensional (3D) Web-based Interactive Review Derived from Patient Specific 3D MR and CTA Data

A Eastaway1, c sturgeon1, A Hudson2, R Aquino3, Y Anzai2, R Wiggins2, E Quigley6

1Univeristy of Utah, salt lake city, UT, 2University of Utah, Salt Lake City, UT, 3University of Utah, Salt Lake City, UT, 4University of Utah, Neuroradiology, salt lake city, UT, 4UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT, 6UNIVERSITY OF UTAH, SALT LAKE CITY, UT

Purpose
- 3D visualization allows for perceptual reinforcement of challenging head and neck anatomy and pathology - Create a web-based platform for patient derived 3D models of cranial nerve pathways for education with web-based interface that can be accessed with mobile devices - Cases will demonstrate patient derived pathology including pathways of peri-neural tumor spread from deep spaces of the supra-hyoid neck, or common and uncommon locations of nerve sheath tumors - Provide examples of commonly misidentified incidental variants

Materials and Methods
1. Volumetric (1 mm) images of an anonymized CTA of the head and neck will be obtained on a Siemens (Berlin, Germany) scanner. Osseous tissue masks of the skull base will be created. Vascular imaging will be used to demonstrate potential vascular loops. Thin section volumetric T2 weighted MRI will be performed on 3T MRI (Siemens, Berlin, Germany). 2. Using splines in Materialise Mimics, cranial nerve pathways will be virtually traced and segmented based on multimodality fusion of osseous landmarks and thin section volumetric T2 MRI DICOM images, and manipulated with commercially available Materialise Mimics and 3-Matic (Leuven, Belgium) software. Individual STereoLithography (STL) files will be created. 3. After segmentation, STL meshes will be combined into a combined multicolor model to create a 3D virtual object. 4. The model will be uploaded into a publicly available web based interface (Sketchfab) and labeled with anatomic and educational content. A unique address and patient specific code will be assigned. 5. Users will access Sketchfab models and interact with each cranial nerve pathway in a 3D environment with an educational content/tutorial. 6. Additionally, the 3D models will be cinematically rendered using existing cinematic rendering techniques to create near anatomic models for use in virtual reality, augmented reality, and desktop based education.

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Results
- Prior studies, including 3D cerebral aneurysm models in a web-based interactive platform, demonstrate increased confidence levels among trainees after tutorials
- Robust teaching platform for understanding complex 3D head and neck anatomy

Conclusions
- Using commercially available and open source software packages, high quality patient specific models of aneurysms can be created and be utilized anywhere with a connected mobile device
- Mobile platforms can be used to teach complex anatomy, pathology, and physiology using a virtually "tangible" patient specific model

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1883

Cranial Nerve Traumatic Avulsions and Iatrogenic Transections: A Neuroimaging and Clinical Review

N Bates¹, Y Guo², K McCullagh¹, D McAllister¹, S Hashmi³, T MASSOUD⁴
¹Stanford University School of Medicine, Stanford, CA, ²Stanford University, Stanford, CA, ³N/A, N/A, ⁴STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
Cranial nerve (CN) injury is an overlooked aspect of neurotrauma. It may also occur after surgical procedures, whether planned or as inadvertent complications. Although CN injury in craniocerebral trauma is common, e.g. for CN1, CN7, and CN8, CN palsies secondary to a specific injury subtype, i.e. avulsions, are rare but clinically important. They may present with immediate onset, or diagnosed late in polytrauma scenarios. High resolution MRI is best to detect CN avulsions. Neuroradiologists should be familiar with the appearances of rare CN avulsions, since they can be challenging and their accurate diagnostic interpretation can greatly contribute to patient management.

Materials and Methods
We review mechanisms, clinical presentations, and neuroimaging examples of traumatic and iatrogenic CN avulsions.

Results
CN2 avulsion is rare, occurring in 38% of patients with traumatic globe luxation (a rare injury) after severe facial trauma. This occurs at 3 locations: optic disc (in 12%), orbital apex (in 55%), and optic chiasm (33%). CN3 is particularly vulnerable to shearing injury over the posterior petroclinoid ligament, but CN3 avulsion is very rare, seen by its separated free margins in the interpeduncular cistern. Similarly, CN6 has a long cisternal course and unilateral palsy may follow minor head trauma, but its avulsion is also rare. CN6 may stretch and avulse between two fixed sites: the pontomedullary sulcus and Dorello's canal. CN7 avulsions can be perinatal at stylomastoid foramen, occurring after forceps delivery, or avulsion of both CN7 and CN8 nerves from the IAC fundus occurring in the presence or absence of temporal bone fractures or brain injury. We will also review the etiologies and clinical presentations of other known post-traumatic CN avulsions for CN1 and CN12. Notably, there are sparse accounts of traumatic avulsions for CN4, CN5, CN9, CN10, and CN11. We also review surgical therapeutic transections of CNs, e.g. CN1 is often resected when sinonasal tumors invade the cribriform plate region, or historical transections for sensory roots of CN5, CN7, and CN9; and iatrogenic inadvertent avulsions of CN1, CN7, and CN8 during neurosurgical procedures.
Conclusions
CN injuries are important causes of morbidity. Traumatic or iatrogenic CN avulsions should be diagnosed early to guide appropriate treatment. This presentation will aid in identifying and understanding the spectrum of these uncommon injuries for improved diagnostic interpretation and patient management.

2808

Dealt a Bad Hand: Sequelae of Mucopolysaccharidosis in the Central Nervous System

K Launier¹, T Mack¹
¹Children's Hospital Los Angeles, Los Angeles, CA

Purpose
Educational objectives: This educational exhibit is intended to: 1. Briefly review the pathophysiology of mucopolysaccharidosis (MPS) 2. Highlight key imaging findings in the spine 3. Provide knowledge reinforcement with multiple choice questions Summary: MPS is an inherited lysosomal storage disorder characterized by enzymatic deficiency in mucopolysaccharide, or glycosaminoglycan (GAG), degradation. Partially degraded macromolecules accumulate in both the intra- and extracellular spaces. There are currently 11 described MPS types, based on the specific enzymatic deficiency and constellation of clinical symptoms. This exhibit will present MPS features with key imaging findings and description of the underlying pathophysiology, as applicable. Intracranial imaging findings seen in MPS are: prominent perivascular spaces, hydrocephalus, cortical atrophy, and white matter lesions. Findings at the craniovertebral junction can be severe and potentially life threatening, including spinal stenosis, atlanoaxial instability, myelopathy, odontoid dysplasia, and dural thickening. Spinal stenosis is treated with decompression and stabilization and can also be seen in the thoracic and lumbar spine. Dysostosis multiplex is the collective term to describe the osseous sequelae of MPS, including in the skull and spine. In the spine, wedge-shaped vertebral bodies, platyspondyly, and bullet shaped vertebral bodies are features. Also, the widened intervertebral disc spaces, disc dessication, disc bulging and herniation can be seen. Thoracolumbar kyphosis can suggest MPS. Skull findings include J-shaped sella and calvarial thickening. In summary, MPS is an inherited metabolic disorder impacting multiple organ systems, including the central nervous system. This overview is intended to summarize the key neurologic findings in this group of complex disorders.

Materials and Methods
N/A

Results
N/A

Conclusions
N/A

2249

Diffusion and Perfusion-weighted MR imaging of primary and metastatic melanoma in the brain and head and neck

D Josifoski¹, Y Ota¹, S Naganawa¹, J Kim¹, A Capizzano¹, A Srinivasan², T Moritani¹
¹University of Michigan, Ann Arbor, MI, ²Univ. Of Michigan Health System, Ann Arbor, MI

Purpose
• Review diffusion and perfusion–weighted MR imaging findings of primary and metastatic melanoma in the brain, and head and neck including scalp/skull, eyeballs, parotid glands and lymph nodes. • Discuss MR parameters of DWI and PWI. • Review usefulness, potential limitations and pitfalls.

Materials and Methods
• Overview of DWI and PWI in primary and metastatic melanoma. • MR parameters and technical factors. - Diffusion-weighted imaging and ADC values. - Dynamic contrast-enhanced (DCE) and dynamic susceptibility contrast (DSC) perfusion. • Appearance of primary and metastatic melanoma prior and post treatment. - Evaluation of treatment effect. - Disease progression vs immune-modulator mediated pseudoprogression and radiation necrosis. • Limitations of diffusion and perfusion MR imaging in brain metastases. • Susceptible to artifact from tumor related hemorrhage and postsurgical craniectomy.

Results
Primary melanoma is commonly imaged with the head and neck region being the overall most common location. Metastatic melanoma has a unique predisposition to unusual locations, with skin and CNS being one of the most common sites. As radiosurgery in combination with new chemotherapy and immune modulator treatment has become first-line treatment for intracranial metastases, there has been increased variation of treatment-related changes. Radiation necrosis/pseudoprogression can appear identical to true disease progression on conventional MR sequences. Advanced MR techniques, particularly DCE and DSC perfusion, in addition to timing of therapy can help differentiate between true and pseudoprogression. Recurrent tumor would demonstrate lower ADC value, increased cerebral blood volumes and increased Ktrans value when compared to radiation necrosis. ADC values are inversely correlated with tumor cellular density, thus cellular injury and apoptosis seen in pseudoprogression will result in an increased ADC.
Interval decrease in rCBV has the best sensitivity for detecting pseudoprogression, while interval increase in Ktrans has the best specificity for true progression. Advanced MR techniques can be used to differentiate melanoma from other metastasis lesions, which can be useful in patients with multiple malignancies. Metastatic melanoma will demonstrate higher Vp compared to non-small cell lung cancer.

Conclusions
Reader will better understand role and benefits of diffusion and perfusion MR imaging techniques in differentiating true disease progression and radiation necrosis/pseudoprogression in brain metastasis.

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1249

Direct and Indirect Findings of Endolymphatic Sac Tumors in von Hippel-Lindau Disease

J Molto Garcia¹, H Kim², P Chittiboina², R Lonser², J Butman²
¹George Washington University Hospital, Washington DC, DC, ²National Institutes of Health (NIH), Bethesda, MD

Purpose
1. To contrast the imaging features of small endolymphatic sac tumors (ELST) in von Hippel-Lindau disease as compared to large ELSTs 2. To present the 3 mechanisms of audiovestibular pathophysiology associated with ELSTs and their radiologic correlates 3. To emphasize the crucial role of imaging to identify small tumors for resection in order to prevent the development of further audiovestibular dysfunction

Materials and Methods
51 VHL patients with ELSTs enrolled in a longitudinal study of VHL. Imaging included high resolution temporal-bone CT (<1.5 mm) and pre and post contrast MR (<3.0 mm, typically 1.5 thick/0.75 mm spacing T1W). Endolymphatic hydrops was assessed using delayed FLAIR obtained 6-12 hours after contrast injection in a subset of cases.

Results
For small tumors (<1cm), CT identification of subtle erosions adjacent to the vestibular aqueduct is highly specific of ELST presence.
Spiculated appearance of bone destruction may not be identified until the tumor is much larger. In some instances, ELSTs may be centered in the distal portion of the endolymphatic sac and can only be identified on MRI. Intratumoral flow voids has been identified as a hallmark of large ELSTs, but is not a feature of small tumors. The 3 mechanisms of ELST associated hearing loss are: 1) direct labyrinth invasion through the otic capsule (only seen in large tumors) 2) intralabyrinthine hemorrhage (presenting with sudden SNHL) 3) endolymphatic hydrops (presenting with Meniere's syndrome) Intralabyrinthine hemorrhage is an indirect sign on non-contrast T1 or FLAIR. FLAIR sequences appear more sensitive, and FLAIR abnormalities may persist long after the T1 images appear to have normalized. Intralabyrinthine hemorrhage can occur independent of tumor size. Endolymphatic hydrops is also an indirect sign that can only be demonstrated through post contrast FLAIR performed 6-12 hours following contrast injection. Endolymphatic hydrops has been reported as the only sign of an occult ELST that could not be directly demonstrated on CT or MRI. Conclusions ELST associated audiovestibular dysfunction can occur suddenly in a manner that is not related to tumor size. Because ELSTs are benign, surgical resection is curative, and eliminates the risk of further audiovestibular dysfunction. Thus, even though ELSTs are benign and slowly growing, direct or indirect radiologic identification of small ELSTs is essential to motivate surgical intervention and thereby minimize audiovestibular morbidity.

43 year-old male with right hearing loss, vertigo and a right-sided ELST. (A) Post-contrast T1 demonstrates punctate enhancement of the right vestibular aqueduct (arrow). Endolymph is characterized by low-signal on delayed post-contrast FLAIR (B) and high-signal on the corresponding T2-weighted sequence (C). Perilymph is characterized by high signal on both. (B) Delayed post-contrast FLAIR demonstrates hydrops of the scala media, seen as “filling defects” (arrows) in the cochlea, which do not match the high-signal on the corresponding T2-weighted sequence.

Don't Gamble with High-Risk Aberrant Vascular Anatomy!: an Exhibit on Normal Anatomic Variants and Their Potentially Catastrophic Consequences

T Vu¹, A Duran¹, N Kagetsu¹
¹Mount Sinai West, New York, NY

Purpose
EDUCATIONAL OBJECTIVES: To review the key features of several normal neurovascular anatomic variants. Discussion will focus on the imaging findings of various aberrant courses of the Internal Carotid Artery, Vertebral Artery, and Posterior Inferior Cerebellar Artery while utilizing different modalities including CT angiography, MR angiography, Venography, and Catheter Angiography. The relevant imaging findings will be correlated with potential clinical complications, especially after head and neck interventions.
Results
SUMMARY OF PLANNED PRESENTATION: Anatomy of Internal Carotid Artery and Variants - Imaging features of the "kissing" carotid variants (both the transsphenoidal and the retropharyngeal course), as well as a few other aberrant courses of the internal carotid artery (of particular interest is a case demonstrating a paratracheal course.) - Discuss the possible complications and necessary precautions before head and neck interventions. Anatomy of the Vertebral Arteries and Variants - Imaging features of a medial retropharyngeal/retroesophageal course of the left vertebral artery and ectatic vertebral artery with vertebral loop that extends to the posterior aspect of the canal. - Discuss the possible complications and necessary precautions before cervical spine interventions. Anatomy of the Cerebellar Arteries and Variants - Imaging features of the inferior extension of the Posterior Inferior Cerebellar Artery below the level of C1. - Discuss the possible complications and necessary precautions before cervical spine interventions. Anatomy of an Aberrant Origin of the Bronchial Artery arising from the Vertebral artery - Imaging findings of an aberrant bronchial artery arising from the vertebral artery. - Discuss the possible complications and necessary precautions before bronchial artery embolization.

Conclusions
Normal variants of the internal carotid arteries, vertebral arteries and cerebellar arteries range from uncommon to rare entities and seldom manifest with clinical issues. In addition to the identification of these variants, it is crucial to recognize the potential complications that can arise from these variations. The clinician must proceed with care when managing these patients to avoid the risk of catastrophic brain injury or even death.
Head and Neck Bone Lesions: Radiological Review of a Case Series. A Pictorial Essay with Diagnostic Clues

A Wolosker¹, D Costa², A Torres³, M Borri⁴
¹Hospital São Luiz-Rede D’Or - Fleury Group- Unifesp, São Paulo, Brasil, ²Hospital São Luiz-Rede D’Or - Fleury Group- Unifesp, São Paulo, Brasil, ³Hospital São Luiz-Rede D’Or - Fleury Group, Sao Paulo, Brazil, ⁴Hospital São Luiz-Rede D’Or - Fleury Group-Unifesp, Sao Paulo, Brazil

Purpose
The aim of this poster is to describe the imaging features of the most common benign or malignant, local, multifocal or diffuse bone lesions in head and neck.
Materials and Methods
A retrospective study of the imaging features of bone lesions in head and neck was made in the last 3 years, with Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) with Diffusion Weighted Imaging (DWI). This study included incidental findings as result of the number of brain and face CT examinations performed daily, pseudolesions, findings during the staging of other diseases and on workup of local clinical symptoms.

Results
Some head and neck bone lesions may be challenging to diagnose and the association with different imaging techniques aid the interpretation. The analysis of radiological characteristics (matrix, morphology, periosteal reaction, cortical involvement) with the additional findings provided by MRI and the clinical information are determinant of a non-histological diagnosis. There are suggestive findings important to highlight that can help distinguish benign and malignant lesions as trabecular structure indicating haemangioma, involvement of the skull inner cortex in typical locations of the pseudolesions, cortical erosion and periosteal reaction with soft tissue extension suggesting malignant lesion. MRI with DWI may help identify cellular malignant lesion, although some benign lesions also show restriction.

Conclusions
In the evaluation of bone lesions in head and neck, CT and MRI are useful in differentiating benign from malignant lesions. In the difficult cases the imaging features in association with age, history and clinical symptoms, and the extensive knowledge of differential diagnoses and pseudolesions make it possible to propose diagnostic clues and a course action: simple survey, pathologic confirmation or complete surgical resection.

Hemodynamics and Beyond: The Role of Advanced Imaging in Risk Stratification of Intracranial Vascular Pathology

W CHANG

ALLEGHENY HEALTH NETWORK, PITTSBURGH, PA

Purpose
Aneurysm rupture has high mortality/morbidity with >50% mortality. However, treatment also carries significant risks. Determining
which aneurysms are likely to rupture is useful. Hemodynamics and flow morphology may have predictive value, with aneurysms with inflow jet flow patterns more likely to grow/rupture, while aneurysms with helical flow patterns are more stable. Wall shear stress (WSS) may also be useful, with aneurysms with high WSS demonstrating growth/rupture and those with low WSS also demonstrating growth. Pressure is another hemodynamic factor, and focal pressure differences may also predispose aneurysms toward rupture. Management of arteriovenous malformations is also challenging with both high morbidity from hemorrhage and higher morbidity from treatment. AVMs have a high risk of bleeding with 40-70% lifetime risk and annual risk of 1-33%. The strongest predictor of hemorrhage is prior hemorrhage, which makes risk stratification on initial diagnosis challenging. Hemodynamics may be useful; some studies have noted different hemodynamic patterns in stable versus symptomatic patients. Hemodynamics also has a role in ischemic stroke, as various flow patterns can predispose to plaque rupture. To date, acquiring these hemodynamic data have been challenging and often invasive, requiring DSA and computational flow dynamics (CFD) to calculate. The emergence of high resolution 4D Flow MRA has created an alternative technique that can acquire hemodynamic data in a non-invasive manner, without the use of intravenous contrast, in many cases. Other advanced techniques have been developed to yield quantitative data from DSA with less processing time.

Materials and Methods
n/a

Results
4DFlow MRA can obtain streamline and WSS/pressure maps for intracranial aneurysms in a non-invasive manner. Flow morphology can be modeled with streamlines to analyze the inflow jet and analyze WSS at the impact zone and pressure within the aneurysm dome. These hemodynamic factors have been shown to have value in predicting risk of rupture and growth. 3D printing is another technique that has been shown to be of value, allowing realistic vascular models to model flow or be used for treatment planning. 4DFlow MRA can also be used to obtain velocity/flow plots and WSS maps for arteriovenous malformations. 3D printing can be used on models to assess anatomy for treatment planning.

Conclusions
Several new techniques have value in risk stratification and treatment planning for aneurysms, AVMs and ischemic stroke.

Figure 1: a) Streamline plot showing helical flow pattern within an aneurysm sac. b) WSS plot showing normal WSS within the same aneurysm. These findings are associated with decreased rupture risk. c) WSS map showing similar WSS values in arterial feeders to a right temporal AVM when compared to normal contralateral vessels. This pattern is associated with decreased risk of hemorrhage. d) WSS map showing increased WSS in arterial feeders to a right frontal AVM when compared to normal contralateral vessels. This pattern is associated with increased risk of rupture/hemorrhage.

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Imaging correlates of Cauda Equina Syndrome and its Mimics

M Aftab1, C Carline2

1Ascension Genesys Hospital, Flushing, MI, 2Michigan State University College of Osteopathic Medicine, East Lansing, MI
Purpose
To evaluate the causes of cauda equina syndrome (CES), their distinguishing features on imaging and their treatment.

Materials and Methods
A systematic review of the literature within the last 20 years (one article from 1983) was done to assess the causes of cauda equina syndrome. We reviewed literature using the pubmed database with a focus on neuroradiology.

Results
Cauda equina syndrome (CES) is a clinical syndrome which presents with low back pain, asymmetric lower extremity motor weakness and sensory loss, saddle anesthesia, urinary incontinence or retention, bowel incontinence and sexual dysfunction. There can be a myriad of causes of CES and the clinical picture in each patient is variable as a patient may present with some signs and symptoms, resulting in partial CES. This can make it difficult to distinguish CES from mimics, therefore emergent and appropriate imaging is critical to establish the diagnosis and etiology. CES can be due to infection, inflammatory conditions, tumors/metastasis, trauma, disc herniation, hematomas and other compressive etiologies. The causes of CES can be differentiated by their location, such as epidural and intradural, and their effect on the spinal cord. The most common cause of CES is lumbar disc herniation, which can be epidural or intradural. Infections and inflammatory conditions can lead to arachnoiditis, myelopathy and transverse myelitis. Tumors, such as myxopapillary ependymomas in the intradural space and chordomas in the epidural space, can push on the nerve roots of the cauda equina to cause CES. Although imaging is usually diagnostic, imaging may be normal in patients with transverse myelitis, procedure related damage, such as a lumbar puncture, and mimics of CES, including a cervical or thoracic mass and some medications. Therefore, it is pertinent to obtain imaging and consider the clinical presentation when determining the cause of CES. The treatment for CES will depend on its etiology, but is usually treated with surgical decompression within 48 hours as it is a medical emergency.

Conclusions
CES is a medical emergency, and imaging plays a critical role in helping to distinguish the various causes of CES based on their characteristics. Disc herniation, infection, chronic inflammatory diseases, trauma, tumors/metastases and hematomas are some of the causes of CES. By recognizing these characteristic features the radiologist can play an important role in the timely management of patients.
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<tr>
<th>Cauda Equina Syndrome and Its Mimics MRI Findings</th>
<th>Intrinsic Nerve Root Abnormalities</th>
<th>Intradural</th>
<th>Epidural</th>
<th>Normal MRI of Cauda Equina</th>
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<td>Infection</td>
<td>HIV</td>
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Imaging Findings in Neuropsychiatric Systemic Lupus Erythematosus

T Min¹, R Peterson², A Gizinski¹, J O'Keefe¹, M Zygmont¹
¹Emory University School of Medicine, Atlanta, GA, ²EMORY UNIVERSITY SCHOOL OF MEDICINE, NORCROSS, GA

Purpose
Systemic Lupus Erythematosus (SLE) is an autoimmune inflammatory disease where production of autoantibodies directed against nucleic acids and their binding proteins can result in damages to any organ system. It has a prevalence of 20-150 cases per 100,000, with women of childbearing age being 10 times more likely affected than men. Incidence of neuropsychiatric clinical syndromes in SLE range widely from 31 to 91%, partly due to lack of widely accepted clinical diagnostic criteria. The American College of Rheumatology case definition for neuropsychiatric SLE (NPSLE) includes 19 wide-ranging clinical syndromes such as cerebrovascular disease, demyelinating syndrome, headache, psychosis and anxiety disorder. Therefore, indication for neuroimaging can be quite nonspecific and SLE remains in differential diagnosis in a broad range of clinical scenarios. The purpose of this educational exhibit is to develop a concise reference guide and a memory aid for neuroimagers to recognize and understand imaging patterns related to NPSLE.

Materials and Methods
Review of literature and institutional case collection.

Results
Nearly half of all patients with NPSLE have normal imaging findings. When abnormal, patients demonstrate demyelinating or cerebrovascular disease syndrome [1], often with non-specific white matter T2 hyperintensities involving the frontal, parietal and occipital lobes, sparing the temporal lobes [2]. Further progression of disease involves the gray matter of the basal ganglia and cerebral cortex [3] followed by diffuse parenchymal atrophy. Additionally, there are a variety of imaging patterns associated with lupus. Infarct patterns include large vessel infarct, small vessel infarct and venous infarct. Intraparenchymal and subarachnoid hemorrhages are also seen, including patterns of hypertensive hemorrhage and aneurysmal rupture [4]. Infections related to NPSLE include meningitis, cerebritis and abscess [4, 5]. Inflammatory patterns are rare and include rhombencephalitis, vasculitis and spinal myelitis [5]. Disease patterns resembling multiple sclerosis and posterior reversible encephalopathy syndrome are also reported in NPSLE [5].

Conclusions
Patients with NPSLE can have widely varying clinical presentation, often leading to nonspecific indications for neuroimaging. Nearly half of all patients with NPSLE have normal imaging although atypical imaging patterns related to SLE must be recognized by neuroradiologists in order correctly diagnose and initiate appropriate therapies.
Imaging Findings in the Setting of Drugs of Abuse: Chasing the Dragon and Other Related Pursuits

N Parikh¹, M Goldberg², M Spearman², C Li², A Sohn², C Wanamaker², W CHANG³
¹AHN, Pittsburgh, PA, ²Allegheny Health Network, Pittsburgh, PA, ³ALLEGHENY HEALTH NETWORK, PITTSBURGH, PA

Purpose
The various drug abuse disorders often present with classic imaging findings. Understanding the classic presentations of these disorders can assist the radiologist in developing an appropriate differential diagnosis and assist clinicians in optimizing treatment. In this presentation, we will discuss imaging findings and classic presentations of alcohol use disorders, heroin/opioid abuse, sympathomimetic drugs of abuse such as cocaine, MDMA and methamphetamines, and other drugs of abuse.

Materials and Methods
Patients initially presenting with acute metabolic or toxic encephalopathy can be a diagnostic dilemma due to the nonspecific nature of the patient's history and presentation. We will review classic imaging findings of patients with various toxic and metabolic disorders secondary to drug abuse seen at our multicenter hospital network. We begin by outlining the presenting symptoms, applicable laboratory values and physical exam findings of select patients. We then describe the pertinent neuroimaging findings. Additionally, if applicable, we provide imaging after appropriate therapy to demonstrate the reversibility of certain metabolic disorders, such as Wernicke's encephalopathy.

Results
Alcohol use disorders have a variety of acute and chronic presentations. Wernicke's encephalopathy typically presents with FLAIR hyperintensity within the bilateral mammillary bodies and medial thalami and is often reversible with prompt thiamine therapy. Marchiafava-Bignami Disease demonstrates restricted diffusion in the corpus callosum or periventricular white matter. Chronic alcohol use can result in characteristic patterns of atrophy. Opioid abuse has a range of imaging findings including anoxic brain injury...
in overdose or symmetric FLAIR white matter hyperintensities and/or basal ganglia hyperintensities with restricted diffusion in the setting of heroin inhalation. Sympathomimetic drugs often cause diffuse narrowing of intracranial arteries as a result of vasospasm, infarcts, or hemorrhage. Other drugs of abuse can have more non-specific imaging findings.

Conclusions
Drugs of abuse can present with classic neuroimaging findings that can help the neuroradiologist suggest an etiology for patients with altered mental status and suspected drug abuse disorders. Understanding the typical imaging findings in drugs of abuse can help neuroradiologists form an accurate differential diagnosis and assist in guiding therapeutic interventions, given the reversible nature of some of these conditions.
Figure 1: a-b) FLAIR hyperintensities in the bilateral medial thalami in a patient with alcohol use disorder, which resolved after 2 weeks of intravenous thiamine therapy, compatible with Wernicke’s encephalopathy. c) Symmetric FLAIR hyperintensity in the white matter in the setting of heroin inhalation ("chasing the dragon"). d) Restricted diffusion in the corpus callosum and periventricular white matter in the setting of Marchiafava - Bignami Disease.

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Imaging Findings of Supraglottic Paragangliomas: Case Series and Review of the Literature

E Unlu, L Ginsberg, M Gule-Monroe

MD Anderson Cancer Center, Houston, TX

Purpose
The imaging findings of six patients presenting with supraglottic paraganglioma, an unusual anatomic subtype of paraganglioma will be presented. The demographics, clinical and pathology findings will be demonstrated, with a review of the available literature.

Materials and Methods
A retrospective review of the imaging findings in 6 patients who presented to our institution with supraglottic paraganglioma was performed. Demographics, clinical records, imaging and pathology reports were evaluated. A search was made of articles in the peer-reviewed literature in PubMed to identify reports of supraglottic paragangliomas. The search strategy included English language articles with the following search terms and keywords: supraglottic paraganglioma, laryngeal paraganglioma, tumors of supraglottic larynx, supraglottic neoplasms.

Results
Two male and four female patients were included in the study. The mean age at diagnosis was 41 years (range 34 - 47 years). Four patients presented with hoarseness, one patient with increased snoring and one patient with globus sensation. Two patients had a family history of paraganglioma with one of these patients presenting with additional bilateral carotid paragangliomas. The lesions were all submucosal in location and the greatest dimension were ranged from 3.2 to 4.7 cm with the mean 4 cm. All patients had contrast enhanced CT imaging before surgery while 3 patients had additional MR imaging of neck. All the lesions demonstrated intense homogeneous contrast enhancement on both CT and MR with mass effect on the airway. The lesions were found to be T1 hypointense, T2 hyperintense and associated with flow voids. There was invasion of thyroid cartilage in one patient which was confirmed pathologically. All patients underwent complete resection with no evidence of recurrence on follow up scans so far.

Conclusions
Our case series demonstrates the imaging findings and clinical features of submucosal supraglottic paragangliomas. This is to our knowledge the largest case series reported of this rare disease entity (1-5).
Image of calcifying and ossifying disorders of the spine.

S Alkhatib¹, K Shah², K Abrams³
¹Pennsylvania Hospital, Philadelphia, PA, ²Northwell Health, New Hyde Park, NY, ³Baptist Hospital, Miami, FL

Purpose
Improvements in the availability of radiologic evaluation of the spine has made spinal imaging for neck and back pain common practice. In recent decades, increased spinal imaging has increased awareness of calcific and ossifying spinal disorders and enthesopathies. These represent a variegated collection of calcium crystal deposition disorders that has been insufficiently characterized in the literature. While these entities share some characteristically similar pathologies, there still exists a lack of understanding of a unifying mechanism of crystalline formation. It is important for radiologists and clinicians to be aware these increasingly recognized conditions to avoid inappropriate procedures and care. We present an overview of these conditions of the
spine, review the clinical features of these disorders and describe our institutional experience with their imaging characteristics. Specifically, we review diffuse idiopathic skeletal hyperostosis, ankylosing spondylitis, ossification of the posterior longitudinal ligament, arachnoiditis ossificans, calcific discitis, calcific tendonitis of the longus colli, crowned dens syndrome, and ossification of the ligamentum flavum. We aim to provide an updated perspective of these conditions in order to guide clinical practice.

Materials and Methods
We queried our institution's electronic record for patients with the following pathologically proven diagnoses: ankylosing spondylitis, arachnoiditis ossificans, diffuse idiopathic skeletal hyperostosis, crowned dens syndrome, calcific discitis, calcific tendonitis of the longus colli, ossification of the ligamentum flavum, and ossification of the posterior longitudinal ligament. Records were reviewed for patients between 2001 and 2014, and only patients with radiologic studies available were included in the analysis. Fifty-three patients were identified, of which representative cases are described in this review. We reviewed the literature for calcifying and ossifying disorders of the spine. We systematically searched PubMed for "ankylosing spondylitis", "arachnoiditis ossificans", "diffuse idiopathic skeletal hyperostosis", "crowned dens syndrome", "calcific discitis", "calcific tendonitis longus colli", "ossification ligamentum flavum", and "ossification posterior longitudinal ligament" and included all papers available in English. We reviewed the references and included the relevant literature in our review.

Results
We briefly review a number of calcifying and ossifying conditions of the spine including ankylosing spondylitis, arachnoiditis ossificans, diffuse idiopathic skeletal hyperostosis, crowned dens syndrome, calcific discitis, calcific tendonitis of the longus colli, ossification of the ligamentum flavum, and ossification of the posterior longitudinal ligament by describing the clinical and imaging characteristics of these disorders with examples from cases encountered and treated at our institution. Fourteen cases of calcifying or ossifying conditions of spine treated between 2001 and 2014 are included.

Conclusions
Inflammatory calcifying enthesopathies and ossifying disorders represent a range of disease, some common and others less frequently seen, but they represent radiographic and clinically important patterns of spinal disease. Due to the increasing use of spinal imaging, recognition of these disorders is imperative for radiologists and clinicians alike. Despite an incomplete understanding of the pathologic mechanisms that causes these diseases, conservative or straightforward surgical treatment can resolve most cases. In most of the disorders presented in this review, CT imaging is essential to identifying the correct diagnosis. The superior ability of MR to depict soft tissue and neural elements makes it an equally vital method in patients with neurologic complaints and complements the sensitivity of CT to identify calcified or ossified lesions in the spine.
Tc99m bone scan in a 36-year-old male with ankylosing spondylitis reveals diffuse patchy radioisotope uptake of the spine with involvement of the costovertebral joints.

45-year-old female with ossification of the ligamentum flavum at multiple thoracic levels. Sagittal reconstruction of thoracic CT images demonstrates multiple, distinct ossific lesions along the dorsal canal (arrows).

Arachnoiditis ossificans in an 83-year-old female with leg weakness and mid-back pain. Sagittal reconstruction CT images demonstrate curvilinear dural-based calcifications (arrows) of the dorsal thoracic spinal cord.

73-year-old female patient with a previous C3-C7 anterior cervical disectomy and fusion with CPPD affecting the C2 odontoid process. The patient underwent decompression and histopathologic study demonstrated large, irregular deposits of calcium in a sample of synovial tissue taken from the C1-C2 mass. Hematoxylin and eosin stain, 10x magnification.

(Filename: TCT_1037_Untitled-1copy.jpg)
Intracranial Calcifications in Childhood

F Goncalves1, L Pinelli2, K Mankad3, C Alves1, S Teixeira1, S Andronikou4, A Vossough5
1Children's Hospital of Philadelphia, Philadelphia, PA., 2Postgraduate School in Radiodiagnostico, Università degli Studi di Milano, Brescia, ITA., 3Great Ormond Street Hospital, London, UK., 4Children's Hospital of Philadelphia, Philadelphia, PA, 5University of Pennsylvania - Children's Hospital of Philadelphia, Philadelphia, PA.

Purpose
Intracranial calcification (ICC) can be either physiological or pathological. Physiological ICC is not an expected neuroimaging finding in the neonatal period but can be seen as children grow older in the pineal gland, habenula, choroid plexus, and occasionally in the dura mater. Pathological ICC can be broadly divided into six groups: infectious, toxic, neurodegenerative, neoplastic, vascular, and syndromic. The first two groups are typically composed of diseases that more commonly result in static encephalopathies, whereas the last four groups are composed of diseases that tend to cause progressive encephalopathy.

Materials and Methods
Various neuroimaging modalities have distinct utilities and sensitivities in the depiction of ICC. Age at presentation, ICC location, and additional neuroimaging findings are useful information that may be useful to narrow down the differential diagnosis of ICC. Bilateral ICC is commonly due to congenital infections or due to neurodegenerative or infectious diseases. ICC involving the basal ganglia and thalami are commonly seen in neurodegenerative diseases. ICC can be seen in isolation or be associated with other neuroimaging features.

Results
TORCH infections are the most common neonatal causes of ICC. ICC in congenital infections can be associated with clastic changes, hydrocephalus, chorioretinitis, white matter abnormalities, skull changes, and cortical development malformations. Specific non-infectious causes of ICC that mimic TORCH infections are known as pseudo-TORCH. Neurodegenerative diseases causing ICC are mainly due to parathyroid and thyroid hormone dysfunction and inborn errors of metabolism, such as MELAS, Kearns Sayre and Cockayne syndrome, interferonopathy syndromes, and Krabbe disease. Tumoral ICCs are more commonly seen in low grade tumors. Artériovenous malformations, artériovenous fistulas, chronic venous hypertension, and cavernomas are also known causes of ICC. Other vascular causes of ICC include atherosclerosis, healed hematoma, radiotherapy treatment, old infarct, and disorders of the microvasculature such as COL4A1- and COL4A2-related diseases. Down syndrome and phakomatosis are also known causes of ICC.

Conclusions
Clinical information such as age at presentation; maternal exposure to teratogens, such as viruses, in addition to the association with chromosomal abnormalities; genetic mutations and postnatal infections, facilitate in the differential diagnosis of the multiple causes of ICC.

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Intracranial Calcifications in Childhood

Intraosseous Dural Arteriovenous Fistula: Imaging and Endovascular Management

T Garg1, R Saraf2
1Seth GS Medical College & KEM Hospital, Mumbai, India, 2Seth GS Medical College & KEM Hospital, Mumbai, Maharashtra
Purpose
1. To review the definition, types, and clinical presentation of intracranial vascular territories.
2. To learn about the endovascular management of intracranial DAVFs.

Materials and Methods
Intracranial DAVFs are abnormal connections between meningeal arteries and dural venous sinuses, or veins, or both within the skull or dura or both. Intracranial DAVFs are rare entities that are used to describe a type of DAVF where the vascular nidus is situated entirely within the bone. In Intracranial DAVFs, the fistula is seen between the meningeal arteries and intracranial diploic veins or the transosseous emissary veins and, therefore, their clinical presentation and natural course of venous drainage pattern is similar to classical DAVFs. Intracranial DAVFs of the anterior condylar canal, posterior condylar canal, foramen magnum, upper clivus, and petrous bone have been described in multiple case reports.

Results
Anatomical analysis of the lesions using CT, MR imaging, and conventional angiography is required to localize the site of the lesion, plan the management, and determine treatment outcome. Abnormal dilated venous pouch within the bone can be demonstrated as osteolytic lesions within the bony structure on non-contrast CT with bone window setting and dilated signal-intensity vein of MR images. Conventional angiography shows the feeding meningeal arteries of the DAVF, which are focused on the wall of the dilated venous pouch, which communicates with the venous structures and is the target area of treatment. Patients with intracranial DAVFs are treated with a transvenous embolization using a right femoral approach, the venous pouch is localized with the help of a microcatheter, and the lesion is occluded with the help of detachable coils or glue or via a transarterial approach where onyx is used for occluding the fistula and multiple fine arterial channels. Immediately after the procedure, angiography is done to confirm complete occlusion of the AVF, and the patient is followed up with clinical examination and imaging.

Conclusions
Intracranial DAVFs are uncommon lesions and represent a challenging clinical entity that requires proper angioarchitectural evaluation and treatment to prevent the associated morbidity and mortality.

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Minor Vascular Territories and Anatomic Variants: Clinical/Anatomic Correlation

W Chang1, C Li2, A Sohn2, M Spearman2, C Wanamaker2, M Kulzer1, M Goldberg2

1Allegheny Health Network, Pittsburgh, PA, 2Allegheny Health Network, Pittsburgh, PA, 3Allegheny Health Network, Pittsburgh, PA

Purpose
While the major vascular territories are relatively well delineated, there are other important vascular territories that may be less familiar to the general radiologist and could have some variability or be present in only a small subset of patients. Infarcts in these territories can be confused with large vessel occlusions, toxic/metabolic etiologies, or in some cases, sequelae of seizures. Understanding the common patterns of pathology in these regions is important in guiding further diagnostic testing or triaging potential interventions and has clinical utility in determining subsequent treatment and prognosis.

Materials and Methods
In this report, we will discuss some of these vascular territories, including the territories supplied by the recurrent artery of Heubner, lateral lenticulostriate branches of the middle cerebral artery, anterior choroidal artery and the artery of Percheron. We will demonstrate the vessels on conventional, CT or MR angiography and outline the affected vascular territories on MRI including diffusion-weighted imaging.

Results
While the caudate head is classically described as being supplied by the recurrent artery of Heubner which is a branch of the A1 segment of the anterior cerebral artery, typically only the inferiomedial portion of the caudate head at the level of the anterior commissure and portions of the anterior putamen are supplied by Heubner. In contrast, the remainder of the caudate head and putamen are typically supplied by lateral lenticulostriate branches of the M1 segment of the MCA. The anterior choroidal artery typically originates at the most distal branch of the internal carotid artery just proximal to the carotid terminus and supplies the posterior limb of the internal capsule, globus pallidus interna, superolateral thalamus including the lateral geniculate body, portions of the mesial temporal lobe including the amygdala and hippocampal head, choroid plexus, optic tract, and portions of the optic radiations. The artery of Percheron is present in up to 1/3 of patients, originates from one posterior cerebral artery, and supplies the paramedian thalamus and rostral midbrain. Infarcts in this region can cause bilateral thalamic or midbrain infarcts.

Conclusions
While the major vascular territories are well known, a number of important vascular territories are less familiar but supply important structures. Understanding this anatomy is important for the neuroradiologist to add value in making accurate diagnoses and guiding treatment decisions.
Figure 1: a) T2W image showing increased T2 signal within the inferomedial caudate head and anteromedial putamen at the level of the anterior commissure, compatible with recurrent artery of Heubner infarct. b) T2W image showing increased T2 signal within the lateral putamen, sparing portions of the anteromedial putamen and inferomedial caudate head at the level of the anterior commissure, compatible with lateral lenticulostriate artery infarct. c) Restricted diffusion in the posterior limb of the internal capsule and portions of the corona radiata, compatible with anterior choroidal artery infarct. d) Restricted diffusion in the bilateral medial thalami, compatible with Artery of Percheron infarcts.

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MRI Classification and Stages of Early Glioblastomas: Awareness Precedes Change

C Toh ¹, M Castillo²
¹Chang Gung Memorial Hospital at Linkou, Taoyuan, Taiwan, ²University of North Carolina at Chapel Hill, Chapel Hill, NC

Purpose
Glioblastomas (GBs) are typically large when diagnosed and their prognosis remains poor with a 5-year survival rate typically less than 5%. Clinically, it is uncommon to detect small GBs and more unusual to document progressive growth of small to large tumors by MRI. It is important to be familiar with imaging findings and growth patterns of early GBs as it may help diagnosis and allow total resection that potentially improves survival.

Materials and Methods
Patients with initial MRI studies demonstrating early-stage GBs obtained from 2 academic institutions are included here. A previously published MR classification describing MRI findings of early-stage GBs was used and selected patients are presented along with clinical information, IDH mutation status and survival information. Early-stage GBs were defined as small MRI lesions demonstrating abnormal signal intensity on T2/FLAIR, and/or postcontrast T1-weighted images but with absence of imaging findings of classic GB such as necrosis, hemorrhage, prominent edema, and heterogeneous contrast enhancement. The lesions were followed and grew and were all subsequently proven to be GBs by histopathology.

Results
3 types of early-stage GBs representing 3 sequential stages of tumor growth were observed. The earliest MRI-detectable abnormalities were non-contrast enhancing FLAIR/T2 hyperintensities found in the cerebral cortex, deep gray nuclei, hippocampi and dentate nuclei. Subsequently the lesions extended to adjacent white matter demonstrating FLAIR/T2 hyperintensities. Contrast-enhancing nodules then appeared at gray-white matter junctions, and became classic GBs by progressive enlargement.

Conclusions
Awareness of imaging features and progressive growth patterns of early-stage GBs is important as these small tumors can progress to classic GBs in short intervals. Early detection of GBs may facilitate a change in current management, understanding of gliomagenesis and development of new therapies.

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A Chiu ¹, K McCullagh², P Bhatt ³, D Martin ², M Wintermark ³, S Hashmi ⁴, T MASSOUD ⁵
¹Stanford University School of Medicine, Stanford, CA, ²Stanford Health Care, Stanford, CA, ³Stanford, San Carlos, CA, ⁴Stanford, Stanford, CA, ⁵STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
The implicit assumption that abnormal neurologic and neuro-opthalmologic findings are signposts for particular lesions of the neuraxis is tainted by the existence of clinical ‘mis-localizing’ signs and symptoms, either as false-localizing signs (FLS), when local disturbances of function are distant from a neurologic lesion, or non-localizing signs, when clinical stigmata lack precise neuroanatomic correlation. The pathogenesis of FLSs is uncertain, but neuroimaging has three important clinical roles: FLSs may lead to inappropriate imaging in the first place; imaging can prevent surgical interventions in the wrong location; and more sophisticated neuroimaging techniques are necessary in the quest for accurate diagnosis to solve the dilemma of FLSs. Neuroradiologists should have a sound knowledge of clinically challenging FLSs, since accurate imaging interpretation may greatly contribute to clinical management.

Materials and Methods
We review clinical presentations, possible mechanisms, and neuroimaging correlates of numerous neurologic and neuro-opthalmologic FLSs.

Results
Neurologic FLSs most often occur in the context of raised ICP. Suggested mechanisms include mechanical distortion resulting in three FLS categories: motor deficits, cranial neuropathies, or spinal cord pathology. Motor system effects include Kernohan’s notch syndrome, a hemiparesis FLS from a supratentorial mass causing transtentorial herniation and contralateral midbrain compression by the tentorial free edge above the pyramidal decussation. Frontocerebellar pathway damage, e.g. post ACA infarct, may result in an FLS ‘cerebellar syndrome’. We also discuss FLSs manifesting as neuropathies affecting many of the cranial nerves. Notably, CN6 palsies are the most common FLS with raised ICP (in 14%). Spinal cord FLSs occur with lesions around foramen magnum or the lower cervical/upper thoracic cord resulting in distant myelopathies and radiculopathies. We also illustrate numerous other neuro-opthalmologic FLSs, as seen in transient monocular visual loss, complex visual hallucinations, other ocular motility disturbances (divergence paresis, convergence insufficiency, and skew deviation), and the localizing pitfalls of anisocoria, including Horner and Rader syndromes.

Conclusions
FLSs are clinical signs that violate the expected clinico-anatomical concordance on which clinical examination is predicated. This presentation will aid in identifying and understanding the imaging correlates of FLSs for improved patient management.
Pearls and Pitfalls of Brain Death Imaging; A Case Based Review.

K El Salek¹, A Rohana², C Mullins³, J Gavito-Higuera⁴
¹Texas Tech Health Science Center El Paso, PLFSOM, El Paso, TX, ²Texas Tech University Health Sciences Center El Paso, El paso, TX, ³Texas Tech University Health Sciences Center, El Paso, TX, ⁴Texas Tech University El Paso, El Paso, TX

Purpose
In this educational exhibit we aim to perform a case based review of the different imaging modalities used as diagnostic tools in the confirmation of brain death (BD). According to the American Academy of Neuroradiology (AAN) BD is diagnosed on clinical grounds based on the assessment of coma and apnea as well as the absence of brain reflexes. However, there are certain clinical scenarios in which the aforementioned clinical criteria cannot be reliably applied, hence the need for additional diagnostic tools such as diagnostic imaging. Imaging in BD is based on structural changes and the absence of perfusion to the infra- and supra-tentorial cortex. The educational objective of this exhibit is to review the structural changes that are seen on CT (computed tomography) and MRI (magnetic resonance imaging) in addition to the three imaging modalities that are deemed appropriate by the AAN in the diagnosis of BD and to discuss their advantages and pitfalls: 1- CA (cerebral angiography); Four vessel angiography is widely accepted as the gold standard, however it is invasive and readily replaced by other methods. 2- NMS (Nuclear medicine scintigraphy); Two Planar Tc-99m pertechnetate vs SPECT -99m HMPAO. 3- TCD (Transcranial Doppler); safe inexpensive test that can be done at bedside, shows high operator and inter-observer variability. On the other hand, CT angiography (CTA) and CT perfusion are emerging as reliable imaging alternatives with CTA achieving 85.7% sensitivity and 100% specificity when using four vessel opacification criteria. Despite a wide use of CTA in Canada and some European countries, the AAN does not currently determine CTA as an acceptable ancillary test in the diagnosis of BD.

Materials and Methods
N/A

Results
N/A

Conclusions
After viewing this educational exhibit and the accompanying cases, participants should be familiar with the clinical criteria, imaging structural changes and various ancillary imaging tools used in the diagnosis of BD according to AAN guidelines. Participants should become familiar with the pitfalls of these imaging modalities and the various clinical scenarios that would favor one modality over the other. Furthermore, we would like to emphasize on the usefulness and diagnostic potential of CTA in the United States as a reliable modality for diagnosis of BD even though it is not considered an appropriate method by the AAN at this time.
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Pitfalls in CT perfusion. Mimics of Penumbra to be Aware of.

R Teh1, A Wong1, M Bobinski1, A Ozturk1, O Raslan1, J Chang1, V Ivanovic1, N Pham1, R Assadsangabi1

1UC Davis Medical Center, Department of Radiology, Section of Neuroradiology, Sacramento, CA
Purpose
Review basics of CT perfusion (CTP) and examples of potential false positives and false negatives that may present diagnostic challenges. We hope to improve reader confidence when interpreting CTP through the provided exhibit.

Materials and Methods
Review of recent literature on the expected changes of CTP in infarction will be provided. The evolution of CTP findings in various time points from initial presentation of stroke will be reviewed. We divide the mimics of penumbra into three general categories: poor quality exams, altered intracranial circulation, or vascular dysregulation. Examples and discussion in each category will be provided.

Results
Examples of technically poor studies include inaccurate arterial or venous selection, inappropriate bolus timing, patient motion, and head tilt. Altered circulation refers to anatomic variations of the circle of Willis, chronic infarction, lacunar and small watershed infarcts, upstream cervical or intracranial carotid stenosis, and luxury hyperperfusion. Vascular dysregulation can be seen in seizures, vascular neoplasms, vascular malformations, posterior reversible encephalopathy syndrome, vasospasm, migraines, and trauma.

Conclusions
Correctly identifying the penumbra and recognizing potential false positives and negatives is required in timely fashion for interpreters of CT perfusion examinations to reduce misutilization of reperfusion therapies and improve patient outcomes. Careful review, correlation with the clinical history, and familiarity with common imaging pitfalls may allow for differentiation between conditions that mimic a penumbra.

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Post Spinal Fixation Reporting: What the surgeon wants to know

A Megahed1, A Saeed Bamashmos2, K Elfatairy3, A Heshmatzadeh Behzadi1, S Smith4
1Yale New Haven Health-Bridgeport Hospital, Bridgeport, CT, 2Yale New Haven Health Bridgeport Hospital, Bridgeport, CT, 3Yale New Haven Health-Bridgeport Hospital, Bridgeport, CT, 4Yale New Haven Health-Bridgeport Hospital, Bridgeport, CT

Purpose
*To overview the different spinal fusion surgeries, approaches and fixation hardware. *To overview the expected post-operative outcomes and signs of successful surgery. *To overview early and late complications of spinal fixation. *To provide a schematic approach to the post-fixation spine scan.

Materials and Methods
*Schematic approach to report a post-fixation spine scan: -Where is the surgery? Is it at the correct level? -What is the surgery? -What fusion hardware is used? Assess each element of the hardware/graft material in terms of: Position, Alignment, Configuration For example: Pedicle screw: Normal position Abnormal position Effect of abnormal position -When was the surgery?/ What are the expected outcomes at this point of time? Are they met? Assessment of bony fusion? Criteria of bridging osseous fusion -Assessment of spine alignment. -Are there any immediate or late complications? # Post operative complications: Hematoma Collections Surgical site infection Abscess Discitis Osteomyelitis Arachnoiditis Fistulas Pseudomeningioceles CSF fluid leaks #Hardware complications: Angulation/Herniation Fracture Loosening Resorption of graft material Failure of the graft material to incorporate into a solid fusion #Alignment complications Pseudoarthrosis Fracture # Of fusion Adjacent level degenerative changes -Assessment of the bony vertebrae. -Assessment of the discs, neural foramina, thecal sac and central cord for disease progression. -Assessment of the prevertebral soft tissues. -Assessment of the adjacent structures.

Results
Illustrations of several post fixation surgeries at our institute applying the schematic approach to post-fixation reporting.

Conclusions
Knowledge of the numerous spinal fixation techniques, devices and post operative imaging features related to the position and integrity of hardware as well as post operative complications is paramount to aid the radiologist in generating reports that address the issues the surgeon wants to know to provide optimal patient management.
Post-Treatment Imaging of Oral and Base of Tongue Cancers: A Comprehensive Review of Locoregional Changes and Complications

D McAllister1, D Martin2, T Massoud3
1Stanford University School of Medicine, Stanford, CA, 2Stanford Health Care, Stanford, CA, 3STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
Oral and base of tongue cancers (TCs) are different diseases. The oral tongue is the most common site of SCC in the oral cavity. Tongue base cancers are associated with HPV, which has a major effect on therapy and prognosis. Treatment may entail surgery with(out) combinations of chemotherapy, radiotherapy, and targeted drug therapy. However, TC has a high rate of locoregional relapse, accounting for treatment failures and poor overall survival. Imaging assessment of residual/recurrent disease after single/multimodal therapies is crucial for clinical planning and prognostic evaluation. We provide a pictorial and educational review of TC post-treatment changes and complications to aid in neuroimaging interpretation and patient management.

Materials and Methods
We comprehensively review the roles of CT, MRI, and PET imaging after TC treatment.

Results
We first review examples of TC cases mainly treated non-surgically, and the types of surgeries and reconstruction options available for TC. After primary treatment, the indications for post-treatment imaging are assessment of response to therapy and tumor control, detection of tumor recurrence, deferment of any planned neck dissection, and differentiating tumor recurrence from chemoradiation changes. CT or MRI can differentiate recurrent TC from mucosal epithelium, lamina propria, and tongue muscles; and PET is sensitive in detecting residual/recurrent nodal disease. New metastases to cervical lymph nodes is a prognostic variable, in addition to size, number, and laterality of these nodes. Imaging is useful to detect other cervico-facial post-treatment changes, including skin invasion, muscle infiltration, dense tethering or fixation to adjacent structures, and any new cranial and other nerve invasion.
addition, recurrent tumors and radiation fibrosis differ in signal intensity patterns. The early phase of radiation changes (high T2) occurs some weeks after treatment; the late phase (low T2) is due to fibrosis. PET/MRI using 18F-FDG has the potential to create a future one-stop examination after TC treatment. We also discuss imaging of: 1) floor of mouth grafts, 2) TC after catheter embolization, 3) complications, e.g. osteoradionecrosis, and 4) post-treatment swallow function using real-time MRI.

Conclusions
Neuroradiologists should be able to distinguish early post-treatment recurrence from expected treatment-related changes. This presentation will aid in neuroimaging interpretation of the post-treatment tongue to improve patient management.

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Posttreatment Imaging of Infiltrating Gliomas in Adults: Distinguishing Glioma Recurrence from Treatment - Related Changes

E Lee1, J Park1, E Lee1
1Dongguk University Ilsan Hospital, Goyang-si, Gyeonggi-do

Purpose
Distinguishing treatment-related changes from recurrent tumor in treated patients with high-grade gliomas is crucial for diagnosis and treatment planning. Posttreatment imaging assessment of high-grade gliomas remains challenging due to overlapping clinical and radiologic features. In this educational exhibit, we review posttreatment imaging findings associated with tumor progression and various therapy related changes, discuss the differential diagnosis among such entities and correlate with the findings on advanced MR techniques such as perfusion, diffusion-weighted imaging and spectroscopy.

Materials and Methods
1) Background and introduction 2) New WHO criteria and general overview for infiltrating gliomas 3) Posttreatment imaging findings of gliomas, - according to the Response Assessment in Neuro-Oncology (RANO) criteria for infiltrating gliomas including low-grade and high-grade gliomas, review of the imaging findings associated with tumor progression and therapy related changes 4) Role of advanced MR techniques for the differential diagnosis between two entities.

Results
Early identification of glioma recurrence may improve outcomes. Surgery, radiation and chemotherapy can lead to contrast-enhanced lesions and surrounding edema as in glioma progression. Clinical information is key to the correct interpretation of changes in imaging findings in treated gliomas. Subacute ischemia, blood–brain barrier breakdown related to recent surgery, pseudoprogression, and delayed radiation necrosis can cause increased or new foci of enhancement that do not reflect true progression of disease. Both antiangiogenic therapy and increases in steroid dosage can decrease tumor enhancement without affecting the underlying disease burden. Standard conventional MRI alone cannot reliably distinguish between glioma tumor recurrence and treatment-effect because of similar imaging characteristics. Although not included in RANO criteria, perfusion MR, MR spectroscopy and DWI can provide valuable information on differentiation between glioma recurrence and therapy related changes.

Conclusions
The radiographic imaging advances can be applied clinically to decrease the misdiagnosis of contrast-enhancing lesions as tumor recurrence and improve posttreatment therapy with more accurate differentiation between tumor recurrence and treatment effects.

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Quantitative Synthetic MRI and MR angiography: Basic Concepts, New 3D Features, Clinical Applications, and Limitations

S Fujita1, A Hagiwara2, S Kato1, C Andica1, K Hwang3, K Sato1, T Akashi1, K Kamagata1, M Suzuki1, A Wada4, S Aoki5, U Tateishi5
1Juntendo University, Tokyo, Japan, 2University of California Los Angeles, Los Angeles, CA, 3MD Anderson Cancer Center, Houston, TX, 4Juntendo University, Tokyo, Japan, 5Tokyo Medical and Dental University, Tokyo, Tokyo

Purpose
In this exhibition, we introduce the basic concept and features of synthetic MRI, including the recently introduced 3D acquisition, along with the application of these techniques to various common brain diseases.

Materials and Methods
List of educational objectives: 1. To provide the audience with basic concept of synthetic MRI, including tissue quantification, tissue segmentation, contrast-weighted image synthesis, and 3D acquisition. 2. To help the audience gain knowledge of deep learning-based approach to synthesize MR angiography image from 3D synthetic MRI 3. To provide the audience with clinical application examples and typical imaging appearances of synthetic MRI in common central nervous system diseases. 4. To give the audience the opportunity to recognize the limitation of synthetic MRI, especially the difference between synthetic and conventional FLAIR images.

Results
Synthetic MRI enables simultaneous tissue relaxometry of T1 and T2 relaxation times and proton density, along with synthesis of contrast-weighted images and automatic segmentation based on the acquired absolute tissue values. Quantitative values derived from the synthetic MRI are overall robust for brain relaxometry across scanners of different vendors, which is a prerequisite for establishing
imaging biomarkers. We also present the recently introduced 3D version of synthetic MRI, which provides accurate volume analysis and reformattting in arbitrary planes. Further, we explain a deep learning approach that generates MR angiography images from synthetic MRI data. Along with the introduction of these features, we share imaging appearances of common central nervous system diseases including primary brain tumors, brain metastases, multiple sclerosis, and vascular diseases. Finally, we discuss the limitations and pitfalls of synthetic MRI in clinical neuroimaging.

Conclusions
Synthetic MRI/MRA has the potential to reduce total scanning time and improve examination throughput, while providing quantitative information for objective analysis.

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Rare Neonatal Neck Masses: Expanding The Differential Diagnosis

S Kralik¹, N Desai², M Kukreja³, H Tran¹, S Birchansky¹
¹Texas Children's Hospital, Houston, TX, ²N/A, N/A, ³Texas Childrens Hospital, Houston, TX

Purpose
Common neonatal neck masses include teratomas and lymphatic malformations, however, other more rare neck masses can present in the neonate. Radiologists may be unfamiliar with these masses and/or unfamiliar with their imaging appearance. The purpose of this exhibit is to demonstrate the imaging appearances of rare neonatal neck masses that may mimic more commonly encountered neonatal neck masses.

Materials and Methods
A radiology database search and review of the electronic medical record was performed and identified neonates with a neck mass who had uncommon histopathologies including: kaposiform hemangioendothelioma, infantile fibrosarcoma, infantile myofibromatosis, congenital infantile hemangioma, neural glial heterotopia, and infected thyme cyst. The ultrasound, CT, and MRI findings for these pathologies will be presented and imaging characteristics will be demonstrated in this presentation.

Results
We encountered multiple neonates with a few rare pathologies that may mimic teratoma or lymphatic malformations that radiologists should be aware of. Kaposiform hemangioendothelioma, infantile fibrosarcoma, and neural glial heterotopia can mimic a teratoma due to the large size of the mass as well as the heterogeneity of the mass on imaging. Kaposiform hemangioendothelioma can appear particularly vascular and aggressive. Neural glial heterotopia can present as a neck mass, most commonly in the parapharyngeal space, and often demonstrates intracranial extension through the skull base. Congenital infantile hemangioma may not be considered in the diagnosis because most radiologists do not encounter infantile hemangiomas in this age group, but imaging features of congenital infantile hemangiomas are similar to other infantile hemangiomas. Infantile myofibromatosis can present in multiple locations in the neck, and appear aggressive on imaging with intraspinal extension, cord compression, and diffusion restriction despite its classification as a benign tumor. An infected thyme cyst often presents shortly after birth as a rapidly enlarging central neck mass due to the infection of the cyst. The location and presence of diffusion restriction is helpful in confirming an infected thyme cyst.

Conclusions
Rare neonatal neck masses are challenging for radiologists to diagnose. Increasing the awareness of these pathologies will assist radiologists in considering these from the more frequently encountered masses in the neonate.
Recognizing and staging Diffuse Axonal Injury on imaging and its effect on clinical management of disease

M Aftab¹, a naik²
¹Ascension Genesys Hospital, Flushing, MI, ²Michigan State University College of Osteopathic Medicine, East Lansing, MI

Purpose
Diffuse axonal injury (DAI) develops when trauma to the cranium induces rotational forces that shear axons along the grey-white matter junction, disrupting nerve transduction. In severe manifestations of DAI, this trauma will cause inflammatory damage and the...
rupture of axons, leaving patients in a state of vegetation. This abstract will review warnings on CT and signs on MRI of DAI and its importance in staging disease.

Materials and Methods
An extensive review of current literature was performed for quality of information regarding the development and progression of DAI. This information was synthesized to provide a comprehensive review of steps in evaluating a patient for suspected DAI.

Results
When assessing patients with acute traumatic brain injury, CT is the most valuable study to perform because it assesses structural damage that places patients in immediate harm. However, CT is limited in sensitivity when detecting white matter changes that occur in diffuse axonal injury. As such, it is appropriate to perform an MRI to assess for DAI in patients that present with significant cognitive impairments with no acute changes detected on CT. T2 weighted and SWI MRI are sensitive in detecting brain microhemorrhages at the grey-white junction, while DTI MRI is sensitive to white matter tract injury. Due to its ability to detect DAI lesions, MRI has since been utilized to stage the disease. A study by Hamdeh et al. used MRI to visualize the histopathological DAI staging criteria created by Adams et al. The following grades of axonal injury were confirmed: I. Lesion Involving Grey-white matter junction of the cerebral hemisphere II. Lesion I + involvement of corpus callosum III. Lesion I + II and involvement of the brainstem While the above stages of lesions do not alter outcomes in patients, the study suggested the creation of a grade IV for DAI. They discovered that lesions specific to the substantia nigra and tegmentum of the mesencephalon were found to be associated with poorer long-term outcomes in patients older than the age of 30.

Conclusions
Given the relative insensitivity of CT for detecting DAI, MRI with SWI imaging should be considered in patients presenting with the appropriate clinical history of high velocity trauma with significant neurologic deficits. MRI can reliably differentiate cerebral contusions from axonal injury in the cerebral white matter, corpus callosum and brainstem. Timely diagnosis of DAI can significantly alter clinical management of disease.
DAI stages imaged above: (A) Stage I involving supratentorial white matter damage. (B) Stage II lesion involving the corpus callosum. (C) Stage III involving the dorsal pons-brainstem. (D) Stage IV involving the substantia nigra.

Retinoblastoma

S. Naganawa¹, S. Kandemirli², G. Bathla³, Y. Ota⁴, J. Kim¹, T. Moritani⁵
¹University of Michigan, Ann Arbor, MI, ²University of Iowa, Iowa City, IA, ³Univ. Of Iowa Hospitals & Clinics, Iowa City, IA, ⁴Kyoto Prefectural University of Medicine, Kyoto, JAPAN, ⁵UNIVERSITY OF MICHIGAN, ANN ARBOR, MI
Purpose
Review the cases of retinoblastoma in our institutions, focusing on the relationship between gene mutation status and imaging findings. Review the clinical course of these patients with retinoblastoma.

Materials and Methods
Retrospective review of retinoblastoma cases in our institutions from 2000 to 2019. Present the cases with gene mutational status and their associated imaging features. Furthermore, we will review the long term prognosis after treatment.

Results
Our presentation will show several cases of unilateral, bilateral, and trilateral retinoblastomas with their imaging features and Rb1 mutational status. We will compare images before and after chemotherapy and enucleation. Our preliminary review reveals late onset sarcomas around orbital region (N = 5), meningiomas around orbital region (N = 4), breast cancers (N = 3), uterine leiomyosarcoma (N = 3). We will show post-treatment complications such as: intra/post orbital osteosarcoma, myxoid liposarcoma, and meningioma, usually lateralized to the affected side, which are probably due to radiation therapy. Also we will show developed sarcomas in distant locations such as uterine leiomyosarcoma, mesenteric leiomyosarcoma, synovial sarcoma in the right thigh, pancreas carcinoma and breast cancers.

Conclusions
Constitutional Rb1 mutations usually cause bilateral retinoblastoma and sometimes may cause small benign retinoma, which can be mistaken as retinoblastoma recurrence. Non-hereditary RB1 gene mutations cause unilateral retinoblastoma. Patients with history of retinoblastoma tend to develop sarcomas mostly near the orbit, but also sarcomas and adenocarcinomas in distant locations. We should avoid radiation exposure to these patients as much as possible.

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Review of Classic and Very Rare Radiation Effects Involving the Head and Brain.

M Oien1, C Carr2, F Diehn2, D Johnson3, D Kim2, D DeLone1
1Mayo Clinic Rochester, Rochester, MN, 2Mayo Clinic, Rochester, MN, 3Mayo Clinic, ROCHESTER, MN

Purpose
Educational objectives:
- Review the spectrum of radiation-related effects in the head
- Discuss common radiation-induced entities, including radiation necrosis
- Highlight unusual entities caused by radiation, including SMART syndrome
- Present both clinical and imaging findings for patients presenting with this disease spectrum

Materials and Methods
Whole brain and stereotactic radiosurgery are important forms of therapy that can allow for definitive treatment, improved disease control, and overall survival improvement in a variety of neurologic malignancies and other conditions. However, it is not without significant side effects and the appropriate diagnosis in the post-radiation patient population can be particularly challenging. We performed a case review of both classic and very rare radiation therapy effects involving the head and brain beyond the usual radiation necrosis. Examples of radiation induced side effects reviewed include stroke-like migraine attacks after radiation therapy (SMART syndrome), enlarging perivascular spaces, labyrinthitis, neurodegenerative disorders, leukoencephalopathy, radiation necrosis, and radiation induced cancer including meningioma, glioblastoma multiforme, osteosarcoma, and hemangiopericytoma.

Results
N/A

Conclusions
N/A
Rituximab related Immune Reconstitution Inflammatory Syndrome in a patient with Lymphoma

C Folterman, A Martinez-Tapia, A Pal

1St Barnabas Medical Center, West Orange, NJ, 2St. Luke's University Hospital, Bethlehem, PA, 3St Luke’s Health Network, Bethlehem, PA

Purpose
Immune Reconstitution Inflammatory Syndrome (IRIS) is a rare inflammatory condition normally seen in HIV patients after initiating HAART therapy. However, it can also be paradoxically seen in HIV negative patients following the cessation of immunosuppressive
and chemotherapeutic agents with underlying progressive multifocal leukoencephalopathy (PML). The purpose of this exhibit is to expand knowledge and awareness that IRIS can also develop in HIV negative immunocompromised patients following discontinuation of therapy.

Materials and Methods
An 82 year old male with history of stage I non-small cell lung cancer and stage IVa marginal zone B-cell lymphoma, for which he had been receiving Rituximab, presented with global aphasia and right hand apraxia. Examination was significant for dysarthric speech and right facial weakness. Rituximab was discontinued four months from the onset of symptoms. HIV labs were negative.

Results
MRI brain imaging with and without contrast revealed two discontinuous regions of increased FLAIR signal with corresponding low T1 within the left frontal and parietal lobes involving the subcortical U-fibers. There was no associated mass effect. Patchy enhancement was noted along the margins of the FLAIR signal abnormality. Findings were initially thought to be attributed to a neoplastic process given the clinical history. After little improvement following a two week course of steroids, repeat MRI was conducted. The area of increased FLAIR signal remained unchanged while there was interval improvement of the associated patchy enhancement. Surgical biopsy was done and found axonal preservation with myelin destruction, consistent with PML. Lymphoid infiltrate indicating a response to the infection was also present, consistent with IRIS.

Conclusions
While PML induced IRIS is typically seen in HIV individuals after starting anti-retroviral therapy, it can also be unmasked or paradoxically develop in other patients being treated with immunomodulators. To our knowledge, few cases of Rituximab associated IRIS have been documented. As radiologists and treating clinicians, we should be aware of these medications’ potential to illicit this inflammatory condition particularly in the context of acute neurological deficits. Findings for PML-IRIS on MRI include increased FLAIR and low T1 signal within the subcortical U-fibers without mass effect. Patchy or punctate enhancement is also likely to be noted along the margins of the signal abnormality secondary to the inflammatory response.
Spectrum of Neuroimaging Findings in Febrile Infection-related Epilepsy Syndrome (FIRES) - a National Specialist Center Study

S Udani¹, A Roy¹, S Culleton², G Talenti³, S Pujar², F Gentile², F D'Arco⁴
¹Guys and St Thomas NHS Foundation Trust, London, UK, ²Great Ormond Street Hospital for Children, London, UK, ³Verona University Hospital, Verona, Italy, ⁴Great Ormond Street Hospital for Children, London, London

Purpose
Febrile infection-related epilepsy syndrome (FIRES) is a rare severe epileptic syndrome occurring in previously healthy children. It is
characterised by refractory status epilepticus following febrile illness. The purpose of this educational presentation is to provide the delegate with an overview and understanding of the spectrum of imaging findings in this condition and to aid the neuroradiologist in excluding mimics and to support the diagnosis of FIRES.

Materials and Methods
We reviewed all the patients in our specialist epilepsy service over the last 5 years. We describe the specific MRI imaging features of 10 patients with a clinical diagnosis of FIRES.

Results
4 patients had normal initial scan. 6 patients had abnormalities in the temporal lobes (2), basal ganglia (3), thalami (2) and brain stem (1) and diffuse cerebral oedema (1). In the chronic phase of the disease, when the child had recovered from status epilepticus the imaging features consisted of brain atrophy and mesial temporal lobe sclerosis in 6/10 subjects in the areas showing previous acute abnormalities.

Conclusions
There is a wide spectrum of imaging findings in children with FIRES. These can be separated into acute and chronic phases of the disease. Understanding the MRI features can aid the neuroradiologist in supporting the clinical diagnosis and thereby facilitating the early initiation of appropriate therapy.

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Spinal Facet Joint Tumors: A Multifaceted Neuroimaging Review

F Kuo1, S Ghaderi Niri1, Y Guo2, E TONG3, T MASSOUD4, S Hashmi5
1Stanford University School of Medicine, Stanford, CA, 2Stanford University, Stanford, CA, 3STANFORD UNIVERSITY, STANFORD, CA, 4STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA, 5N/A, N/A
Purpose
Spinal facet joint (SFJ) neoplastic involvement is infrequent, and mostly seen in the setting of diffuse spinal osseous metastatic disease. Transarticular joint invasion with true synovial involvement and spread to the surrounding bone is rare in any spinal joint, and especially in SFJs. Neuroradiologists should be familiar with benign and malignant SFJ/perifacet neoplasms, but the relatively uncommon occurrence of these lesions can be a challenge. We provide a pictorial and educational review of SFJ tumors to aid in neuroimaging interpretation and patient management.

Materials and Methods
In this exhibit, we review the spectrum of benign and malignant neoplasms that can arise in an SFJ itself or secondarily spread across the joint space, and provide examples of these entities on spine imaging.

Results
Both CT and MRI provide diagnostic information allowing for characterization of articular and periarticular lesions, and are generally complementary in a thorough work-up of SFJ tumors. Though benign lesions are less frequent than metastases, they include a variety of different entities that might be distinguishable based on their imaging appearances. We will review the imaging appearances of benign SFJ tumors including tenosynovial giant cell tumor, osteochondroma, chondromyxoid fibroma with aneurysmal bone cyst, lipoma, osteoid osteoma, and fibrous dysplasia. We will also review the imaging signatures of malignant neoplasms such as chondrosarcoma, Ewing sarcoma, synovial osteosarcoma, and metastatic disease. Desmoid tumors are classified as semi-malignant, growing locally and invasively; these lesions can rarely occur at SFJs. Finally, we will also address mass-like non-neoplastic entities that can involve the SFJ such as pigmented villonodular synovitis (PVNS). Importantly, some imaging features of SFJ tumors can also be found in other epidural masses such as lymphoma, meningioma, nerve sheath tumor, metastasis, and myeloma, and these should be considered in the differential diagnosis. Moreover, in cases that present with SFJ bony destruction, other primary bone lesions such as aneurysmal bone cyst, osteoblastoma and osteoclastoma should be considered in the differential diagnosis for lesions involving the vertebral posterior elements.

Conclusions
SFJ tumors are rare and can present with back pain indistinguishable from other more benign causes. This presentation will aid in neuroimaging interpretation and understanding of SFJ neoplastic lesions to improve patient management.

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The Many Faces of Lymphoproliferative Disorders: Reviewing Patterns and Differential Diagnoses

F Pereira¹, A Alves Fonseca², M Marins¹, R Nivoloni¹
¹Vera Cruz Hospital, Campinas, SP, ²Irmandade da Santa Casa de São Paulo, Sao Paulo, Sao Paulo

Purpose
Lymphoproliferative malignancies constitute a wide spectrum of haematological malignancies and their prevalence is widely increasing. Lymphoma of the CNS consists of two major subtypes: secondary CNS involvement by systemic lymphoma (the most common) and primary CNS lymphomas (PCNSL), in which the lymphoma is restricted to the brain, leptomeninges, spinal cord, or eyes, without evidence of it outside the CNS at primary diagnosis. Our purpose is to review and discuss the many faces of lymphoma on the CNS, head and neck and spine, focusing on the various forms of presentation in the image and the differential diagnoses.

Materials and Methods
After reviewing our institution teaching files, we selected cases demonstrating lymphoproliferative disorders, focusing in CNS, head and neck and vertebral/paravertebral involvement, like rhinopharynx, orbit, lymphoma of the skull and the multiple forms of presentation on the brain (parenchymal, periventricular, angiocentric lesions), and brainstem.

Results
Lymphomas may have a characteristic appearance on traditional CT and MR imaging, but none of these imaging characteristics will unequivocally differentiate CNS lymphomas from other neoplasms or non-neoplastic diseases (eg, multiple sclerosis, stroke, cerebral toxoplasmosis, pyogenic abscesses). DWI, perfusion MRI, and MR spectroscopy are increasingly used in clinical radiologic practice and may help to differentiate CNS lymphomas from other lesions. We review the radiologic features of the lymphoproliferative disorders in immunocompetent and immunodeficient patients, demonstrating the many forms of presentation.

Conclusions
Knowing and recognizing the various presentation patterns of lymphomas and differentiating them with other neoplastic conditions or not, are essential for early diagnosis and for the direction of the requesting physician.
The Role of High-Resolution Intracranial Vessel Wall Imaging in Intracranial Vasculopathies

L Feitoza¹, F Reis¹, V Subtil Viuniski², J DUARTE³
¹Universidade Estadual de Campinas, Campinas, Sao Paulo, ²Hospital das Clinicas de Porto Alegre, Porto Alegre, Rio Grande do Sul, ³HCPA, Porto Alegre, Rio Grande do Sul

Purpose
1. To illustrate the spectrum of different intracranial vasculopathies using HR-VWI sequences
2. To demonstrate the applicability of this technique in the differential diagnosis and aiding in detecting vascular involvement.

Materials and Methods
Conventional imaging techniques for intracranial arteries (CTA, MRA and DSA) demonstrate abnormalities of the vessel lumen, but may fail to demonstrate vessel wall changes. The high-resolution vessel wall magnetic resonance imaging (HR-VWI) had been used due to its direct visualization of the vessel wall.[1] In this exhibit we provided a pictorial review of some vasculopathies in which the technique may be useful in clinical practice.

Results
Pictorial review of intracranial vasculopathies that show the potential benefits of HR-VWI: Intracranial atherosclerotic disease A 60-year-old man presented with right lower limb weakness for 2 months with progression to the face and upper limb day 1 day ago (Figure 1). Giant cell arteritis 69-year-old woman with giant cell arteritis admitted with seizures (Figure 2). Intracranial arterial dissection A 9-year-old boy was admitted in the emergency department with seizures (Figure 3). Syphilis-associated vasculitis A 26-year-old man presented acute-onset right hemiparesis, diplopia upon horizontal gaze and fever. The CSF and blood samples were positive for syphilis. A test for HIV was positive (Figure 4).

Conclusions
HR-VWI somehow transcribes the pathophysiological mechanism of vascular disease. It can be useful in cases where direct visualization of the vessel wall helps narrow the differential diagnosis (including infectious vasculitis) according to the pattern of involvement. Monitoring vasculitis treatment is also a potential benefit. This sequence also allowed to detect cranial nerve involvement (not detected in conventional sequences in this case).
Figure 1. Intracranial Atherosclerosis. Axial FLAIR and DWI MRI depict acute ischemic lesions in deep white matter of the left cerebral hemisphere. CTA and MRA show severe stenosis of the left internal carotid artery and left middle cerebral artery. HR-VWI postcontrast reveals eccentric wall thickening and enhancement, which suggests atherosclerotic component.

Figure 2. Giant cell arteritis. Large areas of recent ischemia in left cerebral hemisphere involving insula, frontal, parietal and temporal lobes. MRA shows no significant changes in the carotid arteries, but HR-VWI demonstrates concentric parietal thickening and enhancing, more pronounced in the left internal carotid.

Figure 3. Internal carotid dissection. Axial CT demonstrates hypodense area in right nucleased capsular region. Axial FLAIR and DWI MRI confirm acute ischemic lesion in the right caudate nucleus and putamen. CTA and MRA depict slight reduction in vessel caliber of the right internal carotid artery. HR-VWI demonstrates linear signal hyperintensity in the anterior and posterior wall of the right internal carotid artery, consistent with carotid dissection.

Figure 4. Syphilis-associated vasculitis. Axial DWI and T2W MRI demonstrate left hemipons infarction. 3D-TOF MRA discloses significant stenosis of the basilar artery. Axial and sagittal HR-VWI postcontrast depict a concentric parietal thickening and enhancing of the basilar artery, which is consistent with vasculitic pattern. There is also an enhancing of the left abducens nerve.
Uncommon imaging presentations of retinoblastoma and complications following treatment

M Kukreja¹, S Kralik², H Tran², S Birchansky², F Lin²
¹Texas Children's Hospital, Houston, TX, ²Texas Children's Hospital, Houston, TX

Purpose
Retinoblastoma is the most common intraocular malignancy in children. It classically presents on imaging as an enhancing intraocular retinal based mass with restricted diffusion and calcifications. However, radiologists should also be familiar with atypical imaging features, as well as recognize unexpected complications. The purpose of this exhibit is to demonstrate the spectrum of uncommon imaging appearances of retinoblastoma and complications following treatment.

Materials and Methods
A radiology database search and review of the electronic medical records was performed to identify pediatric patients with confirmed retinoblastoma. Our cohort of patients studied is those with uncommon imaging appearance at the time of diagnosis and/or unusual complications during or following treatment.

Results
Uncommon imaging appearances at presentation were found to include extraocular extension, optic nerve involvement, periorbital inflammation, associated vitreous/subretinal hemorrhage, lens dislocation, iris rubeosis, intracranial and intraspinal dissemination and trilateral disease. We also present a very rare variant diffusely involving the anterior chamber. Malignancies after disease diagnosis and treatment such as pilocytic astrocytoma, sarcomas and esthesioneuroblastoma are reviewed. Additional complications were found to include stroke in the setting of intra-arterial chemotherapy, as well as a case of thiamine deficiency during treatment.

Conclusions
Although most cases of retinoblastoma have a classic imaging appearance at presentation and follow an expected course with treatment, some are unusual and can make the diagnosis and management more challenging. We present several uncommon cases that will help radiologists recognize these entities.

When Standard Lumbar Punctures Fail—New and Old Alternative Image-Guided Approaches to Needle Access of the Subarachnoid Space. A Pictorial and Technical Review

A Trinh¹, P Bhatt¹, N Bates¹, S Ghaderi Niri¹, S Hashmi², T MASSOUD³
¹Stanford University School of Medicine, Stanford, CA, ²N/A, N/A, ³STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
Percutaneous lumbar puncture (LP) is used to access the subarachnoid space (SAS) for cerebrospinal fluid (CSF) withdrawal, injection of drugs or imaging agents, or monitoring CSF pressure changes during lumbar infusion studies. Patients requiring LPs can be challenging, and imaging guidance for SAS access has grown in demand and use, often leading to neuroradiologists being the primary providers of this procedure. However, a fluoroscopic LP may be impossible for several anatomical or logistical reasons. We provide a pictorial and educational review of 8 alternative new and old techniques to aid neuroradiologists in percutaneous access of the SAS for those uncommon instances when standard LPs fail or are not possible.

Materials and Methods
We review and illustrate the techniques and complications of 8 alternative procedures to insert a spinal needle into the SAS. We present these by location, from cephalad to cauda along the spinal axis.

Results
1) Cisternal tap (suboccipital puncture) is now extremely rare. A spinal needle is inserted midline between inion and C2 spinous process, and directed superiorly through the atlanto-occipital membrane into cisterna magna under lateral fluoroscopy. Two potential major complications are SAH and medullary puncture. 2) Fluoroscopic lateral C1-C2 puncture for SAS access in the dorsal third of the spinal canal, to avoid a possible more ventral fenestrated vertebral artery or anomalous low PICA. 3) Posterior thoracic SAS puncture between T9-T11, as per spinal anesthesia using a 27G needle; several drops (each is 60 microL) of CSF may be sufficient for lab analysis. 4) High LP between L1-L3 in the lateral decubitus position helps avoid the gravity-displaced conus. 5) Transforaminal fluoroscopic or CT-guided LP by targeting the mid posterior aspect of the vertebral foramen appears safe in preliminary experiences to date. 6) Transosseous translaminar LP is possible through a spinal needle coaxially threaded in a bone biopsy system in patients with fused posterior elements after surgery or ankylosing spondylitis. 7) Transforaminal-sacral SAS puncture through S1 or S2 foramen, as per spinal anesthesia. 8) Trans-sacral hiatus approach to the sacral cistern has also been described when the sacrum is sufficiently straight.

Conclusions
Neuroradiologists should be familiar with all possible image-guided percutaneous techniques to access the SAS. This presentation will aid in understanding all alternatives when standard LPs are contraindicated, difficult, or fail.
"Are you the gatekeeper? What the radiologist needs to know about the anatomy, function and pathology of the thalamus"

s fardin¹, N Madan¹, J Hassan¹
¹Tufts Medical Center, Boston, MA

Purpose
1. Review the anatomy, physiology, and vascular supply of the thalamus. 2. Describe the magnetic resonance imaging (MRI) characteristics of the main pathologies affecting the thalamus. 3. Discuss the important imaging features to narrow the differential diagnosis such as the presence of extrathalamic lesions or paired lesions.

Materials and Methods
This presentation includes MRI images to illustrate the imaging characteristics of thalamus pathologies considering the pattern of involvement. In addition, the presentation will include a brief review of the pathophysiology and imaging differential for each of these diagnoses. For example: the hockey puck sign in CJD, Wernicke's encephalopathy, hypoxic injury, artery of Percheron and venous thrombosis insults, as well as neoplasms and demyelination.

Results
not applicable

Conclusions
The thalamus is a complex structure involved in several cognitive, motor, and sensory processes. Thalamic pathologies can be classified into vascular, metabolic, demyelinating, trauma, neoplastic, congenital, and infectious. Multimodal MR imaging, which includes morphologic sequences, diffusion-weighted imaging, and perfusion imaging as well as spectroscopy, is a useful tool for the diagnosis and management of these conditions.
"Critical Illness–Associated Cerebral Microbleeds/Cerebral microbleeds associated with critical illness" in a patient with sickle cell disease.

H Sotoudeh¹, A Singhal², P Chapman¹
¹University of Alabama Birmingham, Birmingham, AL, ²University of Alabama at Birmingham, Birmingham, AL

Purpose
"Critical Illness–Associated Cerebral Microbleeds/Cerebral microbleeds associated with critical illness" is a new condition which has been described in 2017. It has been defined as extensive microbleeds involving the juxtacortical white matter and corpus callosum but sparing the cortex, deep and periventricular white matter, basal ganglia, and thalami, with occasional microhemorrhages internal capsule or posterior fossa involvement. This condition has been described in patients in critical condition, who are admitted in ICU and often on a ventilator. It has been described in patients with leukemia, lymphoma, sepsis, sickle cell disease, cystic fibrosis,
vasculitis, ARDS, encephalitis, influenza infection and pneumonia. In this presentation we describe a case of sickle cell disease admitted in ICU with "Critical Illness–Associated Cerebral Microbleeds/Cerebral microbleeds associated with critical illness".

Materials and Methods
Medical history and imaging findings of a patient with sickle cell disease admitted in ICU will be reviewed.

Results
The patient is a 38 year-old female with Hemoglobin SC disease and retinopathy who was admitted to the ICU service because of worsening hypoxia with concern for acute chest syndrome versus fat embolism. On the next night of admission she became somnolent and hypoxic. The patient transferred to ICU for further care. Because of altered mental status brain CT and MR were performed and the MRI showed numerous foci of microhemorrhages in the subcortical regions of cerebral hemispheres, corpus callosum especially in the splenium, basal ganglia and cerebellum. Very few lesions of tinnny diffusion restriction was noted to correlate with micro hemorrhages.

Conclusions
"Critical Illness–Associated Cerebral Microbleeds/Cerebral microbleeds associated with critical illness" is a very rare condition but should be in mind in ICU patients with critical conditions. It can happen because of sickle cell disease and must not be confused with fat embolism syndrome which is also happens in these patients after bone marrow infarction because of sickle cell crisis. The both condition may present by numerous foci of susceptibility artifacts on SWI sequence but fat embolism often is associated with numerous foci of diffusion restriction on DWI sequence while in "Critical Illness–Associated Cerebral Microbleeds" diffusion restriction is not the dominant radiologic picture.

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1386

4D-CT Parathyroid for the General Radiologist: A Pictorial Essay of Illustrative Cases

J Gosis1, A Sepahdari2, S Karnezis1, A Azizyan1, N Salamon1, A Vijayasarithi1
1University of California, Los Angeles, Los Angeles, CA, 2Scripps Health System, La Jolla, CA

Purpose
Educational Objectives: Describe the purpose of 4D-CT for evaluation of primary hyperparathyroidism and pre-surgical planning

Review 4D-CT imaging protocol and illustrate the typical appearance of parathyroid adenomas and how they differ from other entities in the neck, including ectopic/accessory thyroid tissue and lymph nodes Review the embryology of the parathyroid glands, including the differences between the superior and inferior parathyroid glands, and use knowledge of the embryology to facilitate a systematic search for orthotopic and ectopic adenomas Illustrate a variety of cases of parathyroid adenomas in orthotopic and ectopic locations and cases of multi-glandular disease Illustrate important mimics of parathyroid disease and important "incidental" findings in the neck and upper chest

Materials and Methods
Outline of powerpoint: Introduction: brief overview of hyperparathyroidism and need for precise preoperative localization for minimally invasive parathyroidectomy Imaging Technique: use of dynamic contrast enhancement with 3 phases (pre-contrast, arterial, and venous) imaged in 3 orthogonal planes; describe typical enhancement characteristics of parathyroid adenomas and how they differ from thyroid tissue and lymph nodes Anatomy: discussion of relevant embryology, including differences between the superior and inferior parathyroid glands and their expected orthotopic and ectopic locations Cases

Results
We have at least 16 cases of positive 4D-CT parathyroid scans collected at our institution illustrating orthotopic and various ectopic locations (e.g. mediastinal, retropharyngeal, intrathymic, and intrathyroidal), bilateral adenomas and multi-gland hyperplasia, parathyromatosis following parathyroidectomy, important mimics, and "incidental" findings including lung cancer, brown tumor of the mandible, carotid artery occlusion and aneurysm.
Conclusions

Primary hyperparathyroidism is a relatively common disease associated with significant morbidity. Minimally invasive parathyroidectomy is the first-line treatment for parathyroid adenomas. With its multi-planar, multi-phase approach, 4D-CT has become the first line tool for preoperative localization. High quality interpretation of these examinations should therefore be part of the general radiologist's skill set. The interpreting radiologist will be expected to describe/localize high suspicion nodules, identify ectopic adenomas and multi-gland disease, highlight relevant anatomic considerations, and describe unexpected important findings.

(Filename: TCT_1386_SampleCases.jpg)

2682

A comparative review of current endovascular treatments of wide-necked large and giant aneurysms

K Kansagra1, M Taon1, J Kang1, S Kao2, D Rex1
1Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA, 2UCLA, Los Angeles, CA

Purpose

Wide-necked (neck diameter > 4 mm or dome-to-neck ratio < 2) large and giant aneurysms (> 15 mm) possess an inherent increased risk of rupture compared to smaller and narrow-neck intracranial aneurysms. Endovascular treatment may be challenging with higher complication risks of infarct and re-canalization of the aneurysm sac in this particular population. Herein, we present a background of the current endovascular devices available for the treatment of wide-neck large and giant intracranial aneurysms. We review the landmark trials and present several case studies from our institution showcasing these devices.

Materials and Methods

A literature review will be performed, with special focus on the background, indications, safety/efficacy, and complication risks of established and novel devices used in the treatment of wide-necked and large aneurysms. Several cases from our institution with a busy neuro-interventional service showcasing these devices will be selected for presentation.

Results

Flow diverters and balloon-/stent-assisted coiling are the best studied and most commonly used approaches for treatment. The 5-year follow-up of the Pipeline for Uncoilable or Failed Aneurysms (PUFS) clinical trial of 107 subjects demonstrated high safety and efficacy of the Pipeline Embolization Device (PED) with low complication risks. A recent 2019 meta-analysis of 29 studies demonstrated comparable safety and efficacy with flow diverters and coiling techniques. Several techniques such as intra-aneurysmal devices/implants (ie. WEB) and bifurcation support systems are increasingly being utilized and several studies have shown comparable safety and efficacy.

Conclusions

Wide-necked large and giant aneurysms possess an inherent increased risk of rupture and are more challenging to treat when compared to smaller and narrow-neck intracranial aneurysms. Factors such as anatomy, size, neck diameter, and location should be
considered when choosing the optimal method of approach. It is important for the neuro-interventionalist to evaluate all treatment options when attempting to manage this entity.

A Pattern Based Approach to Stroke Mimics on MRI

S John¹, H Leong¹
¹CHANGI GENERAL HOSPITAL, Singapore, Singapore

Purpose
Stroke mimics constitute between 10 to 30% of acute stroke presentations. Imaging, particularly MRI helps exclude a large number of these. Several however, demonstrate restricted diffusion on MRI and remain difficult to differentiate from stroke both clinically and on imaging. The purpose of this review is to describe a pattern based approach to stroke mimics on diffusion weighted imaging (DWI) to aid easier recognition and diagnosis.
Materials and Methods
With the advent of endovascular therapy as standard of care for hyperacute stroke, magnetic resonance imaging (MRI) for stroke has increased in volume and reporting has become time-sensitive. "Time is brain", mandates both accurate and fast reporting. This is invariably on a background of incomplete/ inadequate clinical data in the emergent setting. Additionally limited stroke MRI protocols while adequate for the diagnosis of infarcts, may be somewhat limited in characterising mimics. We describe known stroke mimics in comparison to the characteristic diffusion weighted imaging (DWI) appearances of the different subtypes of stroke including thrombotic, embolic and hypoxic injury. We include both common and less common conditions with typical and atypical findings, as well as rare conditions with characteristic imaging appearances.

Results
Ischemic stroke subtypes demonstrate specific patterns on DWI. Thrombotic vascular occlusion classically demonstrates restricted diffusion confined to defined arterial territories. Mimics include tumours and large abscesses. Typical mimics of embolic strokes which are usually multiple and small, involving more than one arterial territory (commonly bilateral), include microabscesses/septic emboli and hemorrhagic metastases. We also demonstrate a case of meningitis simulating embolic stroke. Mimics of hypoxic injury with cortical restricted diffusion including postictal changes and encephalitis. We also demonstrate acute thrombus in a cortical vein mimicking cortical stroke and rarer causes such as Creutzfeld Jakob disease and heat stroke. Specific imaging patterns such as bilateral infarcts seen in internal cerebral vein thrombosis simulating artery of Percheron occlusion, as well as the rarer Balo's concentric sclerosis and neuronal inclusion disease (NIIDS) with characteristic patterns on DWI are also included.

Conclusions
A pattern specific description of stroke mimics aims to list the possible differentials for acute stroke on MRI in a manner that will help stratify diagnosis for the busy on-call radiologist.
A Pictorial Review of Common Imaging Appearances of Distal ICA Aneurysms Using Noninvasive Angiographic Techniques

N MATTHEES1, F Hurd2, J Hughes3
1BARROW NEUROLOGICAL INSTITUTE, PHOENIX, AZ, 2St. Joseph Hospital and Medical Center, Phoenix, AZ, 3Barrow Neurological Institute, Phoenix, AZ

Purpose
Intracranial saccular aneurysms are a common pathology that the neuroradiologist must be familiar with, occurring in 1-2% of the population(1). In addition, up to 30% of patients presenting with intracranial aneurysms have been shown to harbor multiple aneurysms(2). The distal internal carotid artery is a common anatomic location for several unique aneurysm sites including cavernous segment, carotid cave region, ophthalmic, superior hypophyseal, posterior communicating, anterior choroidal and carotid terminus.
aneurysms as well as cervical and petrous segment pseudoaneurysms. Although digital subtraction angiography (DSA) is the gold standard for evaluation of distal ICA aneurysms, current practice patterns for many neuroradiologists is centered on non-invasive angiographic techniques, namely computed tomography angiography (CTA) and magnetic resonance angiography (MRA). It is therefore important for the radiologist to have an understanding of the normal appearance of the various distal ICA aneurysms. This pictorial review will discuss the anatomy of the segments of the ICA as well as branch vessels. We will also review the common imaging appearance of the various distal ICA aneurysms as well as pearls and pitfalls in the localization of these aneurysms utilizing noninvasive angiographic techniques. We will showcase examples of the various distal ICA aneurysms on both CTA and MRA with comparison DSA imaging as the reference standard. We will discuss the unique anatomy of the carotid cave region, the proximal and distal dural rings, and the value of the optic strut.

Materials and Methods
N/A

Results
N/A

Conclusions
N/A
A Visual Primer on Functional MRI for Surgical Planning

H March¹, J Thiessen¹, R Barajas¹, J Pollock¹
¹Oregon Health and Science University, Portland, OR

Purpose
Functional MRI is clinically useful in the setting of preoperative planning prior to surgical resection of CNS tumors or epileptogenic foci. Neurosurgeons utilize these images to plan a resection approach that minimizes damage to eloquent cortex. As neuroradiologists, we can assist by designing paradigms and coaching patients to elicit activity from specific eloquent cortex including motor, expressive and receptive language, vision, and memory. Patients also sometimes have variant functional anatomy with important surgical implications, such as bilateral language dominance, and there are many secondary or accessory regions such as the dorsolateral prefrontal cortex that are useful to recognize while scanning. This educational exhibit aims to illustrate both typical and variant functional anatomy encountered via clinical fMRI, the paradigms used to elicit their activity, and the clinical relevance of each area of activation.

Materials and Methods
A retrospective review performed of all functional MRI done at our institution, looking for examples of typical and variant eloquent cortical activation encountered during preoperative clinical imaging and volunteer paradigm development scans.

Results
Included in the exhibit would be fMRI images of multiple separate motor regions, visual activation, language activation sites, memory, and their variants. Imaging paradigms will also be shown, with examples of what we use clinically and what our patients see while being scanned.

Conclusions
Functional MRI is clinically useful in the context of preoperative planning prior to CNS tumor or epileptogenic focus resection. Neuroradiologists can assist with image acquisition by designing paradigms that generate activity in eloquent cortex and should be aware of important variant functional anatomy.
Adult degenerative spinal deformity radiographs for preoperative planning - what really matters?

K Hsieh¹, R Chaudhary², K Raghuram¹
¹University of Texas Medical Branch, Galveston, TX, ²University of Texas Medical Branch, Galveston, TX- TEXAS

Purpose
Scoliosis radiographs are performed for routine work-up of spinal deformity. This electronic exhibit reviews key parameters in assessing spinal alignment and planning corrective surgery to aid neuroradiologists in providing a thoughtful and useful radiology report.

Materials and Methods
Parameters reviewed include: -Scoliosis nomenclature including Cobb angle and Lenke Classification of curve types. -Coronal and sagittal balance. -Sagittal spinal radiologic parameters including thoracic kyphosis and lumbar lordosis. -Pelvic parameters including sacral slope, pelvic tilt, and pelvic incidence. -Dynamic instability. -Spinal deformity study group spondylolisthesis classification. -Pelvic Obliquity/Leg Length Discrepancy. The presentation would include an image with measured parameter and description of measuring technique, normal range and/or target goals and surgical significance of the measured parameter.

Results
Spine-pelvic malalignment has been shown to correlate with pain and disability. Realignment objectives of surgery should be patient-specific and involve attention to the following 3 parameters: -Sagittal vertical axis less than 5 cm. -Pelvic tilt less than 25 degrees. -Lumbar lordosis proportional to the pelvic incidence. Pre and postsurgical examples will be provided.

Conclusions
Neuroradiologists should be familiar with the various parameters of spinal deformity that are commonly used for preoperative planning and likely to influence optimal clinical outcome.
sagittal vertical axis

sacral slope

pelvic tilt

Pelvic incidence

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Anatomical and Functional Cortical Anatomy: A simplified Learning Module

Y Aswani¹, B Tantiwongkosi²
¹UTHSCSA, San Antonio, TX, ²University of Texas Health San Antonio, SAN ANTONIO, TX

Purpose
Knowledge of cerebral cortical anatomy is critical for neuro-radiologists and clinicians. We aim to present a simplified pictorial review of cerebral cortical anatomy with an emphasis on clinical and pathological correlation.

Materials and Methods
We selected multiple normal and abnormal brain CT, MRI and fMRI scans that show classic cross sectional cortical anatomy and normal variants of different ages. Localization of lesions (including tumors, AVM, stroke, trauma and cortical malformations) is shown side by side to the normal anatomy to highlight the importance of clinical correlation and precise preoperative localization.

Results
The exhibit entails: 1) Cerebral cortical anatomy is divided into a) Frontal lobe (superolateral, medial and inferior surfaces) b) Parietal lobe (medial and lateral surfaces) c) Temporal lobe (lateral and inferior surfaces) d) Occipital lobe (lateral and medial surfaces) 2) Emphasis on localization of important landmarks, e.g. central sulcus (8 localization methods), sylvian fissure, parieto-occipital sulcus, calcarine sulcus, among others. 3) Correlation with clinical findings, perimetry and fMRI (primary motor, primary sensory, secondary motor/language, Broca's, Wernicke's, primary visual, secondary visual and primary auditory cortices).

Conclusions
The simplified learning module helps neuro-radiologists and clinicians to precisely locate the cortical lesions leading to appropriate diagnosis, follow up and preoperative planning.

(Filename: TCT_2130_ASNR.jpg)

Anatomy of the Brainstem: Learning from Lesions

E Nimchinsky¹, G Di Marco¹
¹Rutgers New Jersey Medical School, Newark, NJ

Purpose
The brainstem, which consists of the midbrain, pons, and medulla, is a small region which contains many critical structures, including most of the cranial nerve nuclei and the parenchymal portions of their nerves, intrinsic tracts interconnecting nuclei and other structures, and the ascending and descending tracts connecting the brain with the periphery. Small infarcts and other lesions in these
regions may have major, even catastrophic, clinical consequences. These structures exist at the limit of resolution for standard MR scanners. However, familiarity with the normal anatomy of the brainstem and with the most common clinical syndromes can help direct a search to identify the relevant pathology, and even direct imaging protocols, if anticipated. Educational objectives: 1. To review the development, anatomy and vascular supply of the brainstem. 2. To identify the anatomic structures affected by infarcts in the brainstem. 3. To correlate common brainstem lesions with well-described neurologic syndromes.

Materials and Methods

In this exhibit, we review the anatomy of the brainstem, and its development and organization. Using routine MRI of the brain, particularly diffusion-weighted imaging and anatomic imaging including T2 and steady-state free precession imaging, we present numerous examples of very small lesions whose location correlates with their clinical presentation. Images are presented in an interactive format, with reference to maps showing the relevant anatomy, and with corresponding histologic preparations.

Results

Lesions in the midbrain often involve the midline and off-midline structures concerned with visuomotor function, including the third and fourth nerve nuclei, the medial longitudinal fasciculus (MLF), or the nerves themselves. Lesions in the pons may affect several nerves, including the sixth nerve nucleus, the paramedian pontine reticular formation (PPRF) and both sensory and motor components of the fifth nerve. Lesions in the medulla may affect lower cranial nerves, including the vestibular system, ascending or descending tracts, and structures interconnected with more cranial portions of the brainstem.

Conclusions

In the brainstem, very small lesions may have very significant clinical outcomes. A thorough understanding of the organization and anatomy of the brainstem may greatly assist the radiologist in identifying lesions responsible for a patient's symptoms, and help direct further imaging.

Aqueduct of Sylvius Intraluminal Obstructive Lesions in Adults: A Neuroimaging Pictorial and Educational Review

Y Guo¹, N Bates², A Trinh², T MATYS³, S Hashmi⁴, T MASSOUD⁵

¹Stanford University, Stanford, CA, ²Stanford University School of Medicine, Stanford, CA, ³UNIVERSITY OF CAMBRIDGE, CAMBRIDGE, UNITED KINGDOM, ⁴N/A, N/A, ⁵STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose

Stenosis of the aqueduct of Sylvius (AqS) causes 3-10% of non-communicating hydrocephalus in adult patients. Primary AqS stenosis (AS) is mostly idiopathic in adults, whereas secondary AS is due to intraluminal obstructive lesions or extrinsic AqS compression. The causes of AqS luminal obstructions are varied and often unanticipated. Full awareness and understanding of such lesions can present a significant challenge to neuroradiologists owing to unexpected pathology and small size of AqS. Moreover, neuroendoscopic
procedures are increasingly used in AS treatment. We provide a pictorial and educational review of adult AqS intraluminal lesions to aid in neuroimaging interpretation and patient clinical management.

Materials and Methods
We comprehensively review the imaging findings of a wide spectrum of lesions that can obstruct AqS in adults, and categorize these by etiology.

Results
We first describe the imaging anatomy and morphometry of AqS. Many pathological entities can result in AqS luminal obstruction, including: 1) Late-onset congenital causes (simple stenosis, forking, septum formation, and glial proliferation) when alterations in CSF dynamics decompensate after many years of remaining undiagnosed. Endoscopic aqueductoplasty is used to treat adult membranous occlusions. 2) Late-onset idiopathic AS presenting with chronic headaches or NPH symptoms, the latter occurs in older patients with larger ventricles. 3) Large ependymal cysts may rarely arise in AqS. 4) Trauma: post-traumatic hydrocephalus is usually communicating due to CSF circulation disturbances and decreased reabsorption. However, obstructive thrombus may accumulate in AqS, or rare subclinical bleeding around AqS may induce septum formation leading to obstruction of CSF flow and a prestenotic funnel-shaped AqS. 5) Foreign bodies, e.g. a bullet fragment can migrate in the ventricles to occlude AqS. 6) Infectious: post-meningoitis, e.g. tuberculosis; and parasitic, e.g. cysticercosis cysts in AqS. 7) Inflammatory: sarcoidosis and SLE. 8) Vascular causes: AVM pedicles or DVA's can traverse AqS lumen to result in obstructive hydrocephalus. We also discuss management of AqS lesions, including the indications for further high-resolution imaging and phase-contrast MR CSF flow studies.

Conclusions
Accurate diagnosis of intraluminal obstructive lesions of the AqS is important prior to endoscopic or surgical treatment. This presentation will aid in neuroimaging interpretation and understanding of these lesions to improve patient management.

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Artificial Intelligence in Acute Cerebrovascular Disease

J Soun¹, D Chow², P Chang³
¹University of California, Irvine, Orange, CA, ²UNIVERSITY OF CALIFORNIA, IRVINE, IRVINE, CA, ³UNIVERSITY OF CALIFORNIA IRVINE, IRVINE, CA

Purpose
To provide an overview of Artificial Intelligence (AI) in acute cerebrovascular disease.

Materials and Methods
AI technology is a rapidly burgeoning field, providing a promising avenue for fast and efficient imaging analysis. AI has the potential to aid in detection, triage, surveillance, and prediction in acute cerebrovascular diseases such as ischemic stroke and intracranial hemorrhage. Learning Objectives: • Define AI in imaging analysis – Explain AI, machine learning, and deep learning – Describe how to assess performance of an AI algorithm • Summarize current AI tools used in ischemic stroke assessment, including: detection, segmentation, large vessel occlusion identification (see Figure 1), ASPECTS scoring, and prognostication • Summarize current AI tools used in hemorrhage assessment, including: detection, segmentation, classification, quantification, and prognostication • Provide an example of an AI-based triage system integrated at the workstation • Discussion of future AI applications in acute cerebrovascular disease

Results
n/a

Conclusions
n/a

Figure 1. An example of a 3D convolutional neural network for vessel segmentation and large vessel occlusion identification.

(Filename: TCT_2191_asnrfig.jpg)
Atypical Aneurysms: A Review of Imaging Features and Advanced Imaging Techniques

M Albertson¹, L Rivera-Rivera¹, K Johnson¹, L Eisenmenger¹
¹University of Wisconsin - Madison, Madison, WI

Purpose
While incidental cerebral aneurysms are a commonly encountered diagnosis for radiologists, the presence of atypical and/or high-risk aneurysms can be overlooked. It is essential for the radiologist to recognize subtle imaging features of atypical aneurysms and be aware of advanced imaging techniques which can increase detection of unstable aneurysms. This presentation will illustrate features of atypical aneurysms and imaging methods for more in depth aneurysm characterization.

Materials and Methods
Through diagrams and case examples, the learner will be able to: 1) Describe theories of aneurysm formation and progression. 2) Identify imaging findings of aneurysms and recognize causes of atypical aneurysms. 3) Review innovative aneurysm imaging methods (e.g. 4D flow MRI and vessel wall imaging).

Results
There are multiple theorized pathways that ultimately result in vessel wall weakening and thinning. A few examples include hemodynamic and oxidative stressors (hypertension and smoking) which lead to an inflammatory biochemical cascade and genetic predisposition related to defects in collagen genes. Less common causes of cerebral aneurysm include infection, tumor emboli, and arteriovenous malformations. Imaging features that can suggest an atypical aneurysm include focal stenosis near the aneurysm, rapid change in appearance of the aneurysm, or multiple aneurysms. Other signs of infected aneurysms include irregularity of the vessel wall, edema or gas surrounding the aneurysm, or disrupted calcification near the aneurysm site. In addition, advanced magnetic resonance imaging (MRI) techniques have been developed that expose vessel wall inflammation and flow dynamics associated with high risk of aneurysm growth and/or rupture, which may be more relevant to management than size alone. These techniques include 4D flow magnetic resonance angiography (MRA), MRI vessel-wall imaging, and MRI with iron oxide-based contrast agents which take advantage of macrophages localization to sites of inflammation, all of which will be reviewed in this exhibit.

Conclusions
When evaluating aneurysms, it is important for radiologists to search for other features suggesting atypical and/or high-risk aneurysms which have ultimate effects on patient management. It is essential for the radiologist to understand mechanisms that lead to cerebral aneurysm formation and progression as well as the imaging techniques available for detection and characterization of aneurysms.
Augmenting Machine Intelligence with Common Data Elements in Radiology Reporting

W Gibbs¹, J Rasouli²
¹Mayo Clinic, Scottsdale, AZ, ²Cleveland Clinic, Cleveland, OH

Purpose
Quality machine learning algorithms that can be trusted for patient care require standardized, structured report data for training. The popularity of artificial intelligence is prompting the creation of new data reporting systems that will enable algorithm development and integration into our work. The purpose of this exhibit is to describe the history, current status and future of radiology reporting using common data elements, with examples focused on spine pathology.

Materials and Methods
1. Discuss the evolution of the radiology report, and the potential to improve communication and patient care, to enhance our value by facilitating integration of evidence and guideline-based management recommendations, and to prepare for future requirements of artificial intelligence and natural language processing.
2. Describe the concepts of standard terminology, common data elements, and CDE macro sets.
3. Detail specific neuroradiology use cases: osseous spinal metastatic disease, thoracolumbar, sub axial cervical, and sacral trauma.

Results
N/A

Conclusions
The use of common data elements and standardization in reporting will allow us to produce high-value reports with increased speed and efficiency. In addition, improving reports will magnify our role and increase our standing with medical partners and within the healthcare system as a whole. The popularity of AI has prompted many to understand and contribute to the creation of systems that...
will enable algorithm development and integration into our work. The use of standardized language, CDEs, macros, and templates will facilitate this future.

Birthmarks Breaking Bad! A Pictorial Neuroimaging Review of Phakomatoses

A Gregorat1, H Rajebi2, B Tantiwongkosi2, A Singh2
1UT Health at San Antonio, San Antonio, TX, 2University of Texas Health at San Antonio, San Antonio, TX

Purpose
Phakomatoses or neurocutaneous syndromes are a heterogeneous group of congenital disorders primarily involving structures derived from the embryological neuroectoderm. Neuroimaging plays key role in accurate diagnosis of this distinct group of conditions, excluding family involvement and surveillance purposes. In this exhibit, we aim to review neuroradiological findings of phakomatoses, discuss the pathognomonic imaging characteristics and describe available follow-up imaging guidelines.

Materials and Methods
After a brief demographic, pathophysiology and genetic review, a comprehensive detailed institutional case-based review of the common and rare phakomatoses will be illustrated. Pathognomonic radiologic features will be discussed and, diagnostic hints and pitfalls will be presented for each entity. A short review of non-neuroradiology related manifestations aiding in the meticulous evaluation will also be demonstrated.

Results
Multiple cases from common (neurofibromatosis type 1, neurofibromatosis type 2, tuberous sclerosis complex, Von Hippel-Lindau syndrome and Sturge-Weber syndrome) and rare (Ataxia telangiectasia, Wyburn-Mason syndrome, Hereditary hemorrhagic telangiectasia, Blue rubber bleb nevus syndrome, PHACE syndrome and etc.) conditions will be illustrated. Main radiologic features with focus on brain, orbital and spinal imaging will be discussed. Available follow-up imaging guidelines, novel genetic testing and emerging targeted therapy will also be reviewed in common conditions.

Conclusions
Phakomatoses are inherited neurocutaneous disorders that are genetically and radiologically distinct from each other. Neuroradiologist plays a seminal role in diagnosis, follow up, surveillance and screening of phakomatoses, yielding to early detection and treatment. Recent advances in the molecular biology of these entities have led to the development of novel targeted treatment options.
Bottom-of-sulcus dysplasia: MR imaging findings and predictive factors for seizure outcome after epilepsy surgery

K Sato\textsuperscript{1}, C Mellerio\textsuperscript{2}, F Chassoux\textsuperscript{3}, C Oppenheim\textsuperscript{2}

\textsuperscript{1}Juntendo University School of Medicine, Tokyo, \textsuperscript{2}Inserm U1266, Université Paris Descartes, GHU Paris, psychiatrie et neurosciences, Paris, \textsuperscript{3}GHU-Paris Sainte-Anne, Paris Descartes Sorbonne University, Paris

Purpose
Bottom-of-sulcus dysplasia (BOSD) is a newly recognized entity corresponding to small focal cortical dysplasia 2 (FCD2) located in the deep part of a single brain sulcus\textsuperscript{(1)}. Recognizing BOSD on MRI is crucial for referring the patient to surgery without complex presurgical workup such as invasive monitoring\textsuperscript{(2)}. BOSD is known for its excellent outcome of seizure control after complete resection resection\textsuperscript{(3)}. Our aim is to share characteristic MR imaging findings and predictive factors of outcome in BOSD.

Materials and Methods
We reviewed previous studies regarding concept of BOSD and searched prognosis factors of BOSD and FCD2 in both clinical and imaging aspects. As for imaging aspects, we investigated possible prognosis factors in 52 histologically proven lesions of FCD2 with minimal 2 years follow-up seizure outcome assessment showing positive MRI. Diagnosis of BOSD was made for 37 lesions after 5 cases exclusion due to judgement mismatch by 2 neuroradiologists. We compared location of lesions and frequency of the following 5 MR imaging findings in FCD2 and BOSD: cortical thickening, white matter-gray matter blurring, white matter signal change, transmantle sign, and sulcus anomaly or dilatation. In addition, we divided FCD2 lesions into 4 types based on size and distribution. For evaluation of outcome, Engel classification and medication status were scored. We investigated relation of each of 5 imaging findings and types with outcome score.

Results
In previous studies, completeness of resection was reported as predictive factor of better outcome after surgery\textsuperscript{(4)}. FCD2 histopathology, younger age at surgery, unilobular lesion, short duration of epilepsy, and temporal lobe location were also reported as contributing factors for better outcome, but they are under debating. In our study, frontal lobe location, transmantle sign, and sulcus
anomaly or dilatation were more frequent in BOSD compared to FCD2, but significant outcome difference was not detected between positive and negative group for these findings. In type analysis regarding size and distribution, the best postoperative outcome was obtained in typical BOSD; small FCD2 limited at the deep part of a single sulcus.

Conclusions
BOSD has excellent outcome and detection of BOSD by its characteristic MR imaging findings such as transmantle sign and sulcus anomaly or dilatation can leads to curative surgery. Our study suggested that both size and distribution of lesions are related to seizure outcome as well as completeness of resection.

![Figure 1](TCT_1708_Figure1.jpg)

**Figure 1.** We divided FCD2 into 4 types based on distribution of lesions.
- **Type 1:** small FCD2 located at the deep part of a single sulcus (= typical BOSD)
- **Type 2:** FCD2 involving both the bottom of the sulcus and the adjacent gyrus
- **Type 3:** FCD2 involving gyrus without bottom of sulcus
- **Type 4:** Large FCD2 extending over one sulcus

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**Bow Hunter's Syndrome: Case Review and Literature Survey**

H Upton¹, A Ferrell¹

¹University of Tennessee Medical Center - Knoxville, Knoxville, TN

**Purpose**
Present a case of Bow Hunter's Syndrome and review pathophysiology, clinical symptoms, diagnostic considerations, and therapeutic options.

**Materials and Methods**
Chart review of known case of rotational vertebral artery occlusion. Pertinent preoperative and postoperative imaging studies were de-identified and extracted from PACS. Review of Radiology and Neurosurgery literature.

**Results**
Case: 64-year-old white male with paresthesias and dizziness particularly with right sided head turning. 8 month history of syncope and severe presyncope with turning his head to the right. PMH significant for Rheumatoid Arthritis. Imaging findings demonstrated focal right V2 stenosis at C6 related to osteophytic ridging along the transverse foramen with complete occlusion on head turn. Patient was treated with surgical decompression and fusion and symptoms resolved. Discussion: Bow Hunter's syndrome, also known as rotational vertebral artery syndrome, results from occlusion or stenosis of the dominant vertebral artery with head turn, resulting in transient, reversible posterior circulation ischemia. Symptoms are those of vertebrobasilar insufficiency. Temporary positional occlusion of 1 vertebral artery during the course of daily activities may be normal, if asymptomatic. Hypoplasia or stenosis of contralateral vertebral artery predisposes patients to vertebrobasilar ischemic attacks during head rotation. Occlusion may occur anywhere along the course of the vertebral arteries but is most common at or above the level of C2 where the vertebral artery is particularly prone to mechanical compression. Dynamic angiography is the established standard of diagnosis and can assess for level of occlusion as well as for additional sites of distal occlusion. Treatment is usually surgical and aimed at the underlying cause of occlusion and may include bracing, surgical fusion, stenting, or vertebral artery decompression.

**Conclusions**
Bow Hunter's Syndrome, or rotational vertebral artery syndrome, is an uncommon condition but presents with characteristic symptoms of vertebrobasilar insufficiency with head turn. The presented case demonstrates right vertebral artery occlusion due to adjacent degenerative disc disease that was successfully treated with surgical decompression and fusion. Most common site of
occlusion is at C2 where the vertebral arteries are prone to mechanical compression. Dynamic angiography is the gold standard of diagnosis. Treatment is usually surgical and directed at the underlying etiology of occlusion.

Brain Death

J Litchman¹, A Siegel¹
¹Dartmouth Hitchcock Medical Center, Lebanon, NH

Purpose

Advances in critical care in the middle of the twentieth century made it possible for patients who had sustained a catastrophic neurologic injury to maintain cardiovascular sufficiency in the face of nervous system compromise. This new disease state came to be known as brain death. Since the first reported cases of "nervous system death" in 1959, the definition of brain death has undergone decades of revision. Today, brain death is defined as the irreversible cessation of brain function, characterized by unresponsive coma, absent brainstem reflexes, and apnea with a proximate cause. The purpose of this educational exhibit is to provide an overview of brain death with special attention directed to the role nuclear medicine imaging plays in brain death diagnosis.

Materials and Methods

First, a brief history of the concept of brain death is given, followed by examples of its pathologic appearance and an explanation of its underlying pathophysiology. The preclinical assessment and clinical examination of brain death are then briefly discussed before the nuclear medicine evaluation of brain death is introduced. Angiographic and scintigraphic radiotracers and techniques are described in detail. The trident and empty light bulb signs, representing normal and absent cerebral perfusion, respectively, are shown. Lastly, six patient cases of both positive and negative studies are presented with examples of planar, flow, and SPECT imaging.

Results

Following a catastrophic neuronal injury, the ensuing ischemia causes a disturbance in cellular osmoregulation, resulting in both vasogenic edema from disruption of the blood brain barrier and cytotoxic edema from biomolecular mediators and membrane pump failure. Given that the brain is encased in a rigid calvarium, increasing edema results in increasing intracranial pressure, which, when elevated beyond the systemic arterial pressure, leads to complete cerebral circulatory arrest, more injury, more edema, and eventual herniation and death. The foundation of the diagnosis of brain death is a comprehensive clinical evaluation. Ancillary testing, however, is performed to confirm brain death when clinical evaluation cannot be reliably performed. For example, cerebral blood flow testing with nuclear medicine angiography or scintigraphy is used to show failure of the cerebral circulation.
Conclusions
Nuclear medicine scintigraphy provides accurate confirmatory data regarding the presence or absence of brain death when clinical evaluation cannot be reliably performed.

(Filename: TCT_1441_BrainDeath.jpg)

Brain infections: how to make their diagnosis more precise.

L Souza1, L Teixeira1, L Lucato2, D Nunes3, C Toyama4, M Castillo5, C da Silva4
1University of Sao Paulo, Sao Paulo, Sao Paulo, 2Instituto de Radiologia, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, São Paulo, 3Laboratorio Fleury, Sao Paulo, Sao Paulo, 4HCFMUSP - BRAZIL, São Paulo, São Paulo, 5Univ. Of North Carolina School Of Medicine, Chapel Hill, NC

Purpose
The purpose of this presentation is to review characteristic magnetic resonance imaging findings that allow the radiologist to be more precise on the diagnosis of brain infections.

Materials and Methods
We will present the magnetic resonance imaging of the brain infectious diseases stressing the more characteristics findings that allow to narrow the differential diagnosis (including single or multiple lesions, location, absence or presence or enhancement and diffusion weighted imaging behavior). The cases will be classify by etiologic agent (viral, bacterial, fungal and parasitic) and by pathophysiologic mechanism (encephalitis, meningitis, abscess, granuloma, cystic or pseudo cystic lesion, cranial nerve involvement).

Results
We will present cases of viral encephalitis (herpes virus, cytomegalovirus-CMV, HIV, progressive multifocal leukoencephalopathy-PML, subacute sclerosing panencephalitis, dengue and yellow fever), abscess (bacterial and fungal), granulomas (tuberculosis, and paracoccidioidomycosis), meningoencephalitis (toxoplasmosis), cystic lesions (neurocysticercosis, hidatic cyst), pseudocysts (criphtococcosis) and its main complications such as hydrocephalus, venous thrombosis and arterial infarcts. We will stress the more characteristic findings such as acute encephalitis in the temporal, frontal lobes and insula in herpes encephalitis, with restricted diffusion and sometimes hemorrhage; ventriculitis, retinitis and sometimes cranial nerve involvement in CMV; brain atrophy in chronic HIV sometimes with slight white matter hyperintensity on T2-weighted images; asymmetric white matter involvement in PML, sometimes with restricted diffusion in the leading edges; brain atrophy in a children in subacute sclerosing panencephalitis; single (bacterial) or irregular and multiple necrotic lesions with restricted diffusion of their necrotic portion in abscess; multiple solid lesions with or without restricted diffusion in granulomas; cystic lesions with scolex lovated in the parenchyma, ventricles and/or subarachnoid space associated or not to calcifications in neurocysticercosis; a solitary big cystic lesion in hydatid disease without restricted diffusion; cystic lesions in the basal ganglia without restricted diffusion, associated or not to menial enhancement in
cment remains to be determined. The focus for analyzing associations between brain imaging and cognition has shifted from individual brain areas to large networks. Examining multiple, specific brain MRI biomarkers promises to improve our understanding of the neurobiology of aging and cognitive performance across adulthood.

Conclusions
Many MR findings can narrow the differential diagnosis in brain infectious diseases.

2634

Brain Magnetic Resonance Imaging Biomarkers of Healthy Aging and Their Relationship with Cognitive Functions Across Adulthood

A Iruela Sanchez1, C Biarnes2, J Garre-Olmo1, R Coronado1, C Prats4, J Fernandez-Real3, R Pamplona5, R Ramos-Blanes7, M Essig8, S Pedraza2, J Puig9

1Canon Medical Systems, Center of Comparative Medicine and Bioimaging of Catalonia (CMCiB), Badalona, Barcelona, 2IDIIDIBGI, Girona, Girona, 3IDIBGI-IAS, Girona, Girona, 4Universitat Politecnica de Catalunya, Barcelona, Barcelona, 5IDIIBGI-Hospital Universitari Dr Josep Trueta, Girona, Girona, 6University of Lleida-IRBLleida, Lleida, Lleida, 7IDIBGI, Girona, Girona, 8University of Manitoba, Winnipeg, Manitoba, 9IDIIDIBGI, Girona, Spain

Purpose
Some relationships between structural and functional brain imaging indexes and cognition in aging have been established, but the role of brain magnetic resonance imaging (MRI) biomarkers in assessing the impact of aging across adulthood remains to be determined. Identifying MRI biomarkers associated with cognition can help elucidate the underlying mechanisms of aging.

Materials and Methods
We analyze data from structural T1-weighted, diffusion tensor imaging (DTI), fluid-attenuated inversion recovery (FLAIR), and resting state functional MRI (rs-fMRI) in combination with neuropsychological assessments across adulthood. We discuss the following proposed MRI biomarkers for brain aging: (1) volume quantification on specific brain areas (e.g., cortical thickness and hippocampal and striatal volume), (2) white matter hyperintensity (WMH) burden, (3) DTI-metrics (e.g., fractional anisotropy) of white-matter microstructure, and (4) rs-fMRI connectivity nodes.

Results
Normal aging is associated with decreases in gray-matter volume and especially in white-matter volume as well as with declines in specific cognitive domains (especially memory, processing speed, and executive function). WMH burden and hippocampal volume are strong predictors of executive function and episodic memory. Entorhinal thickness, striatal volume, and FA are associated with processing speed; FA and striatal volume are also associated with executive function. Age-related disruptions in functional connectivity have been reported in default mode, cognitive-auditory, cognitive-speech or speech-related somatosensory, and right and left frontotemporal networks. Reduced connectivity within networks and increased connectivity between networks have been correlated with poor cognitive performance.

Conclusions
The focus for analyzing associations between brain imaging and cognition has shifted from individual brain areas to large-scale networks. Examining multiple, specific brain MRI biomarkers promises to improve our understanding of the neurobiology of aging and cognitive performance across adulthood.

2036

Brain MRI in Patients with Implanted MR Non-conditional Devices

J Strong1, C Bolling2, M Spampinato3

1Medical University of South Carolina, Charleston, SC, 2MUSC, Charleston, SC, 3Medical University Of South Carolina, Charleston, SC

Purpose
Medical devices are classified by the FDA as MRI safe, MR conditional, MR non-conditional, and MR unsafe. Performing brain MRI studies in patients with non-conditional devices poses a significant challenge. However, there are numerous scenarios in the care of patients with CNS disorders when the benefits of obtaining an MRI are felt to outweigh the risks. In this presentation, we will review the steps required to perform brain MRI exams in patients with non-conditional devices in the safest possible manner.

Materials and Methods
Our exhibit will include: 1) An introductory section reviewing the differences among MR safe, MR conditional, MR non-conditional, and MR unsafe devices. 2) A list of parameter changes that should be implemented when MRI studies must be obtained in patients with MR non-conditional devices. 3) Other potential pitfalls that could be encountered, as well as a comparison of image quality between different techniques.

Results
The decision of whether to have a patient with an MR non-conditional device undergo a brain MRI depends on several factors, such as the urgency of the study or whether an alternate imaging technique is suitable. The final decision will have to be made by the referring...
physician and the radiologist, after weighing the pros and cons of the exam. Obtaining informed consent from the patient is recommended. Steps can be taken to lower the risks of heating and device damage, including MRI protocol adjustments, as well as manipulation of device settings. In this section, we will discuss the general principles and specific protocol changes that will lower the SAR and thus decrease the degree of heating. A table including a list of parameter changes will be included as a quick reference guide for decreasing the SAR. We will also present a table including a breakdown of MR sequence scan times and predicted SAR when utilizing SAR lowering techniques versus standard technique.

Conclusions

With proper supervision by the radiologist and MR physicist, patients with implanted non-conditional devices may undergo a brain MRI. MR scanning in this patient population requires special attention to MR imaging protocols specific to each study indication and implant. Knowledge of the steps required to lower the SAR allows scanning patients as safely as possible, while still obtaining images that are acceptable in terms of diagnostic quality.

2356

Brain Stem Anatomy and Lesions: A Pictorial Review

H Hatipoglu

1University of Health Sciences, Ankara, N/A

Purpose

The purpose of this educational exhibit is to discuss contemporary imaging of the brain stem lesions and its implications related to patient management.

Materials and Methods

In order to compile the cases in this exhibit, we screened our imaging database from 2010 through 2017.

Results

After a discussion of the imaging anatomy and techniques, we will highlight the imaging characteristics and differential diagnoses of entities such as tumors, ischemic lesions, vascular malformations, demyelinating diseases, infections, degenerative conditions, and vasculitides.

Conclusions

Familiarity with the imaging characteristics of the entities that involve the brain stem is important. Imaging findings should be interpreted in conjunction with the clinical information as many entities can generate similar appearances.
Brain Tumor Genetics and Pathology Neuroradiologists Need to Know: Clinical, Radiological and Pathological Correlations

B Tantiwongkosi\textsuperscript{1}, N Salamon\textsuperscript{2}, P Wangaryattawanich\textsuperscript{3}, A Singh\textsuperscript{4}, M CHEN\textsuperscript{5}, A Gilbert\textsuperscript{6}

\textsuperscript{1}University of Texas Health San Antonio, SAN ANTONIO, TX, \textsuperscript{2}UCL, Los Angeles, CA, \textsuperscript{3}University of Pittsburgh Medical Center, Pittsburgh, PA, \textsuperscript{4}UT Health San Antonio, San Antonio, TX, \textsuperscript{5}MD ANDERSON CANCER CENTER, HOUSTON, TX, \textsuperscript{6}University of Texas Health San Antonio, San Antonio, TX

1337
Purpose
This pictorial review illustrates pertinent imaging, pathologic findings and genetic correlation of common and rare primary brain tumors that neuroradiologists need to know in an era of rapidly evolving molecular genetics with emphasis on clinical, radiologic and pathologic correlations.

Materials and Methods
Patients included in this study had primary brain tumors, resected from August 2016 - September 2019, with proven pathology and concurrent CT and/or MR imaging; molecular and/or genetic profiles were included when performed. Clinical information, treatment strategies, and follow-up imaging are incorporated to demonstrate disease course and prognosis especially for tumors that exhibit similar histomorphologic features, but harbor different genetic profiles.

Results
Utilizing the most recent WHO brain tumor classification system, we evaluated imaging and molecular features with clinical, radiological, and pathological correlations of the following tumors: 1. IDH-mutant astrocytoma, 2. IDH-wild type astrocytoma, 3. IDH-mutant glioblastoma, 4. IDH-wild type glioblastoma, 5. Diffuse midline glioma, H3 K27M-Mutant, 6. Solitary fibrous tumor and hemangiopericytoma, 7. Medulloblastoma (WNT-activated, SHH-activated, group 3 and group 4), 8. Atypical Teratoid / Rhabdoid Tumor and 9. Ependymoma, RELA Fusion–Positive. The molecular profiles of each tumor, along with the typical clinical course and representative pathological and neuroradiological features, are attached to the abstract.

Conclusions
It is essential that neuroradiologists are familiar with clinically relevant genetic information needed for accurate diagnosis and prognosis of common and rare brain tumors.

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2021

Brainstem Stroke Syndromes Revisited: Clinical-Radiologic Correlation using Active Learning Methods

H Tore¹, Y Koksel¹, M Gencturk¹, C Streib¹, A McKinney¹
¹University of Minnesota, Minneapolis, MN

Purpose
Brainstem is composed of numerous nuclei and white matter tracts connecting the cranial epicenter to the spinal cord and peripheral nerves and vice versa. Any insult to a part of the brainstem can cause distinct clinical syndromes. Understanding the anatomy of the nuclei and white matter tracts helps diagnose particular syndromes and the possible part of the brainstem involved. This exhibit will review the previously described brainstem stroke syndromes with their clinical presentation and imaging findings using a problem-based approach.
Materials and Methods
We compiled an interactive active learning exhibit of brainstem stroke syndromes. We included imaging studies from our teaching files in our institution. We introduced each case with their clinical presentation followed by their cross-sectional images (i.e., MRI and CT). Next, we asked the reader to localize the lesion and define the anatomic structures that are involved. Each question was followed by the correct answer and a corresponding diagram. At the end of each case, we presented a short description of the syndrome with its imaging findings, anatomic structures involved and their clinical correlates.

Results
Brainstem stroke syndromes cause a variety of presentations from a single cranial nerve palsy to hemiplegia to a locked-in syndrome. Brainstem stroke syndromes such as Dejerine, Reinhold, Foville, Wallenburg will be demonstrated.

Conclusions
It is often difficult for the radiology and neurology trainees to pinpoint a particular territory due to variety of the eponyms and overlap of the presenting findings. Active learning methods have been shown to improve information acquisition and retention. Our exhibit provides an interactive problem-based module to learn brainstem stroke syndromes.

2409
Can Iron Deposit in Multiple Sclerosis Lesions Analysis Optimize the Diagnostic Process?

V Subtil Viuniski1, F Reis2, B Chwal3, D Nakata3, L Feitoza4, J DUARTE5

1Hospital das Clínicas de Porto Alegre, Porto Alegre, Rio Grande do Sul, 2Unicamp, Campinas, SAO PAULO, 3Hospital de Clínicas de Porto Alegre - HCPA, Porto Alegre, Rio Grande do Sul, 4Universidade Estadual de Campinas, Campinas, Sao Paulo, 5HCPA, Porto Alegre, Rio Grande do Sul

Purpose
1. To present how iron deposits are visualized in T2 susceptibility weighted images (SWI) in Multiple Sclerosis (MS) white matter (WM) lesions. 2. Correlate iron deposits and dissemination in time (DIT) in MS

Materials and Methods
MS is a disease characterized by active degradation of the myelin sheath of the central nervous system. The autoimmune/inflammatory response has been suggested as a secondary reaction to the cytodegenerative process aimed at the oligodendrocyte-myelin complex causing cellular death. Iron is one molecule that may be implicated in this process and is present in other neuronal metabolic activities. In excess, leads to enhanced production of reactive oxygen species(ROS) and further neurodegeneration. In MS magnetic resonance images(MRI) it may be found in white and gray matter. The differential diagnosis between MS and other diseases can be challenging, but with the acquisition of T2SWI it is possible to detect the presence of non-haeme iron compounds surrounding the typical WM lesions and more impressively estimate the time of inflammation. This may aid the establishment of DIT, required by the McDonald criteria. Images were acquired using a 3T MRI with 16-channel head coil.

Results
Previous studies correlated these pathology and MRI findings, as demonstrated: 1. Active Lesions: enhanced by Gadolinium(Gd) in T1, presence of ROS, no visible iron deposits; 2. Chronic Active Lesions: activated microglia/macrophages drawing an iron rim, non-enhanced by Gd; 3. Chronic Silent Lesions: susceptibility is almost similar to normal WM;

Conclusions
We demonstrated the presence of non-haem iron deposits in MS through MRI T2 SWI and the different forms that it may present throughout the disease. Establishing DIT in a single MRI study may enable us to diagnose and determine the disease progression in a more effective and economic manner.
Can You Handle the Pressure?: A Pictorial Review of Intracranial Hypertension and Hypotension and its Causes.

G Otero-Soto¹, L Rodriguez-Ortiz¹, E Rodriguez Cruz¹, L Bimbela-Nieves¹, L Garcia-Irizarry¹
¹UPR School of Medicine, San Juan, PR

Purpose
Describe clinical presentation and physical exam findings of patients with decreased and increased intracranial pressure. List the constellation of imaging findings of intracranial hypotension and hypertension. Review most common pathophysiology of intracranial hypotension and hypertension. List image-guided procedures that support the diagnosis of intracranial hypotension.

Materials and Methods
Retrospective review of the medical record and images from our institution.

Results
N/A

Conclusions
Intracranial environment and function depends on optimal equilibrium between the pressure of the brain parenchyma and the pressure of the extra-axial spaces. When this homeostasis is disrupted, abnormalities in intracranial pressure regulation ensue, giving way to symptomatic pathology of intracranial hypertension and hypotension. Radiologists have a leading way in diagnosing each of these entities, since the imaging findings associated to them are highly specific. Through this pictorial review, we aim to discuss the constellation of MRI findings in order to avoid missing critical information of abnormal intracranial pressure and providing the clinician with key details that will aid in patient management.
Central nervous system findings in Langerhans Cell Histiocytosis

P Batchala1, P Nepal2, T Rizvi1, J Donahue1, S Patel1, T Eluvathingal Muttikkal1
1University of Virginia Health System, Charlottesville, VA, 2St.Vincent’s medical center, Bridgeport, CT

Purpose
We aim to present the central nervous system (CNS) findings in Langerhans Cell Histiocytosis (LCH) including the less common imaging appearances.

Materials and Methods
LCH is a protean multisystem disease. Compared to skeletal abnormalities, CNS involvement is uncommon, seen only in 6-11% of patients. Even rare is isolated CNS involvement which can pose a diagnostic challenge. Diabetes insipidus is the most frequent manifestation of CNS involvement, affecting the hypothalamic-pituitary axis. Other neurological manifestations are ataxia or psychomotor abnormalities from 'neurodegenerative-like lesions', and neurological deficits or hydrocephalus from mass-forming lesions that involve meninges, pineal gland, choroid plexus or rarely brain parenchyma.

Results
Hypothalamic-pituitary axis involvement by LCH is seen as thickening and enhancement of the pituitary stalk by >3mm (Fig.1A) with absence of posterior pituitary T1 bright spot due to lack of neurosecretory granules (Fig.1B). However, such findings are non-specific and can also be seen in Germinoma and other inflammatory disorders. The 'neurodegenerative-like' lesions of LCH are typically seen as symmetrical T2 hyperintense lesions involving cerebellar dentate nuclei, basal ganglia and sometimes the brainstem (Fig.1C and ID). They can closely resemble Neurofibromatosis type 1 (NF1) related signal changes which also exhibit a similar distribution. Mass-like lesions of LCH can involve the meninges, pineal gland, choroid plexus or brain parenchyma (Fig.1E), and demonstrate intense post contrast enhancement similar to solid neoplasms. However, unlike high grade neoplasms, LCH mass-like lesions show hypoperfusion (Fig.1F).

Conclusions
CNS findings of LCH in isolation mimic neoplasms or NF1. But identifying them in synchrony or with extra-CNS manifestations should clearly raise suspicion for LCH.
Cerebellar cysts: imaging spectrum and differential diagnosis

A Alves Fonseca¹, F SCORTEGAGNA², R Hoffmann Nunes², L do Amaral³, F Pacheco², A Rocha⁴
¹Irmandade da Santa Casa de São Paulo, São Paulo, SP, ²Irmandade da Santa Casa de São Paulo and DASA, São Paulo, SP, ³Beneficência Portuguesa, São Paulo, SP, ⁴Santa Casa de Misericórdia de São Paulo and DASA, São Paulo, São Paulo

Purpose
Cerebellar cysts are uncommon findings in clinical practice and may be seen in selected disorders both malformative and disruptive etiologies. The purpose is to review and discuss this relevant imaging pattern, exemplifying mimicking disorders in order to scrutinize a practical approach for the differential diagnosis.

Materials and Methods
After reviewed our institution teaching files, the authors selected cases demonstrating cerebellar cysts, excluding cystic tumors and parasitic cysts. Consideration of the following aspects will assist in narrowing of the differential diagnosis and, if required, planning of targeted diagnostic workup: cyst location (cortical-subcortical, within the white matter, focal or widespread); cerebellar morphology (cortical architecture, areas of dysplasia, hypoplasia, resulting in change in shape of the fourth ventricle); brainstem morphology (hypoplastic pons, clefts, tectal dysplasia, and kinking); supratentorial abnormalities (migration anomalies, polymicrogyria, white matter signal abnormalities, cysts within the white matter, heterotopias, and hydrocephalus); and clinical setting (muscle involvement, ataxia, oculomotor apraxia, intellectual disability, and ophthalmological abnormalities).

Results
The pathogenesis of cerebellar cysts is heterogeneous. For didactic purpose, the authors suggest the categorization based on the underlying pathomechanism. Cysts may involve/represent normal structures, such as Virchow–Robin spaces; it could be "destructive", such as in some types of pontocerebellar hypoplasias; it could be "malformative", such as in some congenital muscular dystrophies, and also in GPR56-related migration disorders; or it could be "disruptive", such as in some cerebellar dysplasias.

Conclusions
The approach of cerebellar cysts and their differential diagnosis requires a knowledge of involvement patterns and its main pitfalls in
order to avoid misinterpretation. This classification aims to allow an imaging pattern recognition approach and takes into account clinical information.

Cerebrospinal fluid (CSF): A-Z. Overview of Imaging modalities for the ventricular system and CSF pathways

A Megahed¹, R Sulaiman², M Elbanan³, M Kureti³, S Smith⁵

¹University of New Mexico, Albuquerque, NM
Purpose
1. To overview the anatomy of the ventricular system and subarachnoid spaces. 2. To overview congenital anomalies of the ventricular system and subarachnoid spaces. 3. To overview the role of ultrasound in the assessment of the ventricular system. 4. To overview the role of CT in the assessment of the ventricular system. 5. To overview the role of different MRI techniques in the assessment of CSF related pathologies.

Materials and Methods

Results
Illustrated images and annotated cases from our institute

Conclusions
Radiology plays an integral role in the assessment of the anatomical structures through which CSF is produced, circulated and drained. A vast array of congenital anomalies and pathologies can involve the ventricles, CSF spaces, and draining sinuses. Ultrasound, CT and MRI are beneficial in the assessment and follow up of these CSF related pathologies.

1613

Characteristic MR imaging finding of Adult-onset Alexander disease on serial follow-up MR: Implication of the Rosenthal fibers

R Yoon1, J Lee2
1Eulji Medical Center, Seoul, Korea, 2Eulji Medical Center, Seoul, Seoul

Purpose
To present the characteristic magnetic resonance (MR) imaging finding and serial changes on follow-up MRI of adult onset Alexander disease confirmed by GFAP mutation

Materials and Methods
Retrospective review of brain and cervical spinal cord MRI of 37 years old and 61 years old women confirmed with AOAD was performed. The diagnosis was made based on the typical MRI appearance and confirmed by GFAP mutation analysis. The 3T MRI examinations of brain and cervical spinal cord without contrast enhancement were performed and follow-up MRI was performed after 2 years and 3 years, respectively. The MR examination of the brain included T1-weighted, T2-weighted images (T2WI), fluid-attenuated inversion recovery (FLAIR) sequences, and T1- and T2WI for cervical spinal cord. Subsequently, the follow-up MRI exams were reviewed by two neuroradiologists.

Results
The first patient presented with history of slowly progressive ataxia, spastic paraparesis for a period of 6 years. The second patient presented with slowly progressive right leg paresthesia, hemiparesis, non-whirling nature of dizziness for 4 years. On brain and spinal cord MRI, all patients had typical tadpole like brainstem atrophy, and high signal intensity (SI) at anterior half of the medulla oblongata on T2WI was seen in one patient, correspondent to the medial lemniscus and the corticospinal tracts. In one patient, abnormal high SI on T2WI and FLAIR was seen in the hilum of dentate nuclei, and rim of high SI along the surface of midbrain, pons and medulla on FLAIR. Both patients showed SI changes prevalent in the posterior periventricular white matter. In one patient, small area of abnormal contrast enhancement was present in the medulla oblongata. Follow-up MRI after 2 and 3 years demonstrated progression of atrophy in medulla oblongata and upper part of cervical spinal cord. With informed consent, molecular genetic analysis of GFAP was performed in both patients, which confirmed the AOAD.

Conclusions
Atrophy and changes in signal intensity in the medulla oblongata and upper part of cervical spinal cord, showing typical tadpole-like brainstem atrophy, minimal to moderate supratentorial periventricular abnormalities were present in both two cases. Awareness of this characteristic MRI finding could allow neuroradiologists to make an appropriate diagnosis, and lead proper patient management.
Chew on This! Imaging of Major Salivary Glands

D Chen¹, K Shifteh¹, K Hsu², J Burns¹, J Goldman¹, R Tenney³
¹Montefiore Medical Center, Bronx, NY, ²MONTEFIORE MEDICAL CENTER / ALBERT EINSTEIN COLLEGE OF MEDICINE, NEW YORK, NY, ³Montefiore Medical Center, The bronx, NY

Purpose
Background: Salivary glands can demonstrate a diverse amount of pathology including developmental, inflammatory, infectious, obstructive, and neoplastic anomalies. Conventional imaging techniques (ie. CT, MRI, US, nuclear imaging, and conventional sialography) are used, together with newer techniques such as MR sialography. Educational Objectives: 1. Review relevant major salivary gland anatomy 2. Describe the clinical utility of available imaging modalities 3. Provide descriptive examples of imaging pearls used to assemble differential diagnoses.

Materials and Methods
Exhibit Outline: 1. Review of major salivary gland anatomy relevant to the clinical radiologist, with emphasis on facial nerve and ductal anatomy, and identification of suprahyoid neck spaces. 2. Review of currently available imaging modalities along with each modality's advantages/disadvantages. 3. Annotated review of various salivary gland pathologies, with focused discussion on developing differential diagnoses based on cumulative imaging characteristics, including: a. Glandular characteristics i. Laterality - Unilateral (infection, neoplasms) vs. bilateral (autoimmune, rare neoplasms) ii. Cystic lesions – Unilateral (ie. infection, sialocele, branchial cyst) iii. Lymphadenopathy – Unilateral (infection, obstruction) vs. bilateral (lymphoma, HIV-related, granulomatous, autoimmune) iv. Intraglandular vessels – Hemangioma, neoplasm v. Calcifications – Sialolithiasis, granulomatous disease vi. Conventional & dynamic enhancement characteristics b. Ductal findings i. Dilation – Fusiform (ie. Inflammatory strictures); globular or cavitory (autoimmune); etc ii. Stenosis of ductal orifice – Trauma vs chronic stones iii. Calcifications c. Facial nerve involvement i. Adenoid cystic carcinoma, acinic cell carcinoma d. Systemic findings

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Results
N/A

Conclusions
Salivary gland disorders are often grouped simply into neoplastic vs. non-neoplastic (often inflammatory) categories. However, careful image analysis can be used to narrow the differential diagnosis.

2813

Chronic Lymphocytic Inflammation with Pontine Perivascular Enhancement Responsive to Steroids (CLIPPERS): What the Radiologist Needs to Know

M Mossa-Basha1, S Rayaz2

1Johns Hopkins, Baltimore, MD, 2New York University School of Medicine, Baltimore, MD

Purpose
The main objective of this educational exhibit is to familiarize the radiologist with the disease process of chronic lymphocytic inflammation with pontine perivascular enhancement responsive to steroids (CLIPPERS). This exhibit aims to: - Improve the participant's awareness of CLIPPERS - Educate the participant of proposed diagnostic criteria of CLIPPERS, including imaging, clinical and laboratory findings. - Demonstrate the appearance of common imaging findings for this disease process - Decrease delayed treatment in suspected cases - Demonstrate examples of imaging mimics - Teach what information is important for the clinical team for treatment

Materials and Methods
This presentation offers case-based illustrations of CLIPPERS and changes to imaging findings following treatment. Included in this exhibit are selected cases of lesions in posterior fossa that mimic the disease including sarcoidosis, encephalitis, central nervous system vasculitis, and lymphoma. We will discuss treatment options and imaging findings associated with treatment response. The presentation will include a discussion of recently proposed diagnostic criteria for the disease process. Failure to recognize the inflammatory condition can lead to a delay in diagnosis and allow for worsening symptoms including cranial nerve and cerebellar dysfunction.

Results
CLIPPERS represents a rare inflammatory disorder primarily affecting the posterior fossa and the brainstem in particular. The disorder was first described in 2010 by Pittock and colleagues as a form of encephalitis centered on the pons and characterized as a T-cell pathology treatable by steroids. The disease process has characteristic imaging, clinical, and pathologic findings but the formal diagnostic criteria are largely unrecognized leading to uncertainty in diagnosis which can delay treatment of brainstem pathology. Imaging features associated with CLIPPERS include T2 signal abnormality at the sites of enhancement, enhancing nodules measuring greater than 3 millimeters in diameter, and decreased abnormalities on MRI following steroid treatment. Recently proposed diagnostic criteria include clinical, imaging, and pathology findings. The disease process can be split into "definite CLIPPERS" in patients all criteria in all 3 categories and "probable CLIPPERS" in patients fulfilling clinical and imaging criteria without available neuropathology.

Conclusions
CLIPPERS is a rare disease process of the posterior fossa, most commonly involving the brainstem. The disease is poorly understood and diagnosis is often delayed, leading to a delay in treatment for a treatable condition. Through education about the diagnostic criteria for the disease and providing understanding of possible mimics, radiologists can suggest the diagnosis earlier and ensure proper treatment earlier in the process.

1152

Classification of Vascular Anomalies by The International Society for The Study of Vascular Anomalies (ISSVA): An Overview in The Head and Neck

S Alharbi1, M Badran1, M NICOLAS-JILWAN1

1KING FAISAL SPECIALIST HOSPITAL & RESEARCH CENTRE, RIYADH, SAUDI ARABIA

Purpose
Vascular anomalies of the head and neck are frequently misdiagnosed, which detrimentally impacts their evaluation and management. This is particularly related to considerable inconsistency in their nomenclature, as classification schemes constantly evolve with the recognition of new diseases and improved understanding of the histopathogenesis and genetic basis of known entities. The updated 2014 classification of the International Society for The Study of Vascular Anomalies (ISSVA) is the new consensus classification for vascular anomalies. It insures consistent communication, which is crucial in this patient population, often requiring multidisciplinary management. We present an overview of the imaging characteristics of the different types of vascular anomalies of the head and neck according to the new ISSVA classification.
Materials and Methods
We reviewed the records of our multidisciplinary clinic for vascular anomalies and selected different imaging studies including CT, MRI and angiograms when appropriate, of patients with various vascular lesions of the head and neck. These encompass the most common vascular tumors, in particular the infantile hemangioma and congenital hemangioma, as well as various vascular malformations comprising venous malformations, lymphatic malformations, mixed venolymphatic malformations, arteriovenous malformations and arteriovenous fistulas.

Results
The distinctive imaging features of each vascular anomaly are highlighted, including its morphology, signal characteristics, enhancement pattern, vascularity as well as additional hallmarks such as the presence of phleboliths or fluid-fluid levels. We emphasize the importance of adhering to the ISSVA classification for adequate classification, diagnosis and management of these lesions.

Conclusions
The updated ISSVA classification should be universally adopted to ensure accurate diagnosis and management of vascular anomalies of the head and neck.

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Clearing the Smoke: Key Findings in the Evaluation, Treatment Planning and Follow-Up of Moyamoya Disease

M Gusman1, R Eldaya1, A Mian1, A Kansagra1, M Miller-Thomas1
1Washington University, St. Louis, MO

Purpose
Although most neuroradiologists are familiar with the imaging appearance of Moyamoya Disease, the subtleties of this pathology are rarely discussed.

Materials and Methods
After reviewing the diagnostic criteria for and differences between Moyamoya Disease and Moyamoya Syndrome, we utilize a case-based approach to highlight the current understanding of the pathophysiology, staging, treatment options, treatment complications, and the role of neuroimaging throughout. Original illustrations clarify concepts and common points of confusion.

Results
Our cases are a mix of adult and pediatric, and favor Moyamoya Syndrome, which is in line with the epidemiology of Moyamoya in North America. Cases include examples of catheter angiography findings, vessel wall imaging findings, and CT perfusion imaging. We show post-treatment imaging following multiple burr holes, pial synangiostosis, encephalodurosynangiostosis, encephaloduroarteriomyosynangiosis, superficial temporal artery-to-MCA anastomosis.

Conclusions
Moyamoya Disease and Moyamoya Syndrome differ in etiologies, but are similar in progression and treatment—all of which is surgical. Direct surgical treatment anastomoses an ECA branch to an ICA branch. There are many variations of indirect surgical treatments, all of which aim to stimulate trans-dural or trans-pial superficial-to-deep ECA-fed collateral formation. Understanding the post-surgical anatomy is essential to avoid common mistakes in post-surgical image interpretation. In patients treated with direct bypass, perfusion imaging may be used to exclude hyperperfusion syndrome, as this may otherwise have a similar appearance to infarct. Infarcts can occur periprocedurally or post-procedurally; surgery decreases but does not eliminate the risk of infarcts in Moyamoya patients.
Clinical and Imaging Correlation of Orbital Apex Lesions: A Case-Based Review

J Wen¹, A Makmur²
¹National University Health System, Singapore, Singapore, Singapore, ²National University Health System, Singapore, Singapore

Purpose
The purpose of this educational exhibit is to review the gross and imaging anatomy of the orbital apex, as well as illustrate a spectrum of pathologies involving the orbital apex with discussion of clinical localizing signs and key ophthalmologic/radiologic findings.

Materials and Methods
A series of cases with pathology involving the orbital apex from our institution will be showcased with emphasis on clinico-radiologic correlation. A short history, physical examination findings and clinical photographs of each patient will be presented. Through a multiple-choice quiz format, the reader will be able to select the most appropriate clinical syndrome. The corresponding radiologic images will then be displayed, followed by short expositions and learning points regarding the diagnosis.

Results
Orbital apex disorders can be classified into three groups, namely orbital apex syndrome (OAS, or Jacod syndrome), superior orbital fissure syndrome (SOFS, or Rochon-Duvigneaud syndrome) and cavernous sinus syndrome (CSS). The overlapping anatomy around the orbital apex means that these syndromes share similar causes and clinical features. Pathology affecting the orbital apex may be broadly divided into traumatic/iatrogenic, neoplastic, infectious, inflammatory, endocrine, vascular and developmental causes. A variety of cases from each of these categories will be displayed. The reader will be given the opportunity to synthesize information from patient history and clinical findings and come to a conclusion of the likely cranial nerves/structures involved, before the answer is illustrated in the form of selected radiologic images.

Conclusions
The orbital apex is an important anatomic landmark which contains a variety of important structures. Pathology in this region can manifest in the form of different syndromes, as described. Familiarity with orbital apex anatomy and the clinical manifestations of a range of orbital apex diseases will improve the radiologic detection and characterisation of these conditions.

The differences in the indirect treatments can be subtle.
EXAMPLE OF A CASE STUDY

HISTORY
16 year old male
- No past medical history
- History of presenting complaint
  - 2 weeks of flu-like symptoms with intermittent fever; took an incomplete course of clarithromycin
  - 1 week ago also developed intermittent headache
  - 4 days ago started having left eye redness with swelling and droopy eyelids, as well as binocular diplopia

PHYSICAL EXAM

Constricted visual field on the left
No anisocoria/RAID; colour vision full
Pupil 3-4mm, sluggishly reactive

Question: Which cranial nerves are affected? Which syndrome is this?
Answer: CN II, III. Orbital apex syndrome (as CN II is involved)

IMAGING

- Opacification of both sphenoid sinuses, in keeping with sinusitis
- Bulky alteration within the left cavernous sinus, extending anteriorly into the orbital apex and posteriorly along the leptomeninges into the middle cranial fossa; no non-enhancing area to suggest thrombus
- Inflammatory standing and enhancement in the pre- and post-septal left orbit with left proptosis
- Enhancement along the left optic nerve suggestive of perineuritis
- Left superior ophthalmic vein thrombosis

LEARNING POINTS
- Orbital cellulitis can be divided into pre- and post-septal
- Post-septal cellulitis is most commonly due to adjacent sinuses, and is a cause of orbital apex syndrome
- Increased intra-orbital pressure may cause traction on the optic nerve
Clinical Applications of FDG PET CT Brain in Oncology and Beyond

A Haughey¹, S Liddy², R Killeen³
¹St. Vincent's University Hospital, Co. Dublin, Europe, ²St. Vincent's University Hospital, Dublin, Europe, ³St. Vincent's University Hospital, Dublin, Ireland

Purpose
We discuss and illustrate the merit of utilising F-18 fluorodeoxyglucose positron emission tomography computed tomography (FDG PET CT) as part of the assessment of both oncological and non oncological diseases of the brain and we provide a detailed overview of the imaging features on both FDG PET CT and magnetic resonance imaging (MRI), of a number of these disease processes.

Materials and Methods
We outline an approach for the evaluation of brain lesions on both FDG PET CT and MRI, using cases from our institution. We provide a detailed review of the appearances of glioma, lymphoma and metastasis and we also provide a detailed analysis of the appearances of demyelination, autoimmune encephalitis and neuroinflammation, on both FDG PET CT and MRI.

Results
Over the past few decades FDG PET CT has increasingly become part of the work up of patients with central nervous system tumours, in combination with MRI and CT. It can assist in differentiating tumour type and is especially useful in cases of primary central nervous system (CNS) lymphoma and can help in delineating tumour extent. FDG PET CT also plays a role in the assessment of neuroinflammatory conditions. FDG PET CT should be reviewed relative to the normative database to help identify subtle abnormalities such as white matter hyper-metabolism.

Conclusions
This presentation underlines the value of FDG PET CT in the assessment of both oncological and non oncological disease processes of the brain.

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Clinical Neuroimaging at Ultra-High Field: Strengths, Shortcomings, and Solutions

C Li¹, S Ma², F Sepehrband³, C Liu⁴, A Rajamohan⁵, N Sheikh-Bahaei⁶, V PATEL⁷
¹Keck School of Medicine at USC, Los Angeles, CA, ²USC Mark and Mary Stevens Neuroimaging and Informatics Institute, Los Angeles, CA, ³University of Southern California, Los Angeles, CA, ⁴Keck Medical Center of University of Southern California, Los Angeles, CA, ⁵N/A, N/A, ⁶Keck School of Medicine of USC, LA, CA, ⁷UNIVERSITY OF SOUTHERN CALIFORNIA, KECK SCHOOL OF MEDICINE, LOS ANGELES, CA
Purpose
Part 1 will discuss the theoretical and practical advantages of ultra-high field (UHF) MR imaging, defined as main magnetic field (B0) strengths greater than or equal to 7T. Part 2 will enumerate common pitfalls with UHF MRI, including physical, technical, and physiological factors that hinder high quality image formation. Part 3 will outline techniques for counteracting the limiting phenomena and will provide real-world examples illustrating the corresponding improvements in MR image quality.

Materials and Methods
In Part 1, we review the physical basis for the primary benefits of UHF imaging: improvements in signal-to-noise ratio and contrast-to-noise ratio, higher spatial resolution, and for dynamic processes, better temporal resolution. The viewer will gain an intuition for how B0 affects these measures of image quality. We illustrate these concepts using an example of BOLD fMRI performed at 7T. In Part 2, we summarize the challenges at UHF that limit the diagnostic quality of clinical images. We address physical factors such as RF inhomogeneity producing dielectric artifact and nonuniform SAR, the accentuation of chemical shift effects, and altered T1 and T2 relaxivities yielding unconventional image contrasts. We discuss technical factors such as the characteristic regional loss of signal produced by circularly-polarized coil designs. Finally, we review the physiologic side effects experienced by patients in the UHF environment as well as the unique aspects of MR safety at 7T. In Part 3, we discuss options for mitigating the effects described in Part 2, including using parallel transmit coil designs, B1 shimming, and flow compensation techniques. We provide before-and-after images to illustrate how these methods improve the clinical utility of UHF MRI.

Results
An example references the attached figure: Coronal T2-SPACE images (A) suffers from signal loss in the right temporal lobe; this can be mitigated using a parallel transmit coil with patient-specific B1 shimming (B). Axial 7T images are degraded by CSF pulsation artifact in the basal cisterns (C); this can be mitigated by the application of flow-compensation techniques (D).

Conclusions
We discuss benefits, pitfalls and mitigation strategies for UHF clinical neuroimaging. After reviewing this exhibit, the viewer will have an improved understanding of the special considerations needed at UHF. We hope that this work will serve as an accessible and useful reference for radiologists and researchers as UHF imaging becomes more prevalent.

CNS Involvement in Patients with SLE: Imaging Characteristics and Pitfalls
C Hasbrook¹, T Moritani²
¹University of Michigan, Ann Arbor, MI, ²UNIVERSITY OF MICHIGAN, ANN ARBOR, MI

Purpose
To demonstrate the variety of imaging findings in central nervous system (CNS) manifestation of SLE.
Materials and Methods
Images from multiple patients will be utilized to demonstrate the spectrum of CNS manifestations of SLE. Discussion of mechanisms of injury will help explain the different types of imaging modalities including PET, NeuroQuant, diffusion/perfusion/susceptibility weighed and vessel wall imaging with SLE CNS involvement.

Results
SLE is an autoimmune disorder affecting many organ systems, including the CNS and peripheral nervous system. A variety of CNS manifestations can occur as neuropsychiatric SLE including diffuse manifestations such as headaches, depression, cognitive dysfunction, mood and anxiety disorders, acute confusional state, and psychosis, and focal manifestations such as seizures, aseptic meningitis, myelopathy, stroke and other cerebrovascular symptoms, movement disorder and demyelinating syndrome. It is thought that diffuse symptoms proceed due to neuroinflammatory processes both in the periphery and the CNS. Demyelinating syndrome is a rare manifestation which can present in different patterns including neuromyelitis optica, multiple sclerosis and ADEM. Posterior reversible encephalopathy is another manifestation of CNS lupus. Opportunistic infection can occur due to immunosuppression including aseptic meningitis, viral or bacterial meningoencephalitis, abscess, progressive multifocal leukoencephalopathy and EB virus associated lymphoproliferative disease. Accelerated atherosclerosis is often associated with corticosteroid treatment. The etiology of CNS lupus is multifactorial including antibody-mediated injury, vasculopathy related to leukothrombus, vasculitis, coagulopathy from antiphospholipid antibody, and cardioembolism. Imaging findings can include non-specific white matter lesions, chronic ischemic small vessel disease, demyelination, volume loss, encephalitis, infarction, hemorrhage, contrast enhancement and diffusion abnormality. Angiography is abnormal in less than 10% of patients, but there is high prevalence of vessel wall lesions on vessel wall imaging.

Conclusions
Given the heterogeneity of presentations, CNS manifestation of SLE can represent a diagnostic challenge. Knowledge of the variety of imaging characteristics is critical not only in diagnosis, but may help guide management and predict outcome.
Purpose
We present a simplified approach to common and uncommon causes of cerebral cortical-subcortical calcifications identified on neuroimaging.

Materials and Methods
Intracranial calcifications are frequent in neuroimaging and are best characterized by CT. A vast majority are physiological affecting dural reflections, choroid plexus, pineal gland, habenular commissure, and basal ganglia.\textsuperscript{1,2} Pathological intracranial calcifications can be classified based on spatial distribution such as intra or periventricular, deep nuclei, sellar-suprasellar, cortical-subcortical or extra-axial locations. Cortical-subcortical calcifications encompass a distinct subset of common and uncommon etiologies. Attention to clinical presentation, morphological pattern and ancillary neuroimaging features can help direct an appropriate diagnosis.

Results
Varied morphological patterns of cortical-subcortical calcifications can be encountered on neuroimaging. 'Gyriform' pattern is classically seen in Sturge-Weber syndrome (SWS) (Fig.1A), meningioangiomatosis (Fig.1B and IC), or chronic ischemic insult. 'Plaque-like' pattern is seen in congenital infections or superficial chronic hematomas. 'Nodular' pattern may indicate granulomatous, post-viral or parasitic etiology. 'Amorphous' or 'cloud-like' pattern is typically seen in tumor related calcifications [oligodendroglioma (Fig.1D) and ganglioglioma in particular], and rarely in cortical dysplasia (Fig.1E) and tuberous sclerosis (Fig.1F). Nodular or wedge-shaped pattern can be encountered in tuberous sclerosis. The clinical presentation and ancillary imaging findings also play an important role in differentiating varied etiologies. For instance, seizures are typical of tuberous sclerosis, SWS and cortical dysplasia. Leptomeningeal enhancement can be seen in both SWS and meningioangiomatosis (Fig.1C). Presence of soft tissue or cystic component or enhancement suggest tumor related calcification. Other rare reported causes of cortical-subcortical calcification includes Gobbi syndrome (occipital cortical calcifications), Urbach-Wiethe disease (mesial temporal lobe calcifications), calcifications from folate deficiency and chemoradiation related mineralizing microangiopathy.

Conclusions
The etiologies of cortical-subcortical calcifications can be differentiated by close attention to clinical presentation, morphology of calcifications and ancillary neuroimaging features.
Comparative analysis of MR imaging characteristics of pilomyxoid astrocytomas, pilocytic astrocytomas with myxoid features, and pilocytic astrocytomas: case based review

S Abi Fadel1, N Bhatt1, A Mahajan2, M Aboian3
1Yale New Haven Hospital, New Haven, CT, 2Yale University - MEDDRA, New Haven, CT, 3Yale University - MEDDRA Radiology, New Haven, CT

Purpose
Pilomyxoid astrocytomas (PMA) are predominantly located in the hypothalamus/suprasellar region. These are slow growing tumors that are distinct and are more clinically aggressive than pilocytic astrocytomas (PA), but recent 2016 WHO classification grouped them into grade I/II category due to critical need to increase understanding of patient outcomes. In our study, we describe imaging features of pilomyxoid astrocytomas with focus on published research. Educational Objectives 1. Review WHO classification 2016 update on PMA. 2. Review imaging features of PMA with emphasis on anatomic location, enhancement characteristics, and metastatic patterns. 3. Review imaging features of PA and pilocytic astrocytomas with myxoid features (PAM). 4. Review the literature of imaging and genetic characteristics of PMA, PA and PAM.

Materials and Methods
We identified 12 patients with pathologically proven PMA, PAM and suprasellar PA with available MRI. 3 of the tumors had whole exome somatic and germline sequencing. We evaluated the diffusion within these tumors using measurement of ADC (10-3 mm2/s) with Visage Imaging software (Pro Medicus Limited, Visage7). Qualitative MRI characteristics of location, size, enhancement, edema, T2 and T1 intensity and multifocality were assessed by neuroradiology attending and fellow. Study was approved by Institutional Review Board (IRB).

Results
Majority of the tumors were well circumscribed, had intra-tumoral cysts, and demonstrated avid enhancement, although central necrosis was only seen in PMAs (5/7). Intratumoral hemorrhage was seen in 2 PMAs and 1 PAM. Among the PMA cases, two patients with atypical imaging features including intraventricular extension of tumor and involvement of frontal lobe parenchyma were BRAF wildtype. Among PAM, one of the tumors was located within the posterior fossa and one was suprasellar. Intraventricular extension of the suprasellar tumor was noted and there was also evidence of intra-tumoral hemorrhage. This tumor had wildtype BRAF and had mutations in PTCH1 and PTPN1 on whole exome sequencing. Pilocytic astrocytomas demonstrated classic posterior fossa or suprasellar localizations.

Conclusions
We present comprehensive analysis of MR imaging characteristics in a cohort of pilomyxoid astrocytomas and published literature, which are currently classified by the WHO 2016 guidelines as Grade I/II.
Figure 1: A) Clinical examples of pilomyxoid astrocytoma (PMA) and pilocytic astrocytoma (PA) based on BRAF mutation status. B) Molecular signature of pilocytic astrocytoma from the literature (Collins et al, 2015).
Comparison of intrathecal gadolinium enhanced myelocisternography with T2 weighted 3D SPACE sequence in evaluation of CSF rhinorrhea.

P Singh1, N Choudhary2, A Kumar1, S VYAS1, C Ahuja3, V Bhatia2
1Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh, 2PGIMER, Chandigarh, Chandigarh, Chandigarh

Purpose
To compare intrathecal gadolinium enhanced myelocisternography with T2 weighted 3D SPACE sequence in evaluation of CSF rhinorrhea.

Materials and Methods
We studied 15 patients of CSF rhinorrhea presenting to PGIMER, Chandigarh, ranging in age from 20 to 55 years for localization of site of CSF leak. The patients were evaluated on 3T MRI machine (Magnetom Verio, Siemens Medical Systems). First, 3D T1WI with fat suppression & T2 3D SPACE images were acquired in supine position. Then under sterile conditions, lumbar puncture was done at L3-L4 or L4-L5 level using 22 gauge needle. 1ml of gadolinium was administered intrathecally in prone position. Patients were kept in Trendelenberg position for 20-30 min, followed by acquisition of fat suppressed 3D T1WI. Patients were observed for a period of 6 hrs and followed up for delayed complications. Standard of reference was surgical outcome.

Results
Patients were classified as having traumatic / iatrogenic or spontaneous rhinorrhea. 40% of patients had traumatic rhinorrhea & 60% had spontaneous rhinorrhea. Females were significantly associated with spontaneous etiology. Cribriform plate defects were associated more commonly with spontaneous CSF rhinorrhea whereas frontal, ethmoid & sphenoid sinus leaks were more common with traumatic rhinorrhea. Multiple sites of leaks were common in traumatic rhinorrhea. Imaging findings were divided into three groups. Localization was definitive when bony defect was seen with herniation of meninges or brain tissue with active contrast leakage. Findings were corroborative when defect was seen and indirect sign of active leak like opacification of cotton pleted, air-contrast level in sinus, sinusitis on ipsilateral side, pneumocephalus on same side of the leak was observed. Findings were indeterminate when no defect was seen or multiple defects were seen without any clue to exact site of leak. Linear tract of contrast through defect was seen in 11/15 patients with intrathecal gadolinium enhanced myelocisternography (CE MRC) & 6/15 patients with T2 SPACE. Sensitivity of CE MRC more as compared to T2SPACE. The accuracy of CE MRC in surgically treated group was 100%.

Conclusions
Intrathecal gadolinium enhanced myelocisternography can localize the site of CSF leak in CSF rhinorrhea more definitively as compared to 3D SPACE technique. It is specially helpful in those cases where findings on other modalities are borderline or indeterminate.

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Congenital Spine Malformations: Review of Spine Development with Pre- and Postnatal Ultrasound and MRI

A Blanchard1, L Eisenmenger2
1University of Wisconsin-Madison, Madison, WI, 2University of Wisconsin - Madison, Middleton, WI

Purpose
Congenital spine malformations represent a broad spectrum of development lesions which can have significant morbidity. It is important for radiology trainees and practicing radiologists to be familiar with these anomalies, as arriving at the appropriate diagnosis has critical implications on clinical decision making in the prenatal and postnatal periods.

Materials and Methods
The exhibit will first review the normal embryogenesis of the spine. Abnormalities in embryological development will thereafter be discussed, particularly those that lead to both open and closed spinal dysraphisms. Examples from each category of developmental lesion will then be presented in a case-based format, which will include sonographic and magnetic resonance imaging in both the fetal and postnatal periods. In each case, the salient imaging findings will be discussed. The management of each anomaly will also be reviewed, and when applicable, the postoperative findings and potential complications will be discussed.

Results
Spinal development begins early in embryonic life. A highly organized and complex sequence of events must occur in order for the spine to develop appropriately. Key developmental events include gastrulation, primary neurulation, secondary neurulation, and staged vertebral development. Neurulation, the process of forming the neural tube, is perhaps the most important of these steps to understand, as the majority of congenital spinal malformations can be traced to errors in either primary or secondary neurulation. Spinal dysraphism refers to a heterogeneous group of anomalies which can be attributed to errors in neurulation. They are classified as either open or closed depending on whether neural tissue is exposed beyond an intact dermis or epidermis. Open spinal dysraphisms (OSDs), which includes myelocle and myelomeningocele, cause progressive neurological disability. Several institutions close these defects in utero to stem the progression of disability. Closed spinal dysraphisms (CSDs) encompass a broader spectrum of disease with more
variable clinical features and management; however they can be equally as debilitating. The radiologist bears the responsibility of accurately diagnosing these disorders.

Conclusions
Congenital spine malformations represent a broad spectrum of lesions with critical imaging findings that radiologists must recognize, as the accurate diagnosis of these anomalies directly guides prenatal decision making, potential intervention, and postnatal care.

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Correlating Imaging and Histological Findings in Differentiating Aβ-Related Angiitis (ABRA) and Cerebral Amyloid Angiopathy–Related Inflammation (CAA-RI)

F Ofikwu¹, N Sharifi², H Orlowski³, R Eldaya⁴, M Miller-Thomas⁵
¹Mallinckrodt Institute of Radiology, Washington University, St Louis, MO, ²Washington University School of Medicine, St. Louis, MO, ³Mallinckrodt Institute of Radiology, Washington University, St. Louis, MO, ⁴Washington University, St Louis, MO, ⁵Mallinckrodt Institute of Radiology, Washington University, St Louis, MO

Purpose
Cerebral amyloid angiopathy (CAA) is a well-recognized entity resulting from cerebral amyloid-β (Aβ) accumulation in the walls of small and medium leptomeningeal and cortical vessels of the brain leading to vascular fragility and a resultant heightened risk of hemorrhage. Vascular inflammation is present in a portion of patients with cerebral amyloid angiopathy (CAA) known as Aβ-Related Angiitis (ABRA) which manifests as angiodestructive inflammation and Cerebral Amyloid Angiopathy–Related Inflammation (CAA-RI) which manifests as perivascular inflammation. The presence or absence of inflammation exerts major influence in predicting manifestation and evolution of the disease. Radiographic and histologic characterization of the inflammatory variants is important to achieve early clinical recognition which will lead to timely institution of treatment. This exhibit correlates the imaging and pathologic findings in differentiating ABRA and CAA-RI.

Materials and Methods
We review the MR and CT imaging of 19 patients with biopsy proven ABRA or CAA-RI. All pathological specimens were reviewed by neuropathologists to evaluate for the cardinal histologic features of ABRA or CAA-RI. All available neuroimaging was reviewed by subspecialty certified neuroradiologists blinded to the diagnosis with special attention to patterns of edema, hemorrhage, and contrast enhancement. Clinical data were recorded for correlation with imaging and histological findings.

Results
Pathologically, granuloma formation and destruction of the vessel wall was confirmed in cases of ABRA and perivascular lymphocytic infiltrate without granuloma formation was confirmed in cases of CAA-RI. All cases had evidence of edema with leptomeningeal enhancement in one or more lobes of the brain reflecting the inflammatory nature of the disease process and serving as
the biopsy target. Microhemorrhages were found to cluster in territories of inflammatory change more commonly in patients with ABRA than in patients with CAA-RI.

Conclusions
Inflammatory imaging changes of edema and leptomeningeal enhancement are common to both ABRA and CAA-RI and correspond to the hallmark histologic findings of granulomatous angionecrosis and perivascular lymphocytic inflammation, respectively. ABRA tended to show clustering of microhemorrhages confined to the inflammatory region more commonly than CAA-RI. The pattern of microhemorrhages may serve as an imaging marker by which to differentiate the two entities.

ABRA

[Images of brain scans]

CAA-RI

[Images of brain scans]

(Filename: TCT_2609_compositeinflammatoryCAA.jpg)
Correlation of Dual Energy Computed Tomography Electron Density Measurements with Cerebral Glioma Grade

r chakrabarti¹, V Gupta², S Vyas³
¹Postgraduate Institute of Medical Education & Research, Chandigarh, India, ²Paras Hospitals, Panchkula, Haryana, ³Postgraduate Institute of Medical Education and Research, Chandigarh, Chandigarh

Purpose
To correlate Dual Energy Computed Tomography (DECT) electron density (ED) measurements with histopathological cerebral glioma grading in order to determine whether DECT ED measurements can be used as a noninvasive tool to determine cerebral glioma grade.

Materials and Methods
Fifty consecutive patients diagnosed with suspected cerebral gliomas on imaging who were scheduled to undergo therapeutic/palliative resection of the same, were included. We tested our hypothesis that with increasing glioma grade, increase in tumor cellularity should translate into increased ED. Pre-operative non-contrast DECT scan of the brain was performed and ED measurements were calculated based on multiple Regions of Interest (ROI) drawn on the non-necrotic, non-hemorrhagic solid part of the tumor and the minimum, maximum and arithmetic mean values calculated and recorded, according to the following formula given by Saito et al. (1): ρe (ED relative to water) = ΔHU/1000 + 1 Absolute ED (x10²³/mL) = ED relative to water x absolute ED of water = ρe x 3.343 = (ΔHU/1000 +1) x 3.343 Minimum, maximum and mean ED and their normalized values (rED) recorded between two groups of gliomas ie. HGGs and LGGs were compared for statistical significance.

Results
Statistically significant difference was found between all the six parameters recorded (minimum ED, minimum rED, mean ED, mean rED, maximum ED, maximum rED) between the LGGs (WHO grades I and II) and HGGs (WHO grades III and IV). The predictive values of the six parameters ranged from 75% (for minimum ED and maximum rED) to 81.25% (for mean rED) in differentiating HGGs from LGGs. An independent analysis of the ED and rED values with the Ki-67 index of the tumor was also conducted. All the six parameters, again, were found to have statistically significant positive correlation with the tumor Ki-67 index with the highest coefficient of correlation seen in maximum ED values (r=0.59) and minimum coefficient of correlation in maximum rED values (r=0.49).

Conclusions
ED measurements DECT in cerebral gliomas are predictive of pre-operative non-invasive differentiation of LGGs from HGGs and also show a direct, linear, statistically significant positive correlation with the Ki-67 index of cellularity, therefore further confirming our hypothesis. Further work needs to be done to validate our findings and seek application of DECT electron density measurement in pre-operative grading of other CNS tumors as well as non-CNS neoplasms.
Purpose
CPT® (Common Procedural Terminology) is the system of medical nomenclature used to report procedures and services to public and private health insurance programs. This code set affects any neuroradiologist billing for services in the United States. Understanding how CPT codes are created and how the code set is maintained will help Neuroradiologists be more effective in the reimbursement process.

Materials and Methods
An interactive, visually-oriented education presentation designed to educate Neuroradiologists on the importance of CPT® in the process of appropriate reimbursement, and the role of ASNR in the process of code creation and code set maintenance. Education Objectives: • Demonstrate the role of CPT in the reimbursement process. • Demonstrate the different types of codes within the CPT code set and how these different codes relate to Neuroradiology practice. • Gain insight into code creation and code set maintenance, and demonstrate the role of ASNR in this process.

Results
N/A
Conclusions
Understanding how CPT codes are created and how the code set is maintained will help Neuroradiologists be more effective in the reimbursement process.

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Cranial Emissary Veins (CEVs): Anatomy and Clinical-Surgical Implications

E Supsupin1, M Fabrega1
1University of Texas Health Science Center McGovern Medical School, Houston, TX

Purpose
The cranial emissary veins (CEVs) are valveless structures that connect the endocranial and exocranial venous networks. CEVs have received very little attention despite their significant roles. We elucidate the anatomy of the CEVs and their important clinical and surgical implications.

Materials and Methods
This presentation aims to address the following: 1. Review the anatomy of important emissary veins namely: a. Mastoid emissary vein (MEV) b. Petrosquamosal sinus (PSS) c. Posterior condylar vein (PCV) d. Occipital emissary vein (OEV) e. Venous plexus of the foramen ovale (VFO) f. Vein of Vesalius (VV, also known as pterygoid emissary vein) g. Superior ophthalmic and facial veins (SOV and FV) 2. Elucidate the connections between the CEVs and dural venous sinuses 3. Describe the important surgical implications of CEVs 4. Discuss the role of CEVs as venous "safety valve" in certain pathologic conditions such as high-flow vascular malformations/fistulas and dural sinus and internal jugular vein occlusions 5. Describe the potential role of CEVs in the intracranial spread of infections 6. Discuss the role of CEVs in preventing acute thermal injury to the brain

Results
CEVs are important structures that may pose as a surgical challenge. For example, the mastoid emissary vein (MEV) can be a source of excessive or uncontrollable bleeding during surgeries of the skull base and middle ear, particularly in retrosigmoid and far lateral approaches. Other potential complications include venous thrombosis and air embolism. Cerebellar infarction and death resulting from MEV coagulation during skull base surgery have been reported. Therefore, recognizing the presence of MEVs and a thorough anatomic knowledge of the same may prevent disastrous complications during middle ear and skull base surgeries. The MEV may serve as conduit of infection. Sigmoid sinus thrombosis may occur as thrombophlebitic extension from an infected mastoid cavity via the MEV. The spread of sepsis has been described in association with CEVs. In Interventional Neuroradiology, the use of the MEV has been reported as a unique and valuable technique for accessing an isolated or inaccessible transverse or sigmoid sinus system in the treatment of dural arteriovenous fistulas. CEVs may serve to cool venous blood and protect the brain from "acute thermal damage". They may act as "safety valve", protecting the brain from dangerous increases in intracranial pressure in certain pathologic conditions such as high-flow vascular malformations/fistulas and dural sinus and internal jugular vein occlusions.

Conclusions
Recognition of CEVs and having a detailed anatomic knowledge of the same may prevent catastrophic complications during middle ear and skull base surgeries. CEVs may facilitate intracranial spread of infections. CEVs may protect the brain from "acute thermal damage" and act as "safety valve" in certain pathologic conditions such as high-flow vascular malformations/fistulas and dural sinus and internal jugular vein occlusions.
Purpose

Disc herniation is the commonest cause of low back pain and sciatica. CT-guided intradiscal injection of oxygen-ozone mixture (O2-O3 diskolysis) has emerged as a valid procedure to treat patients who fail to respond to conservative (pharmacological and rehabilitative) treatment. The aim of this work is to illustrate the technique of the procedure and the mechanisms of action of ozone, to review the effectiveness of ozone treatment in short and long-term follow-up studies reported in literature, focusing on related risks and complications.

Materials and Methods

Technique. How to select patients to treat (according to clinical, neurologic and neuro-radiologic criteria), contraindications, how to perform the procedure (including materials, instruments and puncture technique) and practical tips to prevent complications, were discussed in detail in the poster. Mechanism of action. Ozone oxidizes the proteoglycans in the nucleus pulposus and reduces the disc volume, which results in pain relief. It has also strong anti-inflammatory and analgesic effects, as it inhibits synthesis of prostaglandins and release of bradykinins and increases the release of antagonists to proinflammatory cytokines. It also reduces venous stasis, improving the microcirculation and reducing pain associated with neural hypoxia.

Results

The reported effectiveness of the procedure is promising, with clinical success rate ranging from 70% to 82% in 12 months follow-up studies. Intradiscal and periganglionic injection of O2-O3 mixture is safe and complications are very rare. Potential complications of the procedure include local haematomas, infections and nerve root lesions. Vitreous-retinal haemorrhages, thunderclap headache caused by incidentally intrathecal puncture, transient nerve injury, one case of vertebro-basilar stroke, one case of discitis and a case of fatal sepsicaemia have been occasionally reported.

Conclusions

Intradiscal injection of ozone represents a safe, minimally invasive, well tolerated and low-cost procedure. Ozone diskolysis provides excellent pain relief in most herniated disc patients who failed to respond to conservative therapy and it may represent, in selected cases, a valid alternative to surgery.
Deep Learning in Radiology: Getting Hands Dirty

A Singh¹, K Clark¹
¹UT Health San Antonio, San Antonio, TX

Purpose
1. To familiarize the audience with the concepts of deep learning for image classification. 2. To show the audience how to make an actual model to classify CT images for the prediction of intracranial hemorrhage. 3. To help the audience learn how to evaluate an AI model.

Materials and Methods
1. In order to prepare the dataset, approximately 1052 CT images (anonymized) of the brain were obtained with and without hemorrhage from PACS. Different patterns of hyperdense intracranial hemorrhages were included. 2. Images were assigned to 2 different folders (training and validation) with approximately 70% images included in the training folder and 30% in the validation folder. Each folder has 2 subfolders titled "hge" (hemorrhage) and "no_hge" (no hemorrhage). 3. The deep learning model was prepared using fastai software. A local GPU machine was used to train the model. 4. A transfer learning approach was used with the help of the publicly available Resnet50 model. 5. The final model was evaluated on a hold-out set of images (which the model has not seen before).

Results
Deep Learning is a subtype of machine learning with specific relevance to radiology due its ability to recognize specific patterns in different images with the help of a convolutional neural network (CNN) composed of multiple hidden layers. We used the fastai library (https://docs.fast.ai/) to create and train the model. This software is based on pytorch with default parameters pre-populated from best practices. This improves the accessibility of deep learning to radiologists. The final results were: Model Accuracy: 97.4% Sensitivity/Recall for hemorrhage: 96.5% Precision/Positive predictive value for hemorrhage: 98.4% After the training, the model was saved in a Github repository and deployed online using Render platform. The final link is
Deep learning is a very powerful technique for image classification and will play an important role in the future of radiology. A potential benefit of this kind of model will be to identify urgent abnormalities which permits prioritization of these studies on PACS worklists. The timely reading of these studies will expedite and improve patient management. In this submission we demonstrate a start to finish AI development pathway from initial source data acquisition to a workable publicly accessible AI tool.

Demystifying Ocular Ultrasound: The Technique, Anatomy and Imaging Findings in Common Clinical Conditions

A Haughey¹, J Duignan², R Killeen³
¹St. Vincent's University Hospital, Co. Dublin, Europe, ²St. Vincent's University Hospital, Dublin, Europe, ³St. Vincent's University Hospital, Dublin, Ireland

Purpose
After reading this presentation, you should be familiar with ocular and orbital anatomy, OUS technique and you should be able to recognise common ocular pathology on OUS

Materials and Methods
We discuss the reasons for performing OUS. We aim to outline a step by step guide on OUS technique including patient positioning, probe selection and the recommended settings and protocol. We also aim to provide a detailed overview of ocular and orbital anatomy using both diagrams and imaging correlates. Finally we illustrate examples of pathology seen on OUS, using cases observed in our institution. We review the findings on OUS of pathologies including staphyloma, phthisis bulbi, cataracts, lens malposition, vitreous hemorrhage, retinal detachment, choroidal detachment, vitreous detachment and retinoschisis, amongst others.

Results
Ocular and orbital anatomy is detailed and complex but with good understanding of the parts of the globe including the components of the ocular wall, the contents of both the anterior and posterior segments and of the vascular supply, optic nerve and orbit, OUS is both
accessible and has a number of advantages as outlined in this presentation. Common pathology is easily identified on OUS if you have the appropriate training and knowledge of this examination.

Conclusions
OUS is an important skill for the Neuroradiologist/ Head and Neck Radiologist. This educational exhibit serves to educate the observer on the findings/anatomy on normal OUS examinations and on the findings on OUS in a multitude of common pathologies using cases as examples.

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Differentiating extrinsic compression of dural venous sinuses from posterior fossa epidural hematoma in children

M Czarniecki1, J Murnick2
1Georgetown University Hospital, Silver Spring, MD, 2Children’s National Hospital, Washington, DC

Purpose
Acute cerebral venous sinus thrombosis (CSVT) of the transverse and/or sigmoid sinuses is a common complication of cranial fracture involving the temporal or occipital bone. CSVT can lead to elevated intracranial pressure, infarct, or death and is therefore often treated with anticoagulation, despite the risks of anticoagulation in the setting of trauma. Epidural hematoma (EH) causing extrinsic compression of the venous sinus is another common complication of fracture and can appear similar to CSVT on MRI, particularly in the posterior fossa. EH should not be treated with anticoagulation, so it is important for the radiologist to accurately differentiate EH from CSVT. This exhibit demonstrates key imaging findings that distinguish these two entities.

Materials and Methods
N/A

Results
Specific findings indicating EH or CSVT include: 1. Jugular bulb involvement. Epidural hematoma lies along the inner table of the cranium and will not extend through the jugular foramen. If clot is seen to extend into or through the jugular foramen (Figure 1C), it is intravascular, and CSVT can be confidently diagnosed. 2. Circumferential dural enhancement. The walls of the venous sinuses are comprised of dura. Intravascular thrombus of CSVT should be circumferentially surrounded by enhancing dura on post-contrast images (Figure 1A). Conversely, EH elevates the dura away from the bone, so no rim of enhancement is seen along the cranial margin of the thrombus (Figure 1B). 3. Clot extent beyond sinus margins. Intravascular thrombus should not extend beyond the margins of the venous sinus. The extent of clot should be inspected carefully in three planes. If it extends beyond the margin of the dural venous sinus (Figure 1D), it represents EH, not CSVT.

Conclusions
After viewing this exhibit, radiologists should be able to accurately differentiate EH from CSVT in the posterior fossa. This knowledge will help guide treating clinicians considering anticoagulation therapy in post-traumatic patients.
Difficult Diagnoses: Acute Neurologic Deficits Due to Spinal Cord Infarct

M Tominna¹, A Wang², D Clement²
¹Beaumont Hospital Royal Oak, Royal Oak, MI, ²Beaumont Hospital, Royal Oak, MI

Purpose
Spinal cord infarct is a challenging diagnosis to make, often missed on initial imaging due to perplexing presentation. The purpose of this exhibit is to review cases of acute neurologic deficits due to arterial or venous spinal cord infarcts that presented as a diagnostic dilemma.

Materials and Methods
Not applicable.

Results
The following cases will be reviewed: 70 y/o female with acute progressive bilateral lower extremity weakness initially thought to be due to an extradural schwannoma. Rapid decline occurred after surgery with imaging showing spinal cord infarct as a result of venous congestion from a dural arteriovenous fistula. 50 y/o female presented with acute ataxia and abnormal signal within the brainstem. Initial considerations included ischemic, demyelinating, inflammatory or malignant etiologies. Subsequent imaging showed findings were related to infarct from vertebral artery dissection. 53 y/o male presented with acute left-sided neurologic symptoms due to Brown-Sequard syndrome several days after undergoing surgical discectomy in the cervical spine. There was restricted diffusion and pathologic enhancement in the lower thoracic spine due to late acute/subacute infarct. 44 y/o male underwent resection of an extraudral thoracic mass. During the surgery there was loss of somatosensory and motor evoked potentials and there was no motor function after surgery in the bilateral lower extremities. MR showed new findings within the cord concerning for cord infarct of the anterior spinal artery.

Conclusions
It is critical for the radiologist to identify spinal cord infarct as the cause of acute neurologic deficits as delay will result in a poor outcome for the patient. A timely diagnosis can make all the difference in the patient's outcome.
Diffusion Imaging: What the Radiologist Needs to Know

S VYAS

1Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh

Purpose
Diffusion weighted imaging (DWI) since inception had undergone significant advancement from qualitative images to quantitative microstructural information. It has become integral part of MR imaging, and provides important information about both microstructural integrity and the connectivity for understanding the morphological and pathological processes. As there has been significant advancement in techniques and parameters in DWI, MR diffusion framework may appears confusing. Systematic approach for understanding the basic physical principle, acquisition techniques and various diffusion metrics may be helpful.

Materials and Methods
MR diffusion framework was studied and analysed from simple qualitative imaging to diffusion kurtosis imaging. We evaluated and tried to simplify the interpretation of various diffusion techniques and significance of diffusion metrics.

Results
DW sequences can be used to detect the diffusion process by incorporating appropriate magnetic field. Change in the relative spatial motion leads to a change in image contrast. b value is an important factor of DW sequences and affects the signal intensity of the diffusion. Advanced MR diffusion techniques include diffusion tensor imaging (DTI), diffusion spectral imaging (DSI), q-ball imaging and diffusion kurtosis imaging. Two main factors which affect the MR diffusion process are b-values and number of diffusion gradient direction and these techniques are acquired by altering these factors. Each technique has its own merits and limitations. DTI unable to resolve the complex fibers organization and changes in grey matter, DSI has long acquisition time, and q-ball imaging unable to produce clinically meaningful diffusion parameters. DKI is an emerging technique, having better signal to noise ratio, clinically feasible acquisition time, and assesses both diffusion and kurtosis related parameters.
Conclusions
Basics of MR diffusion and its advancement are essential to the radiologist for understanding the clinical applications. By knowing the significance of the diffusion parameters, it helps in understanding and interpretation of the changes in various pathological processes.

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Diversity of Wernicke's Encephalopathy: Causes, Symptoms and MRI findings

Y Ota¹, T Moritani¹, A Handa², S Naganawa¹, J Kim¹, A Srinivasan¹, A Capizzano¹
¹University of Michigan, Ann Arbor, MI, ²University of Iowa, Iowa city, IA

Purpose
To review biochemical mechanisms, causes, clinical symptoms and radiological findings of Wernicke's encephalopathy (WE)

Materials and Methods
WE is a severe and life-threatening illness resulting from thiamine deficiency. Without proper treatment, severe neurologic disorders such as Korsakoff psychosis and even death may occur. The classical clinical triad (abnormal mental status, gait ataxia, and ophthalmoplegia) is found in only one-third of the patients. The leading cause of WE is alcoholism, which accounts for about 20% of the cases. The neuroradiologist should know characteristic radiological findings as well as underlying causes and symptoms to ensure appropriate and immediate treatment. Biochemical mechanisms of WE: Thiamine is a key vitamin for maintaining membrane integrity and osmotic gradients across the cell membranes. Deficiency of thiamine causes intracellular accumulation of toxic metabolic intermediates, which leads to cytotoxic and/or vasogenic edema. Causes of WE: Alcoholism, cancer, gastrointestinal surgery, transplantation, hyperemesis gravidarum, prolonged fasting/starvation, dialysis, prolonged parenteral nutrition, anorexia, AIDS, infection, and thyroid disease. Symptoms of WE: The classical triad of clinical symptoms is found in only one-third of the patients. Atypical clinical presentations include stupor, hypothermia, hypotension, vestibular dysfunction without hearing loss and beriberi heart disease.

Results
MRI findings: Common distribution of WE lesions: Classical lesions are typically seen in the medial thalamus, mammillary bodies, hypothalamus, wall of the third ventricle, tectal plate, and periaqueductal area. In these areas, the maintenance of cellular osmotic gradients is considered to be strictly related to thiamine levels. Uncommon distribution of WE lesions: Uncommonly, lesions are seen
in the frontal cortex, the precentral and postcentral gyri, putamen, caudate nucleus, fornix, red nucleus, substantia nigra, corpus callosum, superior and middle cerebellar peduncles, cerebellar dentate nuclei, vermis and paravermian regions of the cerebellum, cranial nerve nuclei, and dorsal medulla. They are often found in association with the classical lesions.

Conclusions
We reviewed biomechanical mechanisms, causes, symptoms, and corresponding MRI findings in WE.

Dorsal Thoracic Arachnoid Web: A Pictorial Review

A Metry¹, V Agarwal¹, D Wecht¹, W Rothfus¹
¹University of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
Describe dorsal thoracic arachnoid webs and their clinical presentations. Review multi-modality imaging findings of dorsal arachnoid webs. Discuss relevant differential diagnosis for dorsal thoracic arachnoid webs.

Materials and Methods
Review pre-procedural MRI and CT Myelography examinations of the thoracic spine with clinical presentation. Review intra-operative US images. Review relevant post-operative imaging findings.

Results
Spinal arachnoid webs are intradural extramedullary transverse bands of arachnoid tissue that extend to the pial surface of the spinal cord. Case reports describe a common dorsal upper thoracic location. Patients can present with back pain, upper/lower extremity weakness, numbness and gait instability. The arachnoid veil itself is difficult to be seen on MRI and CT Myelography but a secondary characteristic imaging feature can suggest its presence, the "scalpel sign". The "scalpel sign" refers to the dorsal spinal focal indentation which resembles a posteriorly pointing blade on sagittal images. Axial CT Myelogram and T2-weighted MR images show focal ventral displacement of the cord without focal spinal cord herniation and a relatively preserved anterior subarachnoid space with widening of the dorsal subarachnoid space. Arachnoid webs may alter the CSF flow dynamics and CSF pressure differential on either side of the web causing myelopathic presyrinx T2 signal changes and syringomyelia, adjacent to the level of indentation. Surgical lysis of the arachnoid web improves patient's symptoms and function with post surgical follow-up MR imaging revealing resolution of the focal cord kink, decreased T2WI signal abnormality, resolution of the syringomyelia and cord re-expansion. Differential diagnosis include: 1. Dorsal arachnoid cyst: Marginated walled cyst causing wide smooth symmetric scalloping of the cord surface with absent normal CSF pulsation artifact. It fills slower than the remainder of the subarachnoid space on CT Myelography. 2. Ventral spinal cord herniation: Axial MRI or CT myelography shows anterior cord tissue herniation outside the margins of the dura through a ventral dural defect with dorsal cord flattening and deformity.

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Conclusions
Arachnoid webs can block the CSF flow causing focal compression of the spinal cord and syrinx. Early recognition of the scalpel radiographic sign and prompt surgical lysis of the arachnoid veil can result in resolution of syringomyelia and improvement in neurological function.
Duplicated Pituitary Gland: A Case Series and Review of the Literature

C Smith¹, S Singh²
¹University of Alabama at Birmingham, Birmingham, AL, ²University of Alabama Medical Center, Birmingham, AL

Purpose
Duplicated Pituitary Gland (DPG) is a rare developmental anomaly, which has characteristic imaging findings as well as unique complex spectrum of associated developmental defects. We present a case series of duplicated pituitary gland and its associated developmental defects. We also provide a review and comparison of other common developmental anomalies of the hypothalamic-pituitary-axis (HPA). • Describe the clinical presentations and imaging findings typical for DPG and the spectrum of its associated developmental defects. • Describe the other common developmental anomalies of the HPA including Pituitary Absence / Hypoplasia, Pituitary Duplication, Kallmann Syndrome (Hypogonadotropic Hypogonadism), and Hypothalamic Dysgenesis. • Review pertinent associations with DPG and the above HPA disorders to guide the differential diagnosis. • Describe and compare imaging findings for DPG and the above HPA disorders.

Materials and Methods
Institutional review of 2 cases of DPG and review of cases associated with developmental anomalies of HPA including Pituitary Absence / Hypoplasia, Pituitary Duplication, Kallmann Syndrome (Hypogonadotropic Hypogonadism), and Hypothalamic Dysgenesis. Review of current literature to identify the epidemiology, pathophysiology, and spectrum of developmental defects associated with DPG.

Results
Figure 1 demonstrates a representative case of DPG with duplicated pituitary stalks (white arrows) and duplicated pituitary glands (white arrow heads) seated within duplicated sella turcicas (right upper image); duplicated odontoid process (left upper image); duplicated/fenestrated basilar artery (right lower image); hypothalamic hamartoma (left lower image). DPG is a rare developmental anomaly, which has characteristic imaging findings as well as unique complex spectrum of associated developmental defects. We present a case series of DPG and its associated developmental defects. We also provide a review and comparison of other common developmental anomalies of the HPA.

Conclusions
It is important to be aware of DPG and its spectrum of associated defects as well as other common developmental anomalies of the HPA, which will aid in narrowing and guiding the differential diagnosis.
Early MRI Features of Pediatric Discitis and Spondylodiscitis: An Interactive Quiz With Clinically Challenging Cases.

U Shafique1, W Zucconi2
1Yale University School of Medicine, Cheshire, CT, 2Yale School of Medicine, New Haven, CT

Purpose
By completing this quiz based exhibit, the participant will: 1. Learn to recognize early imaging features of pediatric disc and vertebral body infection. 2. Learn to integrate clinical history, exam findings and laboratory parameters in the assessment of such patients. 3. Review etiology, natural history and complications of the disease process. 4. Review best practices regarding management, sample/biopsy, and follow up of the patient.

Materials and Methods
Material will be presented in a case-based, quiz format, providing immediate feedback, and review of information in an interactive presentation platform. 5 to 6 cases will be presented with additional questions and answers format to identify early imaging abnormalities, variability and reliability of clinical presentation data, etiologies, next steps in diagnosis, percutaneous sampling and follow up.

Results
With the availability of MRI, it is now possible to detect early discitis and spondylodiscitis before it progresses to advanced osteomyelitis and its complications. Most bacterial discitis and osteomyelitis are now treated on an empirical basis based on imaging study abnormalities, so it is important that a radiologist should be able to raise the suspicion of discitis/ spondylodiscitis. Imaging findings include reduction in the height of the intervertebral disc with hyperintense in T2-weighted images, the end plates may be irregular and blurred. Confluent hypointense signal on T1 in vertebral bodies with associated hyperintense signal on STIR and post contrast enhancement may be identifiable. Additional heterogenous hyperintense signal on T2/ STIR and associated enhancement may be seen in paravertebral and prevertebral soft tissues. In case of multifocal involvement of multiple vertebral bodies and appropriate clinical settings, suspicion for Chronic recurrent multifocal osteomyelitis (CRMO) may be raised, which is a type of noninfectious osteomyelitis. In case of unresponsiveness to antibiotics and progression of disease, percutaneous biopsy may be recommended.

Conclusions
Timely diagnosis of pediatric discitis and spondylodiscitis is critical to initiate proper pharmacotherapy and prevent morbidities including development of devastating neurological complications and spinal deformities. As the concept of quality reporting is emerging, it is the responsibility of the radiologist to help in management of the patient by recognizing the imaging features, clinical presentation and recommend need of further imaging, biopsy and follow up.
Effects of Radiation Therapy on the Brain and Spine: An Interactive Imaging Exhibit

A Li¹, M Iv²

¹Stanford University, East Palo Alto, CA, ²STANFORD UNIVERSITY, LOS ALTOS, CA

Purpose
Educational objectives: 1. Understand the general pathophysiologic processes by which radiation affects the brain and spine. 2. Recognize imaging features of common and uncommon radiation-induced injury. 3. Recognize various pathologies of interest from a series of unknown cases in an interactive quiz format.

Materials and Methods
Outline of cases: I. Acute effects, e.g. increased intracranial pressure, diffuse brain edema and herniation, spine marrow edema and hemorrhage II. Subacute/Early-delayed effects, e.g. pseudoprogression versus tumor progression, subacute rhomboencephalitis, carotid rupture, fatty marrow replacement, irradiation osteitis, vertebral insufficiency fractures, avascular necrosis III. Late-delayed effects a. Radiation necrosis b. White matter injury and leukencephalopathy c. Radiation-induced myelopathy d. Radiation-induced tumors, e.g. meningiomas, gliomas, sarcomas, spine/bone tumors (e.g. osteochondromas) e. Vasculopathy, e.g. atherosclerosis, moyamoya vasculature, vascular malformations including cavernous malformations and telangiectasias, organizing hematomas, intravascular papillary endothelial hyperplasia (Masson's lesion), aneurysms f. Ischemia, e.g. lacunar infarcts g. SMART (Stroke-like migraine attacks after radiation therapy)

Results
N/A

Conclusions
Summary: The effects of radiation therapy (RT) on the central nervous system can occur anytime from days to years after RT completion and can manifest in various ways on imaging. Familiarity with the different magnetic resonance imaging appearances of RT effects may help to improve diagnosis and avoid misinterpretation (i.e. to better differentiate between treatment effect from disease
progression as well as to recognize and identify short-term and long-term sequelae of RT including secondary RT-induced tumors. In this exhibit, the timeline of presentation, in particular, the acute (during or shortly after RT), subacute/early-delayed (up to 3 months after RT), and late (greater than 3 months to years after RT) periods from the time of RT completion, will be used to systematically highlight and describe each type of RT-induced lesion in both the brain and spine. We will also discuss alternative differential diagnoses that may mimic specific RT-induced lesions. Finally, a series of unknown cases will be presented in an interactive quiz format to reinforce the concepts introduced.

![Figure 1. Radiation-Induced Vasculopathy](TCT_1726_figure11.jpg)

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2522

Enhancing Dural Venous Sinus Thrombosis: A Common Cause of False-Negative MRIs

A Kadribegic, J Chen, M Goldberg, W Chang, M Spearman, C Wanamaker, C Li

Allegheny Health Network, Pittsburgh, PA. San Diego Veterans Administration Health System, San Diego, CA. AHN, Pittsburgh, PA

Purpose

Dural venous sinus thrombosis (DVST) can be a confounding clinical entity that can go undiagnosed without dedicated venographic imaging. MR imaging (MRI) and MR venography (MRV) are commonly the first-line imaging studies, as patients with DVST are often young and benefit most from limited exposure to iodinating radiation associated with CT venography (CTV). One potential pitfall of MRI and MRV is enhancement of thrombus, theorized to occur due to vascularization of the thrombus itself, which can mimic a patent vessel [1]. This appearance can easily lead to false-negative interpretations on contrast-enhanced MRI and MRV. In this presentation, we provide examples of DVST enhancement on contrast-enhanced MR studies, as well as guidance on incorporating information from different CT and MR techniques to more accurately diagnose DVST.

Materials and Methods

We present the pathophysiology and clinical presentation of DVST and classic imaging findings on routine CT and MRI, as well as CTV and MRV. We also review the normal venous drainage territories of the brain. We then present several examples of DVST...
enhancement on MRI that obscured diagnosis, as well as guidance on synthesizing information provided by CT and MR to more accurately diagnose DVST.

Results
DVST classically appears as filling defects on both CTV and MRV. On CTV, the defect is caused by iodinated contrast opacifying the surrounding vessel but not the thrombus itself on early imaging. On MRV, however, the cause of the filling defect is dependent on the particular venographic technique, whether it's time-of-flight, phase-contrast, contrast-enhanced, or some combination. DVST can also have varying appearances on non-contrast CT and structural MRI, due to the presence of organizing blood products and disruption of normal laminar flow, which can aid in its diagnosis. Knowledge of the patterns of normal brain venous drainage aids in clinical suspicion for DVST.

Conclusions
In this presentation, we will discuss the typical clinical and radiologic presentation of DVST, present atypical cases of enhancing DVST, and provide an approach for accurate image interpretation if thrombus enhancement is suspected.
Figure: Example of enhancing dural venous sinus thrombus in the right sigmoid sinus (arrows). (A) Non-contrast T1-weighted sequence showing no intrinsic T1 hyperintensity. (B) T2-weighted sequence showing lack of flow-related signal void, indicating slow flow vs. thrombus. (C) Contrast-enhanced T1 MPRAGE sequence showing heterogeneous enhancement throughout. (D) CT venogram showing occlusive filling defect, consistent with thrombosis.

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Epilepsy In Children: What The Radiologist Needs To Know To Take Part In A Successful Epilepsy Multidisciplinary Program

M Raja¹, R Benini², J AlRayahi³
¹Hamad Medical Corporation, Doha, Qatar, ²Sidra Medicine, Doha, Qatar, ³Sidra Medicine, Doha, Ad Dawha

Purpose
To discuss the prerequisites for building a successful surgical epilepsy program with practical tips to optimizing the role of neuroimaging

Materials and Methods
Our review is based on the experience of a single centered tertiary pediatric hospital with a successful epilepsy program & review of literature. The following objectives will be covered while giving examples of patients' who underwent comprehensive preoperative neuroimaging evaluation: • To understand the global burden of pediatric epilepsy and indications for referral for epilepsy surgery • To understand differences between adult and pediatric epilepsy • To understand the roles and expectations of different specialties in an epilepsy multidisciplinary team, including the neurologist, radiologist and neurosurgeon • To learn the role of MRI, fMRI, PET and SPECT in the diagnosis and preoperative evaluation in children with refractory epilepsy • To learn updates on the genomics of cortical malformation and review its embryology

Results
Approximately 10.5 million children are diagnosed with epilepsy worldwide with 25-30% expected to have drug-resistant epilepsy. However, a much smaller fraction undergo preoperative evaluation & neurosurgical intervention. The 2004 ILEA survey showed the most frequent etiology for pediatric epilepsy surgery patients to be cortical dysplasias, followed by atrophy/sequelae of stroke & hippocampal sclerosis. Therefore, our MRI techniques should be tailored to increase the detection rate of some of the more common etiologies such as FCD. In addition, given the rate of MRI negative studies and occasional discordance between seizures semiology, EEG findings & MRI, other advanced studies such as PET & SPECT are imperative. fMRI is also an essential preoperative tool for lateralization & localization of the eloquent cortices. Finally, the radiologist should have basic knowledge of different curative & palliative epilepsy surgeries to better tailor the studies

Conclusions
Pediatric epilepsy results in devastating social & economic impact. The need for a dedicated multidisciplinary epilepsy program is imperative in the management of refractory epilepsy in children, especially given the differences in etiology compared to adults. We will discuss the roles of different specialties within an epilepsy multidisciplinary team. We will also discuss common pathologies in pediatric refractory epilepsy and the indications & practical approach of various neuroimaging techniques including conventional MRI, fMRI, PET & SPECT
Essential Genomics of Pediatric Diffuse Gliomas for Neuroradiologists

S Pisani Petrucci¹, Y LI¹, D Solomon², S Cha¹
¹University of California San Francisco, San Francisco, CA, ²University of California, San Francisco, San Francisco, CA

Purpose
Genomic data has become increasingly important in the classification and diagnosis of central nervous system (CNS) tumors, as evidenced by the molecularly-based restructuring of the diffuse glioma group within the 2016 World Health Organization Classification of Tumors of the Central Nervous Systems. In this exhibit, several key imaging features and the new molecularly-integrated diagnostic classification of diffuse gliomas will be reviewed, with a particular emphasis on molecular profiles and MR imaging characteristics in pediatric diffuse gliomas.

Materials and Methods
Using cases from our institution, material will be presented as an image-rich, interactive digital educational exhibit. At the conclusion of the exhibit, additional cases will be presented in a quiz format for self-assessment and reinforcement of major teaching points.

Results

Conclusions
Through this exhibit, neuroradiologists will gain fundamental knowledge of the key genetic mutations in pediatric diffuse gliomas. This knowledge is important given the implementation of a new WHO CNS tumor classification system combining phenotypic and genotypic features to reach "integrated diagnoses." Combining molecular genomic data and imaging features of pediatric diffuse gliomas will provide greater insight into tumor biology, improve diagnosis, assess prognosis, and offer targeted treatment options.
Glioblastoma, IDH-wildtype vs IDH-mutant

Post-con T1

IDH-wildtype/ primary GBM
- Strong contrast enhancement
- Large ratio of necrosis to tumor volume
- Marked peritumoral edema
- Poorer prognosis

IDH-mutant/ secondary GBM
- Mild contrast enhancement
- Lower ratio of necrosis to tumor volume
- Cortical nonenhancing component
- Relatively lower peritumoral edema
- Better prognosis

GBM tumor tissues with robust contrast enhancement demonstrate genomic changes that confer an aggressive phenotype, including mutations of cell-cycle regulatory proteins and upregulation of angiogenesis and hypoxia-survival genes.

Chord diagram demonstrating the interrelationship of genetic mutations among different pediatric diffuse gliomas

Tumors and peripheral blood were sequenced for 510 cancer-associated genes in a defined institutional panel. Arcs connect genes found among multiple tumor types. Unique genes have no arc. Highlighted in RED is p53, demonstrating that p53 mutations were detected among nearly all diffuse pediatric glioma types.

- Anaplastic astrocytoma
- Diffuse astrocytoma, IDH-mutant
- Diffuse astrocytoma, IDH-WT
- Diffuse mid glioma, H3K27M
- Glioblastoma, IDH-WT
- Glioblastoma, IDH-mutant
- Oligodendroglioma, IDH-mutant
- Oligodendroglioma, NOS

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Evaluation of Acute Ischemic Stroke Using CT perfusion: RAPID versus Syngo.via

T Ly¹, F Ghazi Sherbaf², N Sankaran¹, D Lin¹
¹Johns Hopkins University, Baltimore, MD. ²Johns Hopkins Medical Institutions, Baltimore, MD

Purpose
To compare CT perfusion parameters obtained by RAPID versus Siemens Syngo.via software in the clinical decision of endovascular treatment (EVT), and correlate with post EVT result and final infarct volume.

Materials and Methods
Thirty-six consecutive patients (18M/18F, mean age 65, range 30-85 years) presenting to our hospital with acute ischemic stroke between August and October 2019 underwent CT perfusion and CT angiography (37 exams). CT perfusion raw data were post-processed using both RAPID (iSchemaView) and Syngo.via (Siemens) to estimate infarct core and penumbra volumes. The parameters were compared, and the values were used to predict clinical decision according to the DEFUSE III trial. The cases following EVT were further reviewed for angiographic appearance and final infarct volume estimated by diffusion weighted MR images within 24 hours following EVT.

Results
The absolute infarct core volume estimated by Syngo.via and RAPID showed fair agreement (Bland-Altman plot, Figure 1) and good correlation, with $\rho_c=0.875$, SE 0.036 ($P<0.0001$, Lin's concordance correlation, Figure 2). On the other hand the penumbra volume showed more variable differences, although there is a generally good correlation, with $\rho_c=0.829$, SE 0.048 ($P<0.0001$). Among 36 patients, 9 underwent EVT; 5 fulfilled the selection criteria for EVT according to both analyses and 3 would have been recommended for intervention according to RAPID only. One case showing a large core volume did not fulfill the selection criteria for EVT, but intervention still proceeded. One case failed EVT, the remaining cases achieved reperfusion TICI 2A (1/9 cases), TICI 2B (2/9) and 3 (5/9). 4/5 cases with TICI 3 showed a stable final infarct volume. However, nearly 50% of the cases (4/9) demonstrated substantial subsequent enlargement of infarct.

Conclusions
The utilization of CT Perfusion and automated analysis software has facilitated clinical decision of endovascular treatment for acute ischemic stroke in an expanded therapeutic window. While the output perfusion metrics showed variable differences depending on the software used, there was generally good agreement and concordance correlation between the analyses based on RAPID and Syngo.via. Among the limited cases triaged to EVT intervention, arrest of infarct volume growth was best achieved following successful reperfusion. Further study is warranted to determine the predictors of infarct growth despite reperfusion.
Evaluation of post-contrast susceptibility-weighted imaging enhancement patterns in patients with multiple sclerosis in 3 tesla magnetic resonance imaging: initial study.

P Coimbra¹, L Sampaio², L Coimbra³

¹Clinica Trajano Almeida, Fortaleza, Brazil, ²Fortaleza General Hospital, Fortaleza, Ceara, ³Christus University Center, Fortaleza, Ceara

Purpose
The present study aims to evaluate the enhancement patterns of active lesions in multiple sclerosis patients in the post-contrast susceptibility-weighted imaging (SWI) sequence, comparing the accuracy of this sequence in identifying such lesions in relation to the sequences currently used in clinical practice.

Materials and Methods
This study is an observational retrospective analysis of brain MRI scans performed on 3 Tesla equipment of patients with a defined multiple sclerosis diagnosis. MR images were accessed through the digital archive of the institution and were acquired from June 2019 to October 2019.

Results
The study population included fourteen patients diagnosed with multiple sclerosis, twelve female and two male, whose ages ranged from 25 to 61 years. We found agreement in identifying active and non-active lesions between the post-contrast SWI and post-contrast T1 spin echo (SE) sequences in all patients included in the study. Two patients demonstrated enhancement lesions in both the T1 SE sequence and the post-contrast SWI sequence. The other twelve patients showed no enhancement lesions in either sequence.

Conclusions
In the present study, using 3T equipment, agreement was identified for T1 SE and post-contrast SWI sequences in the identification of active multiple sclerosis lesions, which were identified in two of the four patients with the diagnosis included in the study. In the other twelve patients, no active lesions with enhancement were identified in either sequence, confirming the agreement between them. Confirming the accuracy of the post-contrast SWI sequence in demonstrating active inflammatory lesions of MS can bring numerous benefits to the diagnosis and follow-up of affected patients, ensuring greater accuracy in detecting typical active lesions, increasing the sensitivity and specificity of imaging findings.
Evaluation of the Inner Ear Utilizing Delayed Contrast-Enhanced FLAIR MRI: Meniere’s Disease and Beyond

R. Beck1, S. Karnezis2, N. Salamon3, A. Sepahdari4, A. Vijayasarathi2
1UCLA, Pasadena, CA, 2University of California, Los Angeles, Los Angeles, CA, 3UCL, Los Angeles, CA, 4Scripps Health System, La Jolla, CA

Purpose
To review the key imaging findings observed during utilization of post-contrast fluid-attenuated inversion recovery imaging in evaluation of endolymphatic hydrops, a hallmark of Meniere’s disease. This includes both imaging features used to identify endolymphatic hydrops, findings seen on post-treatment follow-up imaging, and associated pathologies co-existent with or clinically mimicking Meniere’s disease.

Materials and Methods
Meniere's disease remains a challenging entity to diagnose both from a clinical and imaging standpoint. Clinically, Meniere's disease is characterized by vertigo, tinnitus, sensorineural hearing loss, and aural fullness. From a postmortem histopathologic standpoint, endolymphatic hydrops is a defining feature of Meniere's disease. A noninvasive specialized MRI protocol using a delayed contrast enhanced FLAIR sequence has demonstrated utility in diagnosing endolymphatic hydrops in vivo. This protocol has been in clinical use for over 6 years at our institution. Our PACS and departmental teaching files will be queried for clear examples of endolymphatic hydrops, normal controls, as well as examples of resolution of endolymphatic hydrops after treatment, perilymphatic fistulas, and appearance of associated pathologies encountered using this modality, such as co-existent vestibular schwannomas. This educational exhibit will detail the imaging protocol, demonstrate normal inner ear anatomy, normal appearance of endolymphatic structures, and provide instructive examples demonstrating endolymphatic hydrops, resolution, and associated pathologies that may be encountered in evaluation of Meniere's disease utilizing this protocol. Additionally, a systematic approach to the interpretation of these specialized studies will be described.

Results
N/A

Conclusions
Accurate diagnosis of endolymphatic hydrops by imaging allows for the possibility of assisting in the difficult diagnosis of an incompletely understood clinical pathology. Through innovative MRI protocols, neuroradiologists are able to aid in the diagnosis. By continuing to refine imaging technique and its evaluation of the pathophysiology of endolymphatic hydrops, we can continue play an important role in the diagnosis and post-treatment assessment of Meniere's disease, as well as co-existent or mimicking pathologies.

Fetal Brain Destructive Lesions – antenatal and perinatal imaging

S. Kanekar1
1Penn State MiltonHershey Medical Center, Hershey, PA

Purpose
1. To classify and discuss the pathology and pathogenesis of the fetal brain destructive lesions. 2. To highlight the imaging findings and diagnostic pearls for this specific diagnosis in the antenatal and perinatal period.

Materials and Methods
We retrospectively reviewed the imaging studies from our PACS system of 122 patients with the fetal brain destructive lesions, which forms the basis of this exhibit. All patients had an antenatal ultrasound. In addition, 36 patients also had a fetal MRI. All patients had CT and/or MRI scan of the brain in the perinatal period.

Results

Conclusions
Imaging plays an important role in diagnoses and genetic counselling of the various fetal brain destructive lesions.
Fetal MRI – Spectrum of Congenital CNS Anomalies: A Systematic Approach

G Singh1, C Lui1, A True1, S Ali1, T Phatak1, J Green1
1Newark Beth Israel Medical Center, Newark, NJ

Purpose
Ultrasonography (USG) is the primary method for antenatal fetal evaluation. However, fetal magnetic resonance imaging (MRI) has now become a valuable adjunct to USG in confirming/excluding suspected abnormalities and in the detection of additional abnormalities. Fetal MRI frequently provides information that helps with optimal prenatal counseling, facilitate management decisions, and guide therapy, thus changing the outcome of pregnancy. With the development of ultrafast sequences, fetal MRI has made remarkable progress in recent times. In this educational exhibit, we illustrate a spectrum of structural abnormalities affecting the central nervous system, as well as, normal anatomic variants.

Materials and Methods
Educational Goals/Teaching Points
1. Discuss the systematic approach to fetal MRI interpretation.
2. Understanding the different sequences of fetal MRI and their applications in evaluating central nervous system.
3. Recognize the MRI appearances of spectrum of congenital CNS anomalies.
4. Confirming/excluding suspected abnormalities seen on the prenatal USG and detection of additional findings.

Results
USG has been primarily used as a prenatal screening tool for decades. Due to circumstances, such as oligohydramnios and obese patients, and limitation of USG with operator dependency and small field of view, an alternate imaging modality was sought after to provide additional information regarding fetal anatomy or pathology. MRI with its large field of view and superior soft tissue contrast resolution emerged as a suitable adjunct to USG. MRI does not involve radiation and is safe for the fetus. MRI provides multiplanar imaging and allows evaluation of large and complex anomalies with context of the entire fetal body. Though the congenital fetal abnormalities have been well described on fetal MRI protocols, the familiarity of radiologists and clinicians with fetal MRI is still limited. This exhibit provides a practical approach to fetal MR imaging interpretation. Through a systematic approach, we will show a wide spectrum of congenital CNS disorders, ranging from common lesions to more complex rare cases.

Conclusions
As with all other imaging modalities, a systematic approach to interpretation can improve diagnostic accuracy and reduce error. Fetal MRI is no exception and has a crucial role in identifying pathologies, which can change patient counseling and, at times, patient management.
Form and Function in Intracranial Neurovascular Stents: A Historical Perspective and State-of-the-Art Pictorial Review for Diagnostic Neuroradiologists

M Caton1, A Copelan1, D Murph1, K Narsinh1, D Cooke1, S Hetts2, C Dowd3, V Halbach1, R Higashida1, M Amans1

1University of California, San Francisco, San Francisco, CA, 2University of California, San Francisco, Hillsborough, CA, 3University of California San Francisco, San Francisco, CA

Purpose
The use of stents in intracranial neuroendovascular surgery has been practiced for decades [1]. However, the spectrum of treatable pathology, available devices, and clinical adoption of intracranial stents (ICS) has exploded in recent years [2]. Diagnostic neuroradiologists play a critical role in evaluation of these devices following deployment yet may not be familiar with state-of-the-art ICS devices and indications. To this end, we present a pictorial exhibit of intracranial stents for arterial and venous cerebrovascular disease with 3 chief learning objectives: 1. To understand the basic principles of stent design, biomechanics, and deployment, and the resulting influence on cerebrovascular hemodynamics 2. To be familiar with the spectrum of intracranial pathology amenable to endovascular stenting 3. To recognize the radiographic appearance of successful intracranial stent deployment and ICS-related complications.

Materials and Methods
This educational exhibit provides an image-rich review of ICS with series of case vignettes in three parts. Key historical developments and innovations in ICS are interwoven to emphasize changes in practice over time.

Results
Part 1 will discuss the "Form" of ICS including the principles of stent design and its evolution, with brief discussion of intracranial rheology and stent biomechanics (radial strength, cell spacing, flexibility, porosity, etc.) (Fig 1A Open-cell/laser-cut design for stent-assisted coiling (SAC) vs. 1B braided/low porosity stent for flow diversion monotherapy). Commonly used devices and their relative strengths, weaknesses, and mechanical properties are discussed with depiction of various ICS on non-invasive imaging modalities.
(CTA, MRA). Part 2 will discuss "function" of ICS in specific disease states including the following topics: Stent-assisted coiling for intracranial aneurysms, the role of ICS in intracranial atherosclerosis in the post-SAMPPRIS era [3, 4], the principles and practice of flow diversion, and the use of stents in dural venous sinus disease. Part 3 will review complications of stent placement including acute thrombosis, in-stent restenosis, and stent migration. We will briefly review contemporary recommendations for follow-up imaging of IC stents including CTA, MRA, and the role of surveillance with catheter angiography.

Conclusions
ICS are essential tool for contemporary neuroendovascular surgery. This educational exhibit demystifies the form and function of ICS for diagnostic neuroradiologists.

(Gadolinium Deposition and Washout: Does It Matter?)

Z Farooq1, D Cohen-Addad1, A Grigorian1, V Velayudhan1
1SUNY Downstate Health Sciences University, Brooklyn, NY

Purpose
Since gadolinium deposition was first described in 2014, a multitude of studies have been published describing the phenomenon, raising concerns regarding the safety of gadolinium based contrast agents (GBCA). Since over 30 million doses of GBCA are administered worldwide each year, understanding the concerns surrounding gadolinium deposition and safety is imperative for radiologists. In this exhibit, we will review different classes of gadolinium based contrast agents used for MR imaging and their salient biochemical characteristics, literature discussing gadolinium deposition in brain, differential deposition of various GBCA based on biochemical characteristics, histological, clinical and commercial impact of gadolinium deposition, and literature suggesting the phenomenon of partial gadolinium washout from the brain on follow up.

Materials and Methods
Pubmed and Google Scholar were searched using the terms 'gadolinium', 'deposition', and 'washout'. Original articles, review articles and case reports discussing gadolinium deposition and washout were reviewed. References of the studies were also searched for additional papers. Results and hypotheses from these articles were summarized for the purpose of this exhibit.

Results
Multiple studies have demonstrated deposition of linear GBCA within the deep nuclei of the brain, particularly the globus pallidus and dentate nucleus. The imaging based studies have mostly used middle cerebellar peduncles or pons as an internal reference to measure the increase in T1 weighted signal intensity of the deep nuclei over follow up scans after serial administration of GBCA. Multiple autopsy studies have also demonstrated deposition of linear GBCA within brain and extracranial tissues of both human and animal subjects. However, there has not been any convincing evidence of histologic tissue damage. Both imaging and autopsy have been equivocal regarding the deposition of macrocyclic GBCA with most of imaging based studies suggesting no deposition with macrocyclic GBCA. In addition, a few recent studies have shown histologic and imaging evidence of gadolinium washout on follow up.

Conclusions
Multiple imaging and histologic studies have demonstrated gadolinium deposition in brain and other tissues with serial administration of linear GBCA, however there is little to no evidence of associated histologic damage. In addition, some recent studies have suggested partial washout of gadolinium on follow up.
Gadolinium Washout: Literature Review

<table>
<thead>
<tr>
<th>Study</th>
<th>Contrast Agent</th>
<th>Subjects</th>
<th>Follow up Period After Last GBCA</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adin et al 2015</td>
<td>Gadopentetate (primarily)</td>
<td>Retrospective review of 184 patients</td>
<td>No post-contrast follow up</td>
<td>2 patients showed return of DN SI to normal</td>
</tr>
<tr>
<td>Smith et al 2015</td>
<td>Gadodiamide</td>
<td>6 rats, administered up to 20 doses</td>
<td>20 weeks</td>
<td>Amount of gadolinium in the brain tissue determined at one week after injection decreased by 50% by 20 weeks</td>
</tr>
<tr>
<td>Behzadi et al 2018</td>
<td>Gadopentetate Gadobutrol</td>
<td>13 patients initially imaged with gadopentetate, later switched to gadobutrol</td>
<td>28 months (mean)</td>
<td>Significant reduction in DN SI after switching to gadobutrol</td>
</tr>
<tr>
<td>Robert et al 2018</td>
<td>Gadodiamide and gadoterate</td>
<td>139 rats injected with five doses of each GBCA, followed for 12 months</td>
<td>12 months</td>
<td>No significant gadoterate deposition. 75% of gadolinium detected after last injection of gadodiamide detected at one year follow up</td>
</tr>
<tr>
<td>Jost et al 2018</td>
<td>3 linear and 3 macrocyclic agents</td>
<td>126 rats injected 8 doses of one of the six GBCA agents or saline</td>
<td>52 weeks</td>
<td>No imaging evidence of linear agent washout. No imaging evidence of macrocyclic deposition. No autopsy evidence of linear GBCA washout. At least 80% macrocyclic GBCA washout</td>
</tr>
</tbody>
</table>

Gadolinium Washout After 6 Year Follow-up

Axial T1 weighted non-contrast image A) after first dose of gadodiamide. Images B) and C) after 4 and 6 doses of gadodiamide show progressive increase in dentate nucleus signal intensity. Follow-up after 6 years without any interval administration of gadodiamide shows decrease in dentate nucleus signal intensity D).
Genetics and imaging features of pediatric pilocytic astrocytomas: A case based review

S Abi Fadel¹, N Bhatt¹, M Aboian²
¹Yale New Haven Hospital, New Haven, CT, ²Yale University - MEDDRA Radiology, New Haven, CT

Purpose
Pilocytic astrocytomas are WHO Grade I tumors that are located within the posterior fossa, hypothalamus/suprasellar region, optic chiasm, and thalamus. These tumors have heterogeneous genetic signature including mutations in NF1, KIAA1549-BRAF fusion, BRAFV600E, less common fusions of BRAF, and mutations in KRAS and PTEN. Some of these mutations have specific imaging features, such as KIAA1549-BRAF fusion is common in the posterior fossa pilocytic astrocytomas. We plan to review the imaging features of pediatric pilocytic astrocytomas with respect to their molecular signature using case based approach.

Materials and Methods
Imaging characteristics of pediatric pilocytic astrocytomas with respect to their genetic signature will be reviewed with respect to their main sites of origin – optic chiasm, hypothalamus/suprasellar region, thalamus, and posterior fossa.

Results
Location of pilocytic astrocytomas in the brain has a strong association with the type of mutation that is found within the tumor. In optic pathway gliomas, majority of the tumors have mutation in NF1 gene. On the other hand, majority of pilocytic astrocytomas that are centered in the posterior fossa are associated with KIAA1549-BRAF fusion. BRAFV600E mutation is common in supratentorial pilocytic astrocytomas, while mutations in KRAS, FGFR1, FGFR1-ITD, and NTRK fusions have not been demonstrated to have a definitive location within the brain. We will present examples of pilocytic astrocytoma in hypothalamus/suprasellar region with BRAFV600E mutation with focus on management of cystic component of the tumor, in posterior fossa with KIAA1549-BRAF fusion, and optic pathway glioma with NF1 mutation. We will also include a case leptomeningeal spread of pilocytic astrocytoma to the spine.

Conclusions
Pediatric pilocytic astrocytomas are heterogeneous in their molecular signature which depends on the location of tumor within the brain. We will present a case based review of the imaging patterns of common genetic subtypes of pediatric pilocytic astrocytomas and their specific imaging features that affect patient management.
Figure 1: Case of juvenile pilocytic astrocytoma BRAF-V600E originating in hypothalamus with mass effect on the optic nerves. Patient developed MNDMna in the right eye and progressive left vision loss over a course of 3 years after initial debulking surgery. Coronal T2 weighted images of the orbits at the level of the optic nerves (A) demonstrate normal size of right and left optic nerves. Patient had normal vision during this exam. Over the course of 3 years, the right optic nerve became atrophic (B and C) as can be seen on coronal FLAIR images. The left optic nerve demonstrates fluid FLAIR hyperintensity.
Glioblastoma Treatment Response Versus Pseudoresponse: A Crash Course on the RANO, iRANO, and Modified RANO Assessment Criteria in Dealing with a Pseudo-friend

J Pao¹, S Girn¹, L Fanucci², N Miner³, D Chow⁴
¹UC Irvine Medical Center, Orange, CA, ²UCI Department of Radiological Sciences, Orange, CA, ³UC Irvine, Orange, CA, ⁴UNIVERSITY OF CALIFORNIA, IRVINE, IRVINE, CA

Purpose
Glioblastoma is the most common primary brain malignancy in the United States. The Stupp protocol has been established as standard of care for the initial treatment of glioblastoma, having been found to confer benefit in survival outcomes. Newer anti-angiogenic agents and immunotherapies have also since been tested and have shown promising results in recent and ongoing clinical trials. However, it is known that these agents can confound the imaging appearance of the tumor on follow-up studies, creating a diagnostic dilemma for radiologists and neurooncologists. Furthermore, available treatment algorithms are dependent on accurate assessment of tumor response to treatment. Current practice calls for a very specific set of imaging and clinical criteria to determine treatment outcomes, namely the Response Assessment in Neuro-Oncology (RANO) criteria developed in 2010. This forms the basis for an additional set of criteria for tumors treated with immunotherapy agents, the Immunotherapy Response Assessment in Neuro-Oncology (iRANO, 2015) criteria. This exhibit will serve as a guide on how to use the RANO criteria while also noting its shortcomings, which the original authors have attempted to address in the now modified RANO criteria (2017). As the arsenal of glioblastoma treatments evolves, applying these assessment criteria will be ever more important for both radiologists participating in clinical trials and for everyday clinical practice.

Materials and Methods
A review of literature on post-treatment glioblastoma imaging and the RANO assessment criteria will be performed. Case examples will be obtained from our institutional database to create the content of this educational exhibit.

Results
N/A

Conclusions
Gone in a Puff of Smoke: A Review of Moyamoya Angiopathy

E KuoY1, S Girn2, N Miner3, E Chu4, D Chow5, A Hasso6, J Soun7, D Florioli4
1UNIVERSITY OF CALIFORNIA, IRVINE, ANAHEIM, CA, 2University of California Irvine, Orange, CA, 3UC Irvine, Orange, CA, 4University of California, Irvine, Orange, CA, 5UNIVERSITY OF CALIFORNIA, IRVINE, IRVINE, CA, 6UNIV OF CALIFORNIA IRVINE MEDICAL CENTER, Orange, CA, 7University of California Irvine, Santa Ana, CA

Purpose
Moyamoya angiopathy is a progressive steno-occlusive process involving the terminal internal carotid arteries (ICA). It is important for radiologists to be able to recognize this process in practice and to be aware of the important post-treatment imaging findings.

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Response Assessment in Neuro-Oncology (RANO) Criteria

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Complete response</th>
<th>Partial response</th>
<th>Stable disease</th>
<th>Progressive disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>TI gadolinium enhancing disease</td>
<td>None</td>
<td>≥50% ↓</td>
<td>&lt;50% but &gt;25% ↑</td>
<td>&gt;25% ↑</td>
</tr>
<tr>
<td>T2/FLAIR</td>
<td>Stable or ↓</td>
<td>Stable or ↓</td>
<td>Stable or ↓</td>
<td>↑</td>
</tr>
<tr>
<td>New lesion</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Present</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>None</td>
<td>Stable or ↓</td>
<td>Stable or ↓</td>
<td>N/A</td>
</tr>
<tr>
<td>Clinical status</td>
<td>Stable or ↑</td>
<td>Stable or ↑</td>
<td>Stable or ↑</td>
<td>↓</td>
</tr>
<tr>
<td>Requirement for response</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Any</td>
</tr>
</tbody>
</table>

*Per RANO criteria, progressive disease should be diagnosed radiographically no sooner than 3 months following completion of concomitant TMZ + RT, unless there is:
1) New enhancement outside the main radiation field
2) Pathologic confirmation of unequivocal tumor progression
Materials and Methods
1. Brief introduction of Moyamoya angiopathy. 2. Overview of the various different imaging techniques with advantages and disadvantages. 3. Review the Suzuki staging system. 4. Review important post-treatment imaging findings.

Results
1. Moyamoya angiopathy can be idiopathic or familial in Moyamoya disease, or due to a variety of underlying conditions in Moyamoya syndrome. A review of the demographics in Moyamoya disease and some sample associated conditions in Moyamoya syndrome will be examined. 2. Case examples of Moyamoya angiopathy with different imaging techniques will be presented, as well as a discussion on the advantages and disadvantages of those. 3. The Suzuki staging system will be reviewed as well as a discussion on the efforts to adapt this system for MR angiography. 4. Review post-treatment imaging for Moyamoya angiopathy, which include direct revascularization (e.g. superficial temporal artery to middle cerebral artery bypass) and indirect revascularization (e.g. encephaloduroarteriosynangiosis or encephalomyosynangiosis).

Conclusions
It is important to be able to recognize signs of Moyamoya angiopathy on various different imaging techniques, as well as what surgeons need to know for pre-operative evaluation and potential post-treatment complications.
Results
As the treatment of various malignancy have evolved, so have the unintended consequences of these therapies. To simply the familiarization of these side effects, one can place them into the four main categories referenced above. One of the most common chemotherapeutic agents is methotrexate. This medication can cause acute neurotoxicity and focal cerebral necrosis. Various chemotherapeutic agents have been shown to cause posterior reversible encephalopathy syndrome. These same agents may affect the spine as well leading to a chemotherapy-induced myelopathy. Bevacizumab in addition to causing neurotoxicity within the cerebrum may affect the head and neck leading to nasal septal perforation. Similar to chemotherapeutic agents, immunotherapies may have various side effects. Specifically, ipilimumab can cause hypophysitis and ocular myositis. Both rituximab and natalizumab may induce progressive multifocal leukoencephalopathy. Radiotherapy may cause leukoencephalopathy and atrophy. At the same time, radiation may stimulate vasculopathies leading to micro-hemorrhages, cavernous malformations, or even moyamoya syndrome. An uncommon delayed complication of radiotherapy is stroke-like migraine attacks after radiation therapy (SMART syndrome). Not unique to the brain, myelopathy may develop within the spine and cataracts may develop within the orbit. Lastly, some commonly used agents such as normal saline, metronidazole, phenytoin, and carbamazepine may present with toxicities within the central nervous system.

Conclusions
Using a systematic approach, these side effects and toxicities on the CNS can become easier for the Neuroradiologist to recall given their specific imaging features.

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Head and Neck Infections of Dental Origin, What the Surgeon Needs to Know?

J López-Arcas¹, J Blanco²
¹Hospital Universitario Infanta Leonor, Madrid, Madrid, ²Hospital de Parla, Parla, Madrid

Purpose
-To review the normal anatomy of the head and neck spaces and its key anatomical landmarks in the diagnosis of odontogenic-related neck infections . -To describe radiological findings of odontogenic infections in, plain simple radiographs, Panoramic Radiographs and in Cone-Beam CT Scan. -To review CT study protocols, findings, patterns of spread and associated complications of head and neck infections of dental origin.

Materials and Methods
Head and neck infections of dental origin, frequently seen at the emergency room can be life threatening mainly due to airway complications. The main diagnostic tool used to diagnose head and neck infections is the CT scan. It can provide useful information about the source of the infection, spreading pathways and associated complications. An accurate radiological report is essential for the ENT/Maxillofacial Surgeon to decide whether to administer medical treatment or to perform a surgical drainage. Panoramic Radiographs, when available, may also provide the clinician/radiologist with complementary information regarding the possible dental origin of the infection.

Results
We present - Normal anatomy of the teeth , deep neck spaces and possible pathways of infection progression from dental foci. - Study protocols. - Imaging findings in Head and neck Infections of Dental Origin 1. Panoramic Radiograph 2. Cone-Beam CT 3. Head and neck CT : sof tissue swelling/abscess, airway deviation, local adenopathy, maxillary or mandible fistulae, cervical fat stranding..

Conclusions
The radiologist plays an essential role in the diagnose of head and neck infections of dental origin . A rapid and accurate diagnosis, mainly based on CT scan findings , is essential for an early treatment onset. A thorough knowledge of the deep head and neck spaces and its relationships with possible odontogenic infection sites is mandatory.
High-resolution Contrast-enhanced CISS for Detailed Anatomical Imaging of the Skull Base

C Zamora¹, E Zamora²
¹University of North Carolina at Chapel Hill, Chapel Hill, NC, ²Montefiore Medical Center, The Bronx, NY

Purpose
The purpose of this exhibit is to familiarize the reader with the technical aspects of contrast-enhanced CISS imaging and to provide an illustrative review of normal anatomy and selected pathologic conditions.

Materials and Methods
This will be an image-rich exhibit based on our institutional experience with contrast-enhanced high-resolution CISS imaging of the skull base.

Results
The central skull base is a relatively small and complex anatomical region that houses several critical neurovascular structures and is also a site for a wide range of pathologies. CISS and its analogue FIESTA are balanced steady state GRE sequences that provide high spatial resolution and contrast between CSF and neurovascular structures. As such, they are the sequences of choice for MR cisternography, particularly for the visualization of the cisternal segments of cranial nerves. Notably, even though visually CISS appears to be heavily T2-weighted, in reality it features mixed weighting and can therefore demonstrate enhancement. Adding intravenous contrast provides several layers of information due to enhancement of vascular structures, soft tissue, and neoplasms. Enhancement of the cavernous sinuses and venous plexuses allows demonstration of cranial nerves beyond their cisternal segments and their relationship to the dura and different lesions.

Conclusions
Imaging of the central skull base is challenging. Balanced steady state high-resolution GRE sequences such as CISS or FIESTA following contrast administration can provide additional levels of information that will help determine optimal treatment and surgical approach.
Contrast-enhanced CISS. A, Normal anatomy showing the diaphragma sellae (black arrows), enhancing cavernous sinus (asterisk), inferior intercavernous sinus (white arrowhead), and cranial nerves. B, Different patient with meningioma invading the right cavernous sinus (black arrowheads) resulting in cranial nerve encasement. C, Sagittal oblique view of normal trigeminal nerve anatomy demonstrating the trifurcation as well as Meckel’s cave containing Gasserian ganglion and proximal rootlets (white arrow). D, Different patient with chondrosarcoma (white arrowheads). Note dural rupture (thin white arrow) with extrusion of tumor and elevation of cranial nerve VI.
Hit Me With Your Best Shot: Primer on Neurological Ballistic Injuries and Complications

N Miner¹, J Pao², E KUOY³, E Chu², J Soun⁴, S Girn⁵
¹UC Irvine, Orange, CA, ²University of California, Irvine, Orange, CA, ³UNIVERSITY OF CALIFORNIA, IRVINE, ANAHEIM, CA, ⁴University of California Irvine, Santa Ana, CA, ⁵University of California Irvine, Costa Mesa, CA

Purpose
Penetrating brain injuries are the most life threatening form of traumatic brain injury and gunshot injuries are the most common type, accounting for the majority of mortality. Only 10% of these patient survive to reach the hospital, half of which die in the emergency room. This exhibit will discuss the types of penetrating wounds, which have implications on the severity of injury, surgical management, complications, and prognosis. We will review the importance, utility, and appropriateness of initial imaging, as well as the important descriptors needed to aid surgeons in treatment planning. Finally, we will discuss common complications surrounding penetrating traumatic brain injury and the important imaging findings.

Materials and Methods
A literature review of penetrating traumatic brain injuries will be performed and cases from our institutional database will be used to create this educational exhibit.

Results
N/A

Conclusions
Outline: Background - Discuss epidemiology, pathophysiology, and prognostic indicators of penetrating traumatic brain injury. Mechanism of injury - Describe the 5 major types of penetrating wounds (penetrating, perforation, tangential, ricochet, and careening) Initial evaluation - Discuss the initial imaging and the use of angiography. - Defining high risk patients - Imaging 'signs' Management - Discuss current medical and surgical therapies - Imaging appearance of post-traumatic complications.
How to Explore the Insula on MRI: Anatomy, Normal Variants and Pathology

j blustain¹, S KRYSTAL²
¹Fondation ophtalmologique A de Rothschild, PARIS, France, ²Fondation ophtalmologique A de Rothschild, PARIS, france

Purpose
The insula has long been one of the most poorly understood structures of the brain, due in part to its location, deep beneath the Sylvian fissure. With the development of functional neuroimaging techniques, great progress has been made in understanding the function of the insular cortex. This tutorial reviews the normal structure and functions of the insula, describes the optimal MRI protocol and the MPR post-processing technique for exploring this complex structure and illustrates the ability to detect subtle insular lesions through examples of cases with various pathologies and clinical-imaging correlation.
Materials and Methods
A brief overview of normal insular anatomy and function will be presented. Examples of the normal anatomic pattern as well as normal variants of that pattern will be illustrated. We then detail an optimal MRI protocol with 3D sequences and MPR post-processing allowing the analysis of the insular cortex in oblique planes. Finally, we provide a practical illustration of these concepts through several neuroimaging cases of subtle insular lesions, with clinical-imaging correlations. Among the cases covered we include examples of cortical malformations, tumor, multiple sclerosis, vascular lesions and encephalitis.

Results
Anatomical studies of the insula in the general population have shown there to be an average gyral and sulcal structure with few normal variants. Because the insula covers a small surface area of the brain, and its cortex forms discrete gyri, oriented in an oblique sagittal plane, it is difficult to identify its architecture and its limits on MRI viewed in standard orthogonal planes. The use of MPR of 3D images to view the insular cortex in oblique planes, parallel to the base of the insula and perpendicular to the segments of the peri-insular sulcus, can improve the analysis of its structure. Through the use of several case studies with clinical-imaging correlation, we illustrate how the use of a proper imaging protocol and MPR reconstruction technique can help to detect and precisely locate subtle lesions of the insula.

Conclusions
After viewing this interactive tutorial, radiologists should have a better understanding of the structure and function of the insula and be more aware of the clinical symptoms that should prompt them to explore the insular region with particular attention. They should be able to define an MRI protocol suitable for exploring the insula and to use MPR post-processing to identify and precisely locate subtle insular lesions.

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Imaging Characteristics and Complications of Intracranial Dural Arteriovenous Fistulas.

H Elbelasi1, D Lukins1
1University of Kentucky, Lexington, KY

Purpose
To review findings and complications of intracranial dural arteriovenous fistula (DAVF) on conventional imaging, with the goal of increasing awareness of imaging signs and thereby improving rates of detection of this diagnostically challenging entity.

Materials and Methods
Findings that should raise suspicion for DAVF on conventional CT and MRI with and without contrast will be reviewed in an image-rich powerpoint format. Examples of complications of DAVF on conventional imaging will also be included.

Results
DAVF are abnormal connections between dural arteries and dural venous sinuses, meningeal veins or cortical veins(1). They are often idiopathic but can form as result of trauma or dural sinus thrombosis(1). Clinical presentation is variable as it depends on the location of the fistula, but can include pulsatile tinnitus, intracranial hemorrhage, and seizures, or proptosis, chemosis, retro-orbital pain, and ophthalmoplegia in the case of cavernous sinus DAVF(1). Digital subtraction angiography remains the gold standard for diagnosis. Although diagnostic accuracy has improved significantly with advanced imaging techniques(2,5), these are only typically employed when there is clinical suspicion for DAVF. In cases where DAVF is not suspected clinically, diagnosis relies on detection of sometimes subtle findings on conventional imaging. Identification of these findings is crucial in order to avoid hemorrhage of the DAVF, which is the most feared complication, as it can lead to grave outcome. We will discuss clues to the diagnosis of DAVF on conventional CT and MRI that can aid the radiologist in suggesting the diagnosis. These findings have been previously described in the literature, and include prominent transcalvarial channels that increase over time(3), prominent vessels in the vicinity of the fistula(1), venous pouches(1), asymmetric venous sinus enhancement(2), dural venous sinus occlusion(2), as well as venous infarction, intracranial hemorrhage and edema (including a specific pattern of medullary edema) due to venous hypertension(1,4).

Conclusions
Dural arteriovenous fistulas are difficult to detect on conventional imaging, particularly when the diagnosis is not suspected clinically. We will review the findings on conventional imaging that can lead to the diagnosis, and hopefully avoid the complications of this challenging disorder.
Imaging CSF Shunts and their Complications

J Pao¹, L Fanucci¹, J Xu¹, N Miner¹, S Girn¹, D Chow²
¹UC Irvine Medical Center, Orange, CA, ²UNIVERSITY OF CALIFORNIA, IRVINE, IRVINE, CA

Purpose
Ventricular shunt placement is widely employed in the management of patients with hydrocephalus. However, complications related to shunt malfunction remain relatively common. An understanding of ventricular system physiology and the imaging features of commonly used shunts is essential to accurately diagnose adverse outcomes. This exhibit will serve as an overview of CSF shunt imaging in the evaluation of shunt failure.

Materials and Methods
A review of past literature and more recent publications on CSF shunts will be performed. Case examples will be obtained from our institutional database to create this educational exhibit.

Results
N/A

Conclusions
Table of Contents I. The brain ventricular system (CSF physiology and function, Monro-Kellie doctrine) II. Hydrocephalus a. Communicating vs non-communicating b. Obstructive vs non-obstructive III. Overview of shunt types (typical components, programmable vs non-programmable shunts) IV. Shunt courses (ie. ventriculoperitoneal, ventriculoatrial, ventriculopleural) V. Imaging evaluation of shunts a. Shunt series radiographs b. Radiographic shuntogram c. NM scintigraphy d. CT e. MRI (and its effects on programmable shunts) VI. CSF shunt complications a. Periprocedural b. Malposition c. Mechanical obstruction d. Shunt fracture e. Overdrainage (slit ventricle syndrome) f. Infection g. Loculation/pseudocyst formation h. Ascites (ventriculoperitoneal) i. Pleural effusion (ventriculopleural) j. Pulmonary arterial hypertension (ventriculoatrial) VII. Review quiz
Purpose
Early and correct recognition of dural venous sinus thrombosis is crucial, as delayed or false positive diagnosis can lead to complications or inappropriate and dangerous therapy. We discuss the key imaging features, their mimics, and the pitfalls inherent in the most common techniques used for venous sinus imaging.
Materials and Methods
The most commonly used techniques for visualization of suspected venous thrombi are unenhanced time-of-flight MR venography, phase contrast, contrast enhanced MR venography, and CT venography (1). Advantages and disadvantages can be seen with each technique, which we review here. Understanding limitations inherent in the techniques themselves, will help the radiologist contextualize findings and avoid pitfalls.

Results
Here we review imaging techniques and features with illustrative cases of pitfalls and mimics that may be encountered. For time-of-flight technique, this includes in-plane saturation and inappropriate planes of acquisition as well as T1-shine through of intrinsically T1-shortened thrombus. For phase-contrast technique, this may include velocity encode settings that are too high or low for venous imaging. With contrast enhanced techniques, acquisition timing as well as occasionally intense enhancement of chronic thrombus mimicking a patent vein (figure: time of flight imaging is shown in A, with post contrast images mimicking a patent vein in B).

Conclusions
The goal of this exhibit is to help clinicians recognize key features of dural venous sinus thrombosis and their mimics, and to review the techniques and limitations inherent in the most common venous imaging techniques.

(Filename: TCT_2198_VenousFigure.jpg)
Imaging Features of Laser Interstitial Thermal Therapy (LITT) in the Brain

K Bieri¹, J Nickerson², J Pollock³, A Raslan¹
¹OHSU, Portland, OR, ²Oregon Health Sciences University, Portland, OR, ³Oregon Health and Science University, Portland, OR

Purpose
Laser interstitial thermal therapy (LITT) is a minimally invasive surgical method that has been shown to be effective in the treatment of focal brain lesions such as tumors and epileptic foci (1,2). LITT is performed using surgically implanted optic fibers to deliver light induced thermal energy to a precise location, enabling selective ablation of targeted tissue. Originally developed in the 1960s, recent advances in technology have led to an increase in the use of LITT (3). Despite this, there is a lack of literature on the imaging appearance of such thermally induced lesions, making routine surveillance and the differentiation between expected post-surgical changes and complications difficult. The purpose of this exhibit is to describe and demonstrate the evolution of the imaging of thermally induced lesions using MRI from a series of uncomplicated epilepsy and brain tumor cases, as well as multiple cases of tumor recurrence.

Materials and Methods
Intraoperative and follow up MRI of sixteen patients who underwent LITT for epilepsy or tumor ablation were retrospectively reviewed for this exhibit. Imaging features of uncomplicated cases were used to establish the expected post-surgical evolution of thermally ablated lesions. This was contrasted with imaging features of thermally ablated lesions that exhibited post-operative tumor recurrence.

Results
Thermally ablated lesions demonstrate a consistent temporal evolution on MRI, defined by progressive changes in imaging features such as lesion size and enhancement pattern. In contrast to this, tumor recurrence is marked by variable, but distinct deviations from this expected progression.

Conclusions
This exhibit demonstrates the expected post-surgical imaging features of thermally induced lesions and differentiates them post-treatment tumor recurrence. This may help routine post-surgical surveillance as well as earlier detection of post-surgical complications.
Imaging Findings in 4H Syndrome

M Dhillon¹, K Memon¹
¹University of Oklahoma Health Sciences Center, Oklahoma City, OK

Purpose
Educational Objective To present a rare case of 4H syndrome, highlighting the typical clinical presentation as well as the key imaging findings.

Materials and Methods
Case Report The patient is a 7 year old female seen in endocrinology clinic for evaluation of short stature. No known past medical history according to her foster mother. She was at the 1st percentile for height and 36th percentile for weight, with a bone age of 4 years 2 months despite chronologic age of 7 years 2 months. She was noted to have dental anomalies as well as some speech and developmental delay. The patient failed a GH stimulation test and subsequently an MRI brain was ordered. This showed no
sellar/suprasellar lesion, however findings were concerning for a possible hypomyelinating leukodystrophy, in particular the hypomyelinating leukodystrophy with hypogonadotropic hypogonadism and oligodontia (4H syndrome) given her short stature and dental anomalies. This was confirmed with genetic testing, which showed the patient to be heterozygous for 2 pathogenic variants in the POLR3B gene, consistent with a diagnosis of autosomal recessive POL3R-related leukodystrophy (also known as 4H leukodystrophy/syndrome).

Results

Imaging Findings There is diffuse T1 hypointensity and T2 hyperintensity of the white matter in the subcortical and periventricular cerebral hemispheres, and to some extent in the middle cerebellar peduncles and medial aspect of the cerebellar hemispheres. White matter has a relatively normal appearance in the periorbital regions, the corticospinal tracts, internal capsules and in the optic radiations, as well as the splenium of the corpus callosum. The more anterior aspect of the corpus callosum does not demonstrate normal white matter signal intensity for this age. The brain volume is within normal limits with a normal sulcation pattern. Discussion Classic imaging findings in 4H syndrome should be recognized. Although this case did not have cerebellar atrophy, this has been seen to be progressive in other cases, and follow-up imaging may be of benefit. Other differentials to consider in cases of hypomyelinating leukodystrophy include Pelizaeus-Merzbacher disease, trichothiodystrophy, 18q syndrome, Salla disease, and hypomyelination with congenital cataracts, although these disorders each have specific unique findings.

Conclusions

4H syndrome is a rare condition with few cases in the literature. It is important to consider this syndrome amongst other differentials in cases of hypomyelinating leukodystrophy.

(Filename: TCT_1377_4Hsyndrome.jpg)

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Imaging Findings in Laser Induced Thermotherapy (LITT) for Brain Tumors

J Starkey

N/A, N/A

Imaging findings in 4H syndrome

A. Axial T2 and B. axial T1 images demonstrate diffuse T2 hyperintensity and T1 hypointensity of the subcortical white matter, with sparing of the optic radiations.

C. Post-contrast axial T1 image shows no abnormal enhancement.

D. T1 sagittal image shows no sellar or suprasellar mass. Normal brain volume with no cerebellar atrophy.

(Filename: TCT_1377_4Hsyndrome.jpg)
Purpose
TEACHING POINTS - LITT is a relatively new technique for treatment of brain tumors. - LITT has typical intra- and post-operative appearances that one should be familiar with.

Materials and Methods
• History of LITT • Technical details of the LITT procedure • Review of typical imaging in: - Preoperative assessment - Intra-operative imaging - Immediate post-operative imaging - Delayed post-operative imaging • Atypical findings and complications

Results
NA

Conclusions
Familiarity with the preoperative and postoperative appearance of LITT will be helpful for neuroradiologists who must interpret such cases.

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Imaging Findings of Central Nervous System Manifestations of Rheumatic Diseases

L Nunez1, S Aristizábal2, O Arevalo3, J Romero4, R Riascos5
1Universidad Industrial de Santander, Bucaramanga, Santander, 2Universidad el Bosque, Bogota, CO, 3The University of Texas Health Science Center at Houston, Houston, TX, 4MASS GENERAL HOSPITAL/HARVARD MEDICAL SCHOOL, BOSTON, MA, 5Univ. Of Texas - Houston, Houston, TX

Purpose
EDUCATIONAL OBJECTIVES 1. Review the imaging findings of the central nervous system manifestations of the principal rheumatic diseases. 2. Show illustrative cases of the central nervous system manifestations of rheumatic diseases that suggest a specific etiology or narrow differential diagnoses. 3. Present a synopsis in a form of a table.

Materials and Methods
TABLE OF CONTENTS/OUTLINE 1. Introduction 2. Rheumatic Diseases 2.1 Rheumatoid arthritis 2.2 Systemic Lupus Erythematosus 2.3 Sjogren syndrome 2.4 Vasculitis 2.4.1 Small vessel vasculitis 2.4.1.1 IgA Vasculitis 2.4.1.2 Microscopic Polyangiitis 2.4.1.3 Granulomatosis with Polyangiitis (Wegener's Granulomatosis) 2.4.1.4 Eosinophilic Granulomatosis with Polyangiitis (Churg-Strauss Syndrome) 2.4.2 Small/medium vessel vasculitis 2.4.2.1 Polyarteritis Nodosa 2.4.2.2 Kawasaki Disease 2.4.3 Large vessel vasculitis 2.4.3.1 Takayasu's vasculitis 2.4.3.2 Giant cell arteritis 2.5 Behcet's syndrome 2.6 Sarcoidosis 2.7 Scleroderma 3. Conclusion

Results
N/A

Conclusions
Rheumatic diseases are a heterogeneous group of chronic inflammatory entities with systemic manifestations that often affect the central nervous system (CNS). Diagnosis of CNS involvement is sometimes challenging and it is important for the radiologist to be cognizant of the main neuroimaging findings of the various entities. In current literature, although there are several case reports and papers that cover neuroimaging findings of each disease separately, there is a gap of synthesis that provides a state of the art understanding of the topic. We present an educational exhibit that reviews the key findings of the central nervous system manifestations of the principal rheumatic diseases.
Imaging Findings of Distinct Molecular Subgroups of Medulloblastoma: All Fingers of the Palm are not the Same

D Kaya1, M Gule-Monroe2
1UT Texas MD Anderson Cancer Center, Houston, TX, 2MD Anderson Cancer Center, Houston, TX

Purpose
WHO 2016 classification of brain tumors integrates 4 molecular defined subgroups of medulloblastoma: Wingless (WNT-activated), Sonic Hedgehog (SHH-activated) and TP53-mutant; Group 3 and Group 4. Each subgroup is characterized by specific molecular features, age of onset, prognosis and imaging findings. The purpose of this educational exhibit is to discuss differences in frequency of molecular subgroups in adults versus children, clinical and imaging features of each molecular subtype of medulloblastoma both at the initial presentation and recurrent disease. We will review current literature and present brief radiological-pathological correlation.

Materials and Methods
MR imaging studies of pathologically confirmed cases with molecular subtyping were reviewed. Reference articles related to pathology and imaging findings of different medulloblastoma subgroups will be provided.

Results
We present the radiological features of various medulloblastoma molecular subgroups. Key features include: a. Location: WNT activated medulloblastoma is found along CPA/ cerebellar peduncle in 75% cases. SHH activated medulloblastoma is associated with cerebellar hemisphere in 54% of cases. Group 3 and groups 4 is usually found at the midline of cerebellum. b. Margin: Ill-defined margin is exclusively seen in groups 3 and SHH activated. c. Enhancement: Group 4 medulloblastoma is characterized by lack of enhancement on CT or MRI.

Conclusions
Understanding of the imaging features of the different medulloblastoma subgroups is important for diagnosis.

J Cameron-Morrison¹, J Sachs², S Tatter²
¹Wake Forest Baptist Health, Winston Salem, NC, ²Wake Forest Baptist Health, Winston-Salem, NC

Purpose
Indications for deep brain stimulator (DBS) placement have expanded significantly over the last decade since the FDA first approved its use for Parkinson's disease in 1997. Currently the most common indications include Parkinson's disease and essential tremor with the subthalamic nucleus (STN), ventro-intermediate nucleus of the thalamus (VIM) and globus pallidus internus (GPI) most commonly targeted. Multiple additional indications are approved or currently under investigation. Due to the frequency at which DBS placement is being performed, both general diagnostic and neuroradiologists need to be familiar with imaging related to DBS. This includes preoperative imaging for anatomic localization and presurgical identification of contraindications, as well as postoperative imaging for lead placement and related complications.

Materials and Methods
This educational exhibit provides an image-rich and case based discussion of imaging related to deep brain stimulators and associated complications. After reviewing the exhibit the reader will be able to identify pertinent anatomy relating to commonly targeted structures on preoperative magnetic resonance imaging (MRI), as well as have a basic understanding of current indications for placement. A brief introduction to currently employed placement techniques will be discussed in the context of intraoperative imaging. A case-based discussion of complications related to deep brain stimulator placement will educate readers on the frequency and imaging findings seen in known complications.

Results
The most commonly targeted locations for deep brain stimulators currently include STN, VIM and GPI. The STN is usually visualized on 3T gradient echo sequences, while the GPI is seen on T1 weighted post contrast images. The VIM is not readily identified on computed tomography (CT) or MR imaging. Knowledge of devices allow for safe postoperative imaging by both CT and MRI in the correct clinical circumstance. While rare, the most common complications in the immediate postoperative period include hemorrhage and ischemia, while later sequelae include infection and device related complications.

Conclusions
Accurate presurgical localization of target structures and knowledge of common complications related to DBS placement are becoming increasingly important with the procedure being utilized more frequently for the treatment of a variety of disorders, including Parkinson's disease, essential tremor, dystonia and various psychiatric disorders.
Imaging of immune-mediated and inflammatory induced myelopathies

S Kanekar

1Penn State MiltonHershey Medical Center, Hershey, PA

Purpose
1. To review the anatomy of the spinal cord and discusses the clinical findings and pathology/pathogenesis of the immune-mediated and inflammatory induced myelopathies. 2. To highlight the imaging findings and diagnostic pearls for the specific diagnosis of the immune-mediated and inflammatory induced myelopathies.

Materials and Methods
Myelopathy is a spinal cord dysfunction and still remains a clinical diagnosis. Though the diagnosis is easy but to pinpoint the cause still remains challenging. Despite the small size of the spinal cord, its presentation largely depends on the tracts affected and the disease process. Neuroimaging and laboratory studies provide supportive evidence or can identify a cause of myelopathy or helps to limit the differential diagnosis in this nonspecific clinical presentation. We retrospectively reviewed the imaging studies of 241 patients with head and neck cancers. All patients had contrast enhanced MRI of the spine and CSF examinations at the time of the presentation. 112 patients had a follow up MR of the spine.

Results
We classified these cases into: Myelitis with autoimmune-/immune-mediated CNS disorders; Multiple sclerosis (MS) Neuromyelitis optica spectrum disorder (NMOSD), [AQP4-positive NMOSD, AQP4-negative NMOSD], Novel autoantibody-positive disorders with myelitis [Anti-MOG myelin oligodendrocyte glycoprotein (MOG) IgG associated disease, Anti-GFAP], Acute disseminated encephalomyelitis (ADEM), Idiopathic transverse, Myelitis, Paraneoplastic, Para-/postinfectious, Anti-TNFα agents. Myelitis as complication of inflammatory multisystem disorders: Sarcoidosis, Systemic lupus erythematosus (SLE), Behçet's disease, Mixed connective tissue disease (MCTD), Myelitis associated with antiphospholipid syndrome, Sjogren-associated myelitis.

Conclusions
Exhibit discuss the imaging findings and diagnostic pearls for the specific diagnosis of the immune-mediated and inflammatory induced myelopathies.

Imaging of Odontogenic Infections: A Pictorial Review of What Can Happen When You Don't Floss!

J Patel, R Le, M Hernandez, T Huynh, D Rao, J Kim

1University of Florida College of Medicine - Jacksonville, Jacksonville, FL, 2University of Michigan, Ann Arbor, MI

Purpose
Dental infections are a common cause of emergency department visits in the United States. The degree of severity can range from localized periapical infections that can be treated with oral antibiotics to complicated infections with multispatial abscess requiring urgent surgical treatment and inpatient admission for intravenous antibiotics. This exhibit will familiarize the viewer with the different patterns of spread for odontogenic infections and the key imaging findings that the radiologist must report in order to guide appropriate clinical management.

Materials and Methods
A basic review of dental anatomy and appropriate dental terminology will be given in order to facilitate accurate communication. This will include description of the structures of the tooth and periodontal region, directional terms used by dentists (e.g. mesial, distal, buccal, lingual, etc.), as well as the American Dental Association numbering system. The pertinent anatomic spaces that can be affected by dental infections will be reviewed, including the oral cavity, sublingual, submandibular, masticator, and buccal spaces. Finally a case-based approach will be used to demonstrate the various forms and severity of pathology that may be seen.

Results
The cases shown will include examples of: 1) Localized dental disease including dental caries and periapical lucency/periodontal disease without complication. 2) Localized periosteal and vestibular abscesses confined to the oral cavity. 3) Spread of infection to the a) sublingual space, b) submandibular space, and c) masticator space. 4) Osteomyelitis In each case, pertinent anatomy will be reviewed to inform the viewer on how to formulate a helpful report that will guide management. For example, the radiologist must understand that the sublingual and submandibular spaces are predominantly divided by the mylohyoid muscle but that they communicate at the posterior edge of the muscle. An abscess confined to the sublingual space might be treated with oral approach incision and drainage; however, an abscess involving both the sublingual and submandibular spaces may be treated by a submandibular approach.

Conclusions
In the emergency setting, non-traumatic dental complaints are commonly secondary to odontogenic infections. After seeing this exhibit, the viewer will be able to accurately characterize the different types and range of dental infections that may present using a confident search pattern, and will be able to assist in guiding appropriate clinical management.
Imaging of Temporal Bone Malformations

R Wycliffe1, M Kumar1, R Samant1, R Van Hemert1, R Ramakrishnaiah1
1University of Arkansas for Medical Sciences, Little Rock, AR

Purpose
Background: The embryological development of the external, middle, and inner ear structures is complex and varied. Knowledge of the development of the normal anatomy of the temporal bone enables a better understanding of temporal bone malformations.

Educational Objectives: 1. Describe the embryology of the external ear, the middle ear, and the inner ear structures. 2. Discuss imaging features of various congenital malformations of the temporal bone that affect the external ear, the middle ear, and the inner ear.

Purpose: The purpose of this electronic exhibit is to provide a better understanding of how developmental aberrations of the external ear, the middle ear, and the inner ear can lead to congenital malformations of the temporal bone.

Materials and Methods
N/A

Results
Summary of Planned Presentation (including cases): The spectrum of external ear malformations discussed in this electronic exhibit include microtia and anotia of the auricle, EAC stenosis, EAC atresia, and 1st branchial cleft cyst. Middle ear malformations included are middle ear hypoplasia or anomaly, ossicular malformation, oval and round window atresia, and congenital cholesteatoma. Inner ear malformations discussed in this electronic exhibit include labyrinthine anomaly, cochlear aplasia, common cavity malformation, cystic cochleovestibular malformation, cochlear hypoplasia, cochlear nerve deficiency, cochlear incomplete partition Type II, semicircular canal malformations, and large vestibular aqueduct. Also included are congenital vascular anomalies such as aberrant ICA and persistent stapedial artery, as well as normal variants of the temporal bone such as dehiscent carotid canal, dehiscence of the jugular bulb, and petromastoid canal.

Conclusions
Conclusion: This comprehensive overview of congenital malformations of the temporal bone, congenital vascular anomalies, and normal variants of the temporal bone will enable a better understanding of the embryonic development and imaging features of congenital malformations of the temporal bone.
Imaging Of The Central Nervous System Infections: A Pattern-Based Approach

M Siddiqui¹, S Sartaj²
¹Saint Louis University, Brentwood, MO. ²Jawaharlal Nehru Medical College, Aligarh, Uttar Pradesh

Purpose
1. List various causes of CNS infection. 2. Describe a pattern-based approach to diagnosis based on clinical presentation, location and imaging characteristics. 3. Recognize mimickers.

Materials and Methods
1. Epidemiology. 2. Clinical presentation, risk factors, and management. 3. CLASSIFICATION BASED ON LOCATION. 4) CLASSIFICATION BASED ON IMAGING. 5) MIMICKERS.

Results

Conclusions
CNS infections are relatively inaccessible to tissue sampling. Recognition and characterization of imaging patterns allow accurate diagnosis. This patterned approach will aid radiologists to quickly narrow the differentials and guide further workup and management.
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Imaging Review and Genomics of Head and Neck Vascular Anomalies: The ABCs and 123s

W Manzano1, E KUOY2, A Hasso3, M Iv4
1Stanford, Stanford, CA, 2UNIVERSITY OF CALIFORNIA, IRVINE, ANAHEIM, CA, 3UNIV OF CALIFORNIA IRVINE MEDICAL CENTER, Orange, CA, 4Stanford University, Los Altos, CA

Purpose
Vascular anomalies, particularly those that manifest on the skin, often serve as markers for an underlying syndrome extending deep into the internal organs. The clinical presentation and imaging findings of these cutaneous vascular anomalies may help determine whether they are isolated manifestations or syndromic components, guiding the choice of follow-up imaging studies. Growing scientific evidence in genetics broadens our understanding and early recognition of these syndromes, as many are associated with a genetic component.

Materials and Methods
Vascular anomalies are divided into malformations and tumors. Vascular malformations are stratified and divided into capillary, venous, lymphatic, arteriovenous, and combined malformations. While many of the syndromes associated with vascular anomalies have multiple anomalies that characterize them, the organization of this presentation will be based on the predominant anomaly in a similar manner to the International Society for the Study of Vascular Anomalies (ISSVA) classification scheme.

Results
This presentation will discuss the current classification and nomenclature of the various vascular anomalies outlined by the current ISSVA guidelines, last updated in 2018. We will review the known genetic associations of these anomalies recognized by the ISSVA, as well as some of the proposed genetic associations currently being researched. We will demonstrate the value of advanced imaging in the differential diagnosis of overlapping genotypic vascular anomalies & malformations based on phenotypic variations.

Conclusions
Imaging has great potential to classify cutaneous vascular anomalies and identify their associated syndromes as many have unique and well-characterized imaging findings. The association between genetics and vascular anomalies that are classifiable upon imaging gives the radiologist an even more prominent role: knowledge of the underlying genetics can broaden the radiologist's impact from the
primary identifier to the first responder, linking the identified syndrome to known mutations and possible genetic therapies/management.

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Imaging Review of Subependymal Lesions

K Tran¹, A Krishnan¹
¹Beaumont Health (Royal Oak), Royal Oak, MI

Purpose
The ependymal and subependymal regions of the brain can give rise to a broad variety of pathologic processes including neoplastic, infectious, inflammatory, and vascular disorders. This exhibit will familiarize viewers with common and uncommon entities directly involving the subependymal region through several case examples which illustrate key imaging features for these conditions. Particular clinical features will also be discussed which may aid in narrowing the differential.

Materials and Methods
Multiple cases illustrating various conditions affecting the subependymal region were collected and will be presented with supporting clinical information to assist in the differentiation of these conditions.

Results
Various cases including glial tumors, lymphoma, infectious ventriculitis, subependymal calcification, subependymal heterotopia, subependymal cysts, spectrum of tuberous sclerosis (subependymal nodules/tubers, giant cell astrocytomas), and others will be presented. Features such as clinical history and presence of other findings in the brain will be discussed to help separate some of these conditions. (Legend for Attached Image) A: Multiple enhancing subependymal masses from primary CNS lymphoma B: Multiple subependymal nodules and subcortical tubers in a patient with tuberous sclerosis C: Pyogenic abscess with associated ventriculitis D: Extensive subependymal grey matter heterotopia
Conclusions
This exhibit will present and illustrate a group of conditions which can affect the subependymal region of the brain, and with supporting imaging and clinical features, help to distinguish between them.
Imaging Standards for Comprehensive Stroke Centers

S Raymond1, D Johnson1, P Schaefer2
1The University of Vermont Medical Center, Burlington, VT, 2Massachusetts General Hospital, Wayland, MA

Purpose
Since 2012, the Joint Commission and American Heart Association created the Comprehensive Stroke Center (CSC) certification to identify select institutions capable of treating the most complex strokes. Certification requires sophisticated clinical capabilities including advanced imaging, neurointensive care nursing, and 24/7 coverage by stroke neurologists, neuroradiologists, neurosurgeons, and neurointerventionalists. Stroke patients are being increasingly diverted to CSCs to receive timely, life-saving care. In competitive healthcare markets, CSC designation is frequently a necessity to retain patients and this demand has driven a wave of new applications in recent years. CSCs require specific imaging technology, in-house radiology coverage, and reporting standards which can place unique demands on the radiology practice. The purpose of this educational exhibit is to describe the imaging standards for CSC certification and act as a guide for radiology practices that support hospitals seeking CSC status.

Materials and Methods
Educational Objectives
- Review the required imaging capabilities including carotid duplex ultrasound, catheter angiography, CT angiography, extracranial ultrasonography, MRI including MRA, and transcranial Doppler.
- Discuss the use of advanced imaging techniques (CTP, MRI) mandated by recent trials for triage of large vessel occlusion presenting 6-24 hours from last seen well.
- Describe the role of diagnostic neuroradiology and coverage requirements.
- Review the expectations for the interventional team, including staffing requirements and angio suite hardware.
- Describe strategies for treating two stroke patients simultaneously.
- Review study reporting and the role for standardized reporting.
- Discuss the stroke quality and performance measures that apply to radiology reports and strategies for tracking and extracting these data.
- Describe the role and expectation for IRB directed stroke research.

Results
N/A

Conclusions
N/A

Incidental (And Not So Incidental) Findings on MRI in Patients with Multiple Sclerosis

M Shriver1, S MOHAN1, D Jacobs1, R Kurtz1
1Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose
Educational Objectives
1. To present common and uncommon incidental findings in the head, neck, chest and abdomen in patients with multiple sclerosis (MS), including some that may mimic MS pathology.
2. To present pathologic findings that occur secondary to MS or the treatment of the disease.
3. To review current guidelines and recommendations for follow up of common incidentally discovered findings.

Materials and Methods
N/A

Results
N/A

Conclusions
Multiple sclerosis (MS) is a chronic demyelinating disorder of the central nervous system, typically requiring initial and routine serial magnetic resonance imaging (MRI) examinations to assess for disease activity. Acquisition of sequential brain and spinal cord MRI allows evaluation of lesion number, activity, distribution and morphology to assist in the clinical diagnosis and management of MS. These serial studies may lead to various incidental or additional findings, for which it is critical for radiologists to maintain vigilance. We will review key incidental and disease/treatment-related pathologies from a single-center MS patient cohort, with findings in the brain, cervical spine/neck, thoracic spine/chest and upper abdomen. A sample of cases that we present are:
- A 61-year-old female that developed IDH wild-type glioblastoma of the left temporal lobe after ten years of treatment for concomitant autoimmune hepatitis with mycophenolate mofetil (Figure A).
- A 62-year-old female that developed hypertrophic olivary degeneration, presumed to be due to demyelinating disruption of the triangle of Guillain and Mollaret (Figure B).
- A 50-year-old female with a symptomatic pontine infarct mimicking an active MS plaque, secondary to left cervical vertebral artery dissection (Figure C).
- A 27-year-old female with a large pulmonary mass, subsequently characterized as pulmonary cryptococcosis secondary to disease modifying therapy (Figure D).

Additional discussed pathologies include a large capillary telangiectasia mimicking a smoldering MS plaque, progressive multifocal leukoencephalopathy, venous sinus thrombosis, neck paraganglioma, parotid mucoepidermoid carcinoma, and venolymphatic
malformation of the neck. Finally, we review the current standards for diagnostic recommendations and reporting of incidental pituitary, thyroid, adrenal and renal lesions.

Injecting Gadolinium Directly into the Brain: Imaging Findings in Contrast Infused Drug Delivery

J Starkey

Purpose
Aim to teach: • Convection-enhanced delivery is a method for injecting chemotherapeutics directly into the brain, circumventing the blood-brain-barrier • Gadolinium is increasingly infused in order to ensure correct catheter placement and dispersion of therapeutics to desired targets • Knowing the typical immediate and delayed imaging appearance of concentrated gadolinium infusion is important to differentiate expected findings from complications

Materials and Methods
• Review of physics regarding gadolinium and T1/T2 shortening • T1 and T2 findings in gadolinium infusion (T1 hyperintense; T2 can be variable depending on concentration) • SWI and T2* findings in gadolinium infusion • Review of imaging findings -
Preoperative MRI - Intraoperative MRI - Postoperative MRI • Differentiating infusion gadolinium from blood products and other mimics • Sample cases • Summary

Results
NA

Conclusions
Knowing the typical appearance of contrast infused drug delivery is important as this technique becomes more widespread.

(Filename: TCT_2624_Case1.jpg)

1994

Inner Ear Malformations: Identifying and Simplifying the Complex Diagnostic Dilemma.

S Jain
1Vardhaman Mahavir Medical College and Safdarjung Hospital, Ghaziabad, Uttar Pradesh

Purpose
Imaging Approach as easy-to-remember flowchart. Parameters of evaluation – Standard and specialized planes, Measuring of key structures in the inner ear & normal values, Facial Nerve course, VIII nerve dysplasia, Imaging predictors of post-surgical complications. Differentiating b/w imaging differentials like CH IV vs IP II, CH II vs IP I, CC vs CADV Malformations & specific syndromes

Materials and Methods
N/A

Results
IEM lie at the heart of 20-40% pediatric SNHL cases, delayed diagnosis of which is detrimental to development of language milestones of the child, and consequent social, emotional and academic well-being. High Resolution CT, being the primary modality is useful to delineate inner ear anatomy and assessment for cochlear implant, while Three-Dimensional MRI images, usually a problem solving tool, are useful to assess membranous labyrinth, facial and cochleo-vestibular nerves. Most patients with inner ear malformations have complicated and overlapping findings. Semaroglu classification, based on embryogenesis, has been discussed in the most comprehensive detail. Easy and accurate distinction between different types of malformations has been aimed using flowchart and tables. Case evaluation starts with assessment in the standard cross sectional planes, in addition to Mid-Modiolar and the Round Window Niche Views in Axial Plane, latter being important to view interscalar septum in apical turns and differentiate between Cochlear Hypoplasia Type IV and Incomplete Partition Type II. After ruling out External and Middle Ear Abnormalities, measurements of standard parameters like Internal Auditory Canal and Vestibular Aqueduct width, lateral semicircular canal (LSCC) Bony Island Area in addition to few novel parameters like Cochlear size, Cochlear Aperture size and Width of LSCC Ampulla are important for differentiation between various anomalies. Significant contribution to diagnosis, treatment planning and prognosis is given by facial nerve course, cochlea-vestibular dysplasias and per-operative risk of CSF gusher which can be predicted using markers like wide communication between inner ear and internal auditory canal, dilated vestibular aqueduct in addition to another novel marker – obtuse angle between tympanic and labyrinthine facial nerve segments.
Conclusions

Entangling the dreaded subject of IEM using a comprehensive but simplified flowchart and aiming at a standardized reporting of IEM using the standard as well as novel markers is important for better management of cases.

Intracranial Manifestations of Disease and Treatment Effects in Melanoma Patients

S Ghosh-Ray¹, P Nathan²

¹Paul Strickland Scanner Centre, London, United Kingdom, ²Mount Vernon Hospital, London, United Kingdom

Purpose

To demonstrate the experience of a wide range of intracranial manifestations of melanoma and treatment related side effects in a cohort of melanoma patients within a tertiary cancer centre

Materials and Methods

Various cases are discussed and demonstrated. Melanoma can metastasise to the intracranial compartment. The clinical presentation, current treatment regime and treatment related effects are all taken into account. Each case is discussed separately with timelines and management decisions based on clinical and radiological findings explained.

Results

Case 1. Patient on immunotherapy for metastatic melanoma arising in the thigh. Routine intracranial MR imaging revealed new lesions arising in the right cerebral white matter. Clinical question: is this tumour relapse, treatment side-effect or a new aetiology? Upon treatment withdrawal and steroid administration the lesion resolved. This was an example of immunotherapy related demyelination. Case 2. Patient on melanoma surveillance presented acutely with neurological symptoms. Routine imaging showed new enhancing white matter lesions. Clinical question: is this tumour relapse or a new aetiology? Treatment with immunotherapy aggravated the lesion burden. New aetiology more likely and management plan changed based on radiological findings. On stopping immunotherapy and starting steroids the lesions resolved. This was an example of denovo demyelination. Case 3. Patient with metastatic melanoma presented acutely with stroke like symptoms. Initial imaging suggestive of haemorrhage or haemorrhagic metastases. Clinical question: is this a spontaneous haemorrhagic stroke or metastatic haemorrhagic disease? After conservative symptomatic management and repeat clinical and radiological assessment - it was treated for haemorrhagic disease.

Conclusions

Melanoma can metastasise to the intracranial compartment. These lesions can be small and affect the meninges as well as the grey and white matter. Immunotherapy is a part of the treatment options in melanoma and can have its own toxic effects in the intracranial compartment. Melanoma patients can also present with non-related pathologies in the intracranial compartment. Differentiating these
different aetiologies have significant implications in patient outcomes and health economics. Close clinical and radiological correlation is the key to reducing risk and improved outcomes.

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**Intracranial Vascular Fenestrations: “A Window to the Vessels”**

P Puac Polanco\(^1\), R Glikstein\(^1\), W Calderon Miranda\(^2\), A Guarnizo\(^3\), C Torres\(^3\)

\(^1\)University of Ottawa, Ottawa, ON, \(^2\)Sabbag Radiologos, Barranquilla, Atlántico

**Purpose**

The purpose of this exhibit is to show the different locations and imaging appearances of intracranial vascular fenestrations and, in some cases, their associations with pathologic conditions.

**Materials and Methods**

A fenestration is an arterial anatomic variant where a segment of a single vessel divides into two channels that coalesce to a single lumen later in its course. The prevalence is widely, from 0.7 to 60%. There have been studies showing the presence of fenestrations in the setting of aneurysms, arterial-venous malformations and ischemic stroke. Vascular fenestrations will be approached on the basis of location and imaging appearances.

**Results**

The embriology of fenestrations will be discussed and their imaging features in different modalities such as MRA, CTA, digital subtraction angiography (DSA) will be depicted.

**Conclusions**

Participants will learn the pathophysiology, association with other co-morbidities, and how to recognize fenestrations based on the imaging findings in different imaging modalities.
Intraspinal Air: Thinking Outside the Vacuum

M Nguyen¹, J Pollock², D Pettersson¹, J Nickerson³
¹Oregon Health & Science University, Portland, OR, ²Oregon Health and Science University, Portland, OR, ³Oregon Health Sciences University, Portland, OR

Purpose
Vacuum phenomenon is the universal term for gas production in the process of disc degeneration, most commonly seen in the intervertebral disc space, although the accumulation of gas by similar mechanisms has been described in nearly every segment in the spine, including the vertebral body, articular facet joint and intraspinal epidural space. Pneumorrhachis is the term specifically applied to air collecting in the spinal canal, and is a relatively uncommon phenomenon with a wide differential diagnosis. In the majority of cases, pneumorrhachis is a subsidiary finding of vacuum phenomenon, presenting along the continuum of disc degeneration, herniation and gaseous extension into the epidural space via annular fissures or tears. But unlike gas confined to the intervertebral disc space, which usually mitigates concern for infection, intraspinal air can masquerade as herniated disc gas, falsely lowering the threshold for concern. In addition to vacuum phenomenon, traumatic and non-traumatic pathways exist for gaseous entry into the spinal canal, further challenging the diagnosis. The lack of comprehensive reviews on this topic is underscored by the increasing detection of intraspinal air with current advances in imaging. We present an etiology-based case series of intraspinal epidural gas, outlining the clinical presentation, radiologic findings and current management in each case.

Materials and Methods
Cases representing the following sources/etiologies for intraspinal epidural gas: - Peritoneum - fistula (figure 1) - Barotrauma - pneumomediastinum - Trauma - stab wound - Iatrogenic - Degenerative

Results
The majority of conditions directly or indirectly producing intraspinal gas are asymptomatic and short-lived. However, clinical relevance in these cases pertains to the exclusion of underlying critical pathology, with the cost of missed infection or malignancy often reflected in increased morbidity and mortality. The diagnostic challenge is apparent on both ends of the clinical spectrum, with superimposed vacuum phenomenon leading to a false-negative diagnosis and coincident injuries more likely leading to a false-positive diagnosis. We aim to increase familiarity with the wide spectrum of pneumorrhachis by presenting different routes of intraspinal gas throughout our case series.

Conclusions
Intraspinal air rarely comes to clinical attention as an isolated phenomenon, but recognition of the source of this finding may guide diagnosis and facilitate management, and thereby improve patient outcomes.
FIGURE 1: 71 year-old male with remote history of rectal adenocarcinoma status post low anterior resection and ileostomy take-down. A, B) Axial and sagittal images from contrast-enhanced CT of the abdomen and pelvis at initial presentation show gas locules in the intervertebral disc at the L5-S1 level, with extension into the epidural space. Imaging at two weeks after initial presentation is depicted with C) Gastrografen enema demonstrating a fistulous connection between the colon and the epidural space, and D) MRI Post-gadolinium T1 showing discitis-osteomyelitis at L5-S1 and epidural phlegmon contiguous with a presacral rim-enhancing collection.

(Filename: TCT_1636_Figure1-PeritonealsourceofIntraspinalGas.jpg)
B Tantiwongkosi1, M Chen2, P Wangaryattawanich3, A Singh4, N Salamon5, A Gilbert6
1University of Texas Health San Antonio, San Antonio, TX, 2MD Anderson Cancer Center, Houston, TX, 3University of Pittsburgh Medical Center, Pittsburgh, PA, 4UT Health San Antonio, San Antonio, TX, 5UCL, Los Angeles, CA, 6University of Texas Health San Antonio, San Antonio, TX

Purpose
This pictorial assay showcases key imaging findings of adult and pediatric intraspinal tumors, with pertinent clinical, radiologic and pathologic correlations, important for the day-to-day practice of neuroradiologists.

Materials and Methods
Multiple cases of common and rare intraspinal tumors of pediatric and adult patients with proven pathology and available CT and MR imaging were evaluated. Pertinent clinical presentation, key imaging findings, intraoperative images, and histomorphologic features are reviewed. When available, post-treatment images are provided to demonstrate long term outcome and prognosis.

Results
The anatomic compartments of the vertebral column and spinal canal are illustrated utilizing CT and MRI with hand-drawn annotations. The spinal tumors are classified by the following conventional anatomic locations: intramedullary, intradural extramedullary and extradural tumors, as well as the conus medullaris, filum terminale, and cauda equina. We present the following entities: Group 1. Intramedullary astrocytoma, ependymoma, hemangioblastoma, glioblastoma lymphoma, and metastasis. Group 2. Intradural meningioma, schwannoma, hemangiopericytoma, lymphoma, and metastasis. Group 3. Conus medullaris, cauda equina and filum terminale myxopapillary ependymoma, paragangioma, schwannoma, lymphoma, teratoma, and metastasis. Group 4. Extradural lymphoma, hemangioma, lipoma, epidural lipomatosis and metastasis. 5. Syndromes: von Hippel Lindau, neurofibromatosis type I, neurofibromatosis type II, and Schwannomatosis.

Conclusions
A compartmental approach is useful for narrowing down the number of entities to consider in the differential diagnosis of spinal lesions. It is essential that neuroradiologists know the key imaging features and common anatomic locations of typical spinal cord tumors in order to make accurate diagnoses.

Jaw Dropping! Uncommon Nonodontogenic Lesions of the Mandible: A Pictorial Case Series

N Hyson1, B Griffith1, P Doshi1
1Henry Ford Health System, Detroit, MI

Purpose
In this exhibit, we will present 11 cases of uncommon benign and malignant nonodontogenic mandibular lesions and review their
distinguishing imaging findings. In doing so, we hope to both broaden the radiologist's differential while providing tools to help distinguish benign and malignant histology.

Materials and Methods

• Using an image based approach, we will present cases of benign and malignant lesions of the mandible from primary and secondary etiologies. Utilized modalities include CT, MRI, PET, and bone scintigraphy. • From our teaching files, primary benign lesions will include fibrous tumor of the mandible, fibrous dysplasia with superimposed aneurysmal bone cyst in the setting of McCune-Albright syndrome, melorheostosis (Figure 1A), and fibrous tumor of the mandible (Figure 1B). • Primary malignant lesions will include two cases of chondroblastic osteosarcoma and primary mandibular non-Hodgkin's lymphoma (Figure 1C). • Secondary processes invading the mandible will include oropharyngeal squamous cell carcinoma, tenosynovial giant cell tumor of the temporomandibular joint, mucoepidermoid carcinoma of the salivary gland masquerading as a Stafne cyst, and metastatic adenocarcinoma of the colon (Figure 1D).

Results

• Mandibular lesions are typically categorized by whether or not they originate from the teeth - odontogenic or nonodontogenic (1). While the prevalence of reported jaw lesions varies from population to population, odontogenic lesions – such as odontomas, ameloblastomas, and radicular cysts – are more common than nonodontogenic lesions (2). • Although benign lesions often show typically nonaggressive features and malignant lesions more aggressive features, this is not always the case in the mandible, and ultimately a biopsy is necessary (3). • When suspecting a nonodontogenic aggressive entity in the mandible, metastatic disease – particularly by direct invasion – must always be considered (1).

Conclusions

While nonodontogenic lesions of the mandible are less common than odontogenic lesions, a broad differential can be narrowed with clinical history, location, and radiologic clues (1,3). Special attention should be paid to invasion of the mandible from adjacent structures. Despite this, biopsy is often ultimately necessary to distinguish benign or malignant histology of mandibular lesions.

(Filename: TCT_1285_Figure1Hyson.jpg)

1882

Lacrimal Gland Tumors: A Neuroimaging Review of a Wide Spectrum of Lesions and their Mimics

K McCullagh1, F Kuo1, A Chiu1, S Hashmi2, T Massoud3

1Stanford University School of Medicine, Stanford, CA, 2N/A, N/A, 3STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose

Lacrimal gland (LG) tumors represent 10% of orbital space-occupying lesions, occurring mostly in middle age. They are generally of two types: epithelial (25%) and non-epithelial (75%). Of the latter, LG lymphomas are the most common, and are 37% of malignant
Importantly, the management of a suspected LG tumor depends on the imaging characteristics. Incisional biopsy is performed if bony invasion or intraorbital extension are present, but biopsy is held off in cases of well-defined masses—these are usually managed as benign mixed tumors (BMT, pleomorphic adenoma). We provide a pictorial and educational review of LG tumors to aid in neuroimaging interpretation and patient clinical management.

Materials and Methods
We comprehensively review the imaging findings of a wide spectrum of LG neoplastic lesions and their mimics, and categorize these by histologic subtype.

Results
We first describe imaging anatomy of the normal bicompartamental LG. Of epithelial LG tumors, 55% are benign, and 45% are malignant. The salivary and LGs share an embryological origin; thus, the most common benign epithelial lesion is BMT. Other less common benign lesions include ductal epithelial cysts, oncocytoma, Warthin's tumor, myoepithelioma, and sialoblastoma. Of malignant epithelial lesions, adenoid cystic carcinoma comprises 60%, with pleomorphic or primary adenocarcinomas, mucoepidermoid carcinomas, and others making up 40%. LG metastases are rare, mostly from breast or lung cancers. Other non-epithelial tumors include plasma cytoma, fibrous histiocytoma, hemangioma, lipoma, nerve sheath tumors, and pseudotumor. In general, on imaging, bony changes are poorly seen on MRI, making CT the better technique. Benign tumors (e.g. BMT) tend to be well-defined with moderate contrast enhancement ± discrete flecks of calcification. Malignant masses are more ill-defined with surrounding infiltration, and calcification is more common and diffuse compared to BMTs. Differential diagnosis includes mimics such as dacryops, dacryoadenitis, and Sjogren's syndrome. We also discuss LG tumor histologic features, genetic abnormalities, and clinical presentations e.g. V1 and V2 hypoesthesias are highly suggestive of perineural invasion of orbital nerves.

Conclusions
Accurate differentiation of benign and malignant features of LG tumors is important in clinical decision making prior to treatment. This presentation will aid in neuroimaging interpretation and understanding of LG tumors and their mimics to aid in patient management.

2611

Late Intracranial and Cranial Effects of Cancer Treatment: Clinical and Investigative Imaging Findings in Survivors of Childhood and Adolescent Malignancies

N Sabin1
1St. Jude Children's Research Hospital, Memphis, TN

Purpose
This exhibit reviews late intracranial and cranial imaging findings in survivors of childhood and adolescent cancer and will include younger survivors as well as those many years from diagnosis.

Materials and Methods
N/A

Results
N/A

Conclusions
Background information and CT and MRI images highlight long-term intracranial and cranial sequelae of pediatric cancer treatment as well as approaches to imaging long-term survivors of childhood malignancies. Research imaging findings concerning functional, neurologic and neurocognitive consequences of pediatric cancer therapy are also included. The exhibit covers the long-term effects of treatment modalities such as chemotherapy and radiation and explores gray and white matter abnormalities, vascular lesions, subsequent neoplasms, osseous changes and the use of techniques such as diffusion tensor imaging and functional MRI in long-term survivors of childhood and adolescent cancer. Educational objectives: 1. Discuss the modalities used to treat pediatric and adolescent cancer and their long-term neurologic and neurocognitive consequences. 2. Describe intracranial and cranial CT and MRI findings in long-term survivors of pediatric and adolescent cancer including gray matter, white matter, vascular and osseous lesions and the optimal ways to image these abnormalities. 3. Review the types and imaging appearances of intracranial and cranial subsequent neoplasms seen in long-term survivors of pediatric and adolescent cancer. 4. Discuss investigative neuroimaging techniques used for evaluation of long-term survivors of pediatric and adolescent cancer such as diffusion tensor imaging and functional MRI and some of the results of those techniques.

1832

Lemon Juice technique in MR sialography

U ERDENE Bold1, S Hiremath2, S Chakraborty3
1THE OTTAWA HOSPITAL, OTTAWA, ON, 2The Ottawa Hospital, Ottawa, Ontario, 3University of Ottawa, Ottawa, Ontario
Purpose
This educational exhibit aims to: • To demonstrate the Lemon juice technique in MR sialography for a blocked salivary duct • To illustrate different imaging modalities of the sialography and its benefits and limitations • To review technical aspects, procedural failure and complications of each modality • To show imaging anatomy and findings of the MR sialography • To highlight the clinical implications of MR sialography for assessing functional status

Materials and Methods
We will describe the technical aspects with images describing normal anatomy in each modality. We will present the data from healthy volunteers showing changes in MR sialographic appearances in pre and post lemon juice stimulation. Multiple cases including sialolithiasis, papillary stenosis, strictures, intraglandular sialectasis and changes related to external compression by tumor will be shown. We will describe the value of lemon juice in MR sialography to stimulate salivation that improves the detection of strictures and functional obstruction.

Results
MR sialography is a non-invasive method to assess the major salivary gland ductal structures. This imaging modality has been greatly used since the mid-1990s simply based on the concept of stationary fluid such as saliva. The saliva gives intrinsic high T2 signal intensity within the salivary ducts used as a physiological contrast. There are several advantages over other imaging modalities which are non-invasive technique, no need for contrast media, lack of radiation exposure and independence from an experienced operator. We emphasize the lemon juice in MR sialography, including technical aspects, procedural failure, and complications as well as benefits and limitations. Also, highlight the clinical implications of MR sialography for assessing the functional status.

Conclusions
We describe the evolution of different techniques including conventional and CT or MR sialography to image salivary ducts and salivary stone diseases. We will illustrate the use of lemon juice in MR sialography for functional assessment of salivary glands and duct systems.

Lessons Learnt from Multidisciplinary Pediatric Epilepsy Conference: Case based Magnetoencephalography (MEG) Primer for Neuroradiologist with MRI Correlation

R Patel1, S Khanpara1, E Bonfante-Mejia1, A Kamali1, M Watkins1
1The University of Texas Health Science Center, McGovern Medical School, Houston, TX

Purpose
Multidisciplinary Epilepsy group consist of Neurologists, Epileptologists, MEG experts, Neuroradiologists and Neuropsychologists. Appropriate treatment of the epilepsy patient is a multidisciplinary effort requiring communication between multidisciplinary epilepsy

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group members. It is important for each subspecialty to have baseline comprehension of the other's area of expertise, as it pertains to patient workup and management. With this exhibit, we will try to familiarize the Neuroradiologist with the basics of the Magnetoencephalography (MEG) and provide correlation with EEG and MR findings in a case-based format.

Materials and Methods
Retrospective search of all surgically cured Epilepsy patient database of our tertiary hospital was performed from 2010 to 2019. Representative cases having MRI, EEG, MEG correlations were selected for a case based format.

Results
MEG is a functional neuroimaging modality that evaluates cerebral activity by recording the magnetic fields produced electrical currents in the brain. Magnetic fields are measured using arrays of sensitive magnetometers called SQUIDs (superconducting quantum interference device). MEG is only modality that provides real time neurophysiological data that is complimentary to EEG Signals, measured directly from intracellular neuronal activity, resulting in high temporal resolution. As compared to EEG, MEG has more sensors utilized for data acquisition (MEG: 300 sensors vs. EEG: 21 electrodes) as well as improved spatial resolution and source localization accuracy (MEG: 3 mm vs EEG 7-8 mm). MEG can confirm spike localization when MRI is non-lesional and EEG appears regional. Epilepsy protocol MRI with MEG sequence and EEG are critical components in the workup of patients with epilepsy. Inter-ictal and ictal EEG patterns then are correlated with MEG, clinical seizure semiology, neuropsychology, and imaging to formulate a sound hypothesis as to the epileptogenic zone.

Conclusions
Many instances seizure focus cannot be localized precisely after a thorough neurologic workup. Many circumstances when MEG can prompt MRI re-evaluation and possibly reveal previously undetected abnormalities amenable to surgical intervention, particularly when it corresponds with findings on EEG, ictal semiology, neuropsychological assessment, and other advanced imaging modalities like SISCOM and PET imaging. In the multidisciplinary approach to medical problem solving, it is very beneficial for the Neuroradiologist to be familiar with MEG and EEG findings.
7 year old male child with intractable epilepsy. Initial MRI read was normal at outside institution. MEG analysis demonstrated right parietal spikes (upper raw images) which prompted MRI re-evaluation which demonstrated previously missed right parietal focal cortical dysplasia (FCD) (bottom raw images).

(Filename: TCT_2315_MEG.jpg)
Lighting up the (Motor) Strip: Diagnosis, Cirrhosis

C Wilson¹, M Thomas², G Hathout¹
¹UCLA Medical Center, Los Angeles, CA, ²Olive View-UCLA Medical Center, Los Angeles, CA

Purpose
Hyperintense signal in the globi pallidi on T1-weighted images is a classic finding in chronic liver disease. The purpose of this educational exhibit is to focus on less familiar, often misinterpreted abnormalities affecting the white matter in chronic liver disease. By the end of the exhibit, participants should meet the following objectives: 1.) Describe common and less common neuroradiologic manifestations of liver disease, with specific focus on signal abnormalities in the corticospinal and corticocerebellar tracts. 2.) Review clinical features and possible pathologic mechanisms for such findings. 3.) Provide a differential diagnosis including common mimics.

Materials and Methods
MR studies from multiple patients with cirrhosis were reviewed. While most of these patients had the classic imaging findings of liver disease, others had less familiar white matter abnormalities, which could be misinterpreted as other disease pathology. Clinical features, pathologic mechanisms and differential diagnoses are provided.

Results
In cirrhosis, abnormal liver function elevates serum ammonia and manganese, which may cross the blood-brain barrier, causing hepatic encephalopathy and hepatocerebral degeneration. Manganese deposition in the globi pallidi and ventral midbrain causes the classic hyperintensity on T1-weighted images in these regions. This finding is sometimes accompanied by symmetric hyperintensities in FLAIR and T2-weighted images which appear to extend along the course of the corticospinal and corticocerebellar tracts. The pathogenesis of these abnormalities is unclear, but may be due to elevated ammonia, dysfunction of methionine metabolism or cytokine dysregulation, all of which accompany chronic liver disease. Figure 1 shows hyperintensity in the globi pallidi on T1-weighted images. Figure 2 shows the less familiar abnormal signal in the white matter of the motor strip bilaterally. Figure 3 demonstrates abnormal signal in the corticocerebellar tracts, starting in the motor strips and going through the cerebral peduncles into the cerebellum. Figure 4 shows hyperintensity in the cerebellum. The differential diagnosis includes motor neuron disease and other leukodystrophies.

Conclusions
The most familiar imaging manifestation of chronic liver disease in the brain is hyperintense signal in the globi pallidi on T1-weighted images. The less well-known presentation of white matter abnormalities in the corticospinal and corticocerebellar tracts is reviewed, and is the focus of this exhibit.
Longitudinally Extensive Transverse Myelitis: A Case-Based Review
Purpose
Longitudinally extensive transverse myelitis (LETM) comprises a subset of transverse myelitis in which the spinal cord lesion extends the length of at least three vertebral levels. In this exhibit we provide a case-based review of the differential diagnosis for this entity.

Materials and Methods
Spinal MRI cases with imaging findings of LETM were retrospectively collected. For each case, the authors reviewed the clinical information and imaging features used to establish an underlying diagnosis.

Results
Transverse myelitis is an inflammatory spinal cord abnormality that may produce a variety of motor, sensory, or autonomic deficits. MRI demonstrates an intramedullary lesion with T2 signal prolongation and variable enhancement. In some cases, the lesion may involve the spinal cord longitudinally for three vertebral segments or more, defined as LETM. Although typically associated with demyelinating processes - especially neuromyelitis optica - the differential diagnosis for LETM is broad and includes infection, granulomatous disease, ischemia, autoimmune diseases, compressive phenomena, vascular and congestive anomalies, and neoplasia. Over a dozen cases with known underlying diagnoses are reviewed with a focus on imaging features, including lesion topography within the spinal cord. Brief clinical vignettes including presenting symptoms, physical examination findings, and laboratory evaluations are provided for each case.

Conclusions
Our review demonstrates that LETM may represent a manifestation of numerous disease processes. Knowledge of the clinical features and careful assessment of the imaging findings, including topography of the lesion within the spinal cord, allow the radiologist to substantially narrow the differential diagnosis.
Lumps and Bumps of the Scalp and Skull

H Al-Jadiry¹, R Chaudhary¹, T Shestopalova²
¹University of Texas Medical Branch, Galveston, TX, ²UTMB, Galveston, TX

Purpose
Lesions of scalp and skull can be diverse from benign to aggressive lesions. Imaging findings can overlap and are challenging. In this exhibit, the aim is to describe radiological characteristics and modality of choice for differentiating and following up these lesion

Materials and Methods
We collected different pathologies from the cross sectional modalities in our institute. Some of the lesions were incidental findings and some have been imaged to evaluate palpable head mass. In this educational exhibit, we will list different disease processes, discuss characteristics imaging findings tips for differential diagnosis and management recommendation. The lesions will be categorized as osseous and soft tissue masses. The exhibit will include but not limited to the following: Osseous 1. Intraosseous hemangioma 2. Metastasis 3. Trans-osseous meningioma 4. Osteoma 5. Fibrous dysplasia 5. Multiple Myeloma Soft Tissue 1.Epidermal inclusion cyst 2.Trichilemmoma 3.Lipoma 4.Angiosarcoma 5.Vascular malformations 6.Superficial skin cancers

Results
Scalp and skull masses are frequently seen in cross sectional imaging often as incidental findings or the patient is undergoing imaging to evaluate for head bump. These entities can range from benign to highly aggressive lesions. Some of these lesions have typical imaging appearance while many of these are difficult to diagnose based on imaging only. Nevertheless imaging can be helpful in guiding appropriate approach to management of these cases

Conclusions
Scalp and skull lesions are commonly encountered and include diverse pathologies. Familiarity to these entities can help in better evaluation and management of patients and avoiding unnecessary workup.
Lupus Cerebritis, an Educational Series with CT and MR Imaging Features

D Lee¹
¹SIUH, Staten Island, NY

Purpose
Systemic Lupus Erythematosus is an autoimmune disease that can affect various organs and has well known associated physical exam and laboratory associations. An important system involved in the disease is the central nervous system, leading to complications such as intracranial hemorrhage, cerebral abscesses, and cerebral ischemia/infarction from CNS vasculitis. This review will seek to discuss the pathophysiology and clinical presentation of SLE and illustrate disease manifestations in the CNS on imaging. The purpose is to
illuminate training radiologists regarding CNS disease in SLE patients from an imaging standpoint. They will then be able to identify pathology that can guide the clinician in treatment and management of the patient.

Materials and Methods
N/A

Results
N/A

Conclusions
Learning objectives
- Describe the pathophysiology of lupus cerebritis and how it manifests on CT and MR imaging
- Discuss various cases of suspected lupus cerebritis with imaging features before and after treatment

2744

Magnetic Resonance Imaging (MRI) in the Diagnosis and Classification of Myelopathies: A Pictorial Review

S Tellapuri¹, C Dixon², M Kontzialis³
¹Rush University Medical Center, Chicago, IL, ²Northwestern University, Chicago, IL

Purpose
Abnormal spinal cord signal on T2/STIR weighed images is a common finding that can occur due to various pathological conditions. The purpose of this exhibit is to familiarize the reader with common causes of myelopathy including degenerative, inflammatory, autoimmune, traumatic, neoplastic, infectious and vascular etiologies with a special focus on the specific imaging features of each entity.

Materials and Methods
We will review imaging characteristics of several causes of myelopathy by grouping them into pathologies extrinsic and intrinsic to the spinal cord. Extrinsic causes will include degenerative disc disease, traumatic, and extradural spinal canal neoplasms. The intrinsic causes will include inflammatory conditions (multiple sclerosis, acute disseminated encephalomyelitis, neuromyelitis optica spectrum disorder, and transverse myelitis), infections, vascular, neoplastic, metabolic, multisystem autoimmune diseases (systemic lupus erythematosus, Sjogren syndrome and neurosarcoidosis), HIV myelopathy, and other less common causes including arachnoid webs and spinal cord herniation. Intrinsic causes will be further subcategorized based upon the clinical onset of symptoms.

Results
The causes of cord signal abnormality will be differentiated depending on the extent of spinal cord involvement, location and number of lesions, tract and vascular territory involvement, and concurrent central nervous system involvement.

Conclusions
A good clinical history and understanding of spinal cord anatomy can aid in arriving at an appropriate differential diagnosis as the various causes of spinal cord myelopathy can result in similar imaging findings. Early diagnosis is essential to avoid progression, optimize management, and for treatment planning. MRI continues to play a crucial role in diagnosing and differentiating myelopathy disorders and in the future may mitigate the need for invasive procedures such as biopsy to confirm the diagnosis.
Magnetic Resonance Imaging of fungal infections of central nervous system

P Singh1, S VYAS1, C Ahuja2, A Kumar1, V Bhatia2, N Choudhary2
1Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh, 2PGIMER, Chandigarh, Chandigarh

Purpose
To familiarize training radiologists with imaging features of invasive fungal infection of central nervous system (CNS).

Materials and Methods
The incidence of invasive fungal disease of brain is increasing due to inherent or acquired immune compromised states, i.e. hematological malignancy, organ transplant, HCST, intensive care etc. The invasion could be hematogenous from lung or local spread from adjacent areas. Imaging plays a central role for diagnosis as clinical and laboratory parameters may often be non specific or negative due to low immunity. Aspergillus and Mucorales are hyphal subtypes and tend to attack larger vessels and present with syndromes of meningitis, mass lesion, strokes (both hemorrhagic and non hemorrhagic), and produce distinctive pattern of brain infection due to angioinvasion, vasculitis, infarction, hemorrhage and pseudoaneurysm formation. 1.5 and 3T MRI images of patients with invasive Aspergillus and Mucormycosis were analyzed in 30 patients. A multiparametric approach was used and included T1SE(pre and post contrast), T2 TSE, FLAIR, DWI, SWI, Perfusion and Proton Spectroscopy). The common patterns of brain involvement were observed and categorised. The images highlighting characteristic findings are presented.

Results
Patterns of Imaging depends on hematogenous spread or extraaxial origin, invasiveness, dominant pathology and may manifest as meningitis, mass lesion, strokes (both hemorrhagic and non hemorrhagic), and produce distinctive pattern of brain infection due to angioinvasion, vasculitis, infarction, hemorrhage and pseudoaneurysm formation. 1.5 and 3T MRI images of patients with invasive Aspergillus and Mucormycosis were analyzed in 30 patients. A multiparametric approach was used and included T1SE(pre and post contrast), T2 TSE, FLAIR, DWI, SWI, Perfusion and Proton Spectroscopy). The common patterns of brain involvement were observed and categorised. The images highlighting characteristic findings are presented.

Patterns of Imaging depends on hematogenous spread or extraaxial origin, invasiveness, dominant pathology and may manifest as meningo-vasculitis (including meningeal enhancement and hydrocephalus), granulomatous reaction, cerebritis (poorly defined area of coagulative necrosis), abscess formation (encapsulation of the former), associated infarction (enzyme elastase related wall damage) or hemorrhage. Arterial stenosis, thrombosis as well as mycotic aneurysms were seen. The extra axial origin presented as contiguous extension to nose, paranasal sinuses or ear. Orbital and cavernous sinus invasion was common with bone destruction. Particularly
patterns and differential diagnosis of invasive nature of fungal cerebritis along with appearance of abscesses were highlighted on multiparametric approach. Characteristics MRS peaks between 3.6 to 3.8 ppm representing Trehalose, a disaccharide, was also seen.

Conclusions
Multiparametric MRI may be fairly diagnostic of invasive CNS fungal infections due to certain characteristic findings. Awareness of imaging findings will facilitate early diagnosis and help institute aggressive anti microbial therapy for improved outcome in an otherwise fatal disease.

2123

Making one’s way through: Safe Entry Zones to the Brainstem

P Puac Polanco¹, J Sinclair¹, E PORTELA DE OLIVEIRA¹, A Guarnizo¹, S Ferracioli², R Glikstein¹, C Torres¹
¹University of Ottawa, Ottawa, ON, ²InRad - HC- FMUSP, Sao Paulo, Brazil

Purpose
To describe the imaging landmarks of safe entry zones to the brainstem To illustrate the use of safe entry zones in the surgical approach of brainstem cavernous malformations (CMs)

Materials and Methods
The surgical approach to the brainstem is a challenging, high-risk procedure for the neurosurgeon. Safe entry zones are relatively safe, but narrow surgical corridors into the brainstem that combined with electrophysiological monitoring are becoming increasingly used techniques to maximize the chances of effective and safe resection. Cerebral cavernous malformations (CCM) have an estimated prevalence of 0.4-0.9% in the general population. Brainstem CMs account for 8-22% of all intracranial cavernomas and have higher rates of bleeding/rebleeding than cavernomas in other locations. In this educational exhibit, we will review and illustrate the anatomy of the brainstem, focusing on the safe entry zones used for the surgical approach of brainstem CMs.

Results
Surgical safe entry zones to the brainstem will be illustrated according to different surgical routes in the anterior, lateral, and dorsal surface of the midbrain, pons, and medulla. We will provide clinical examples emphasizing the recognition of these safe entry zones by imaging. Clinical presentation, general surgical techniques, and other clinical considerations that play a role in choosing the correct approach will also be discussed.

Conclusions
A detailed understanding of the approach of brainstem CMs according to lesion location, clinical presentation, and surgical techniques allows better communication and collaboration with the neurosurgeon in the management of these challenging and complex lesions.

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2535

Management of Patients with Acute Stroke: Brain is More Imaging than Time in the New Era

J Puig¹, J Shankar², K Naei³, C Leiva Salinas⁴, V Cuba Camasca⁵, S Pedraza⁶, M Essig⁷
¹IDI-IDIBGI, Girona, Spain, ²University of Manitoba, Winnipeg, MB, MB, ³Icahn School of Medicine at Mount Sinai Hospital, New York, NY, ⁴University of Missouri, Los Angeles, CA, ⁵Hospital Clinic of Barcelona, Barcelona, Catalonia, ⁶IDI-IDIBGI, Girona, Girona, ⁷University of Manitoba, Winnipeg, Manitoba

Purpose
Thrombus recanalization and the subsequent restoration of blood flow is strongly associated with improved outcome in patients with acute ischemic stroke (AIS). The ultimate goal of neuroimaging is to help in the triage of patients for revascularization therapy, with the underlying idea to select candidates based on individual vascular and physiologic information rather than on rigid time windows. The effectiveness of these therapeutic options is not entirely time dependent. In line with the 2018 AHA/ASA guidelines for

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management of AIS, we will review and discuss the role of CT perfusion, diffusion-weighted imaging, and perfusion-weighted imaging as advanced imaging techniques to facilitate decision making for mechanical thrombectomy.

Materials and Methods
According to the current evidence, we will develop the following points: (1) Endovascular treatment in acute stroke with early window (<6h from symptoms onset): evidence from clinical trials; (2) Endovascular treatment in acute stroke with late window (6-24h from symptoms onset): evidence from clinical trials; (3) Multimodal imaging-based treatment selection; (4) Role of mismatch; and (5) Role of collaterals.

Results
Where the randomized clinical trials published in 2015 established the indication of EVT within 6 to 8 hours after stroke onset, DEFUSE 3 and DAWN recently demonstrated that EVT can benefit select patients up to 16 hours and up to 24 hours after onset, respectively. The overwhelmingly positive results of these trials have led to changes in treatment guidelines and widespread adoption of EVT, and the 2018 AHA/ASA guidelines now recommend CTP, DWI, PWI be included in the standard imaging evaluation for patients within 6- to 24- hour after onset of symptoms to facilitate decision making for EVT.

Conclusions
In patients presenting with anterior large-vessel occlusion between 6 and 24 hours after AIS onset, additional advanced imaging (CTP, DWI, or PWI) is recommended to select patients who are more likely to benefit from treatment and to exclude patients who may be unaffected or adversely affected by EVT. This new approach might increase the proportion of patients eligible for revascularization. In this new era where 'imaging is brain', radiologists must be able to provide accurate and timely information to help clinicians decide on the appropriate treatment for AIS patients, and healthcare systems should be organized to facilitate the delivery of this treatment.

Figure. 70-year-old male with a history of diabetes and hypertension who presented right hemiparesis and mutism (NIHSS score, 17) 30 minutes from last know well. On non-contrast CT, early signs of ischemia in relation with loss of gray-white differentiation were assessed (total ASPECTS, 8) (arrows). CT angiography presenting with occlusion of M2 segment of the left middle cerebral artery (not shown). CT perfusion maps demonstrated decreased CBF and increased Tmax, reflecting infarct core and penumbra. Brown indicates areas of CBF<30% (14.05 mL) and red indicates areas of Tmax > 6 s (93.89 mL). In this case, there was a relative mismatch of 85%. Based on the DEFUSE 3 trial criteria (infarct core < 70 mL, mismatch volume > 15 mL, and mismatch ratio > 1.8), these findings qualified the patient for endovascular treatment. Persistent occlusion was presented after intravenous alteplase administration and patient was transferred for mechanical thrombectomy (number of passes, 3). The final recanalization grade was 2B according TICI. The infarct area is seen at 24 hours on DWI with signs of hemorrhagic infarction consisting in confluent foci throughout the infarct zone (HI2).

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Managing the Social Side of a Meeting: Observations from Twitter on the Usage of #ASNR19

G D'Anna¹, M Chen², J McCarty³, A Kotsenas⁴
¹Humanitas Mater Domini, Castellanza, Varese, Italy, ²MD ANDERSON CANCER CENTER, HOUSTON, TX, ³University of Texas Health Science Center at Houston, Houston, TX, ⁴MAYO CLINIC, ROCHESTER, MN

Purpose
To analyze Twitter usage of the #ASNR19 during the 2019 ASNR Annual Meeting utilizing Symplur signals platform, compared to the 2018 ASNR Annual Meeting.

Materials and Methods
We observed data extracted by Symplur Signals about 2019 ASNR Annual Meeting. We performed analysis of #ASNR19 hashtag between 15th and 25th of May. The data were compared (when possible) with analysis performed in 2019 with ASNR18.

Results
During the reference period, 4,177 tweets, of which 2,856 retweets, contained #ASNR19. 656 users participated in the usage of #ASNR19. This is compared to 3,020 tweets, of which 1,870 Retweets for #ASNR18. 523 users participated in #ASNR18. Symplur categorized 331 users as "Doctor" These tweets generated 8.179M impressions (ASNR18: 8.124M). Although overall the number of tweeters and tweets were higher, the number of tweets per person declined, 6.4 per tweeter on average versus 5.8 per tweeter on average. English was predominant language of choice, but we found increasing use of Spanish (14 tweets), French and Japanese (4 tweets). Location of most Twitter users were from the United States. Other countries included the UK (21 users), Canada and Spain (18). In terms of Twitter accounts, @theASNR social media account was the center of the #ASNR19 discussion.

Conclusions
Social media is an important tool at scientific meetings in connecting people, disseminating knowledge and engaging in discourse across the world on important topics. In recent years, social media usage has increased at the ASNR annual meeting with larger number of users and a broader audience, and a larger number of topics discussed. Although we saw "continued rise" in the use of the #ASNR19 the average number of tweets per person declined with minimal increase in impressions. This raises the question as to whether social media usage has plateaued. The ASNR 2019 annual meeting occurred at the same time as the ACR 2019 annual meeting, and this may have reduced potential users who may have participated in #ASNR19. Additional confounding factor is improper use of the hashtag #ASNR2019 instead of #ASNR19. Opportunities remain for specialty societies to encourage focused use before, during and after annual meetings. For example, use of the meeting hashtag prior to the event for tweet chats on hot topics to be discussed at the meeting may encourage engagement. Societies can use the hashtag as a tool to promote current research in the specialty as well as connections among its members.

Memento: Comprehensive Imaging Review of Dementia; a Primer for Neuroradiologists

H Rajebi¹, G Fahimi¹, U Salman², G Naratadam¹, B Tantiwongkosi¹, A Singh¹
¹University of Texas Health at San Antonio, San Antonio, TX, ²University of Texas Health San Antonio, San Antonio, TX

Purpose
Accurate and early diagnosis of dementia are warranted to guide management and provide support to patients. Although neuroimaging is not specific, the combination with clinical assessment improves the diagnostic accuracy. In this exhibit, we aim to explain the structural (CT and MRI), functional (99mTc-HMPAO-SPECT, DaTscan, and FDG-PET) and molecular (Amyloid-labelled PET) multimodality imaging characteristics of common and rare causes of dementia with a detailed review of the underlying anatomic, metabolic, pathophysologic and symptomatic concepts in each category.

Materials and Methods
The main radiologic features of common and uncommon causes of dementia from our institutional database with a brief presentation of epidemiologic, genetic and clinical features will be illustrated. Imaging hints and pitfalls in the diagnosis of each category with the goal of hypothesizing a systematic approach to narrow down the differential diagnosis will also be discussed.

Results
First, a brief review of structural, functional and molecular imaging evaluation of dementia will be presented. Next, a case-based review of various pathologic causes of dementia including but limited to, common cause of dementia (Alzheimer disease and its variants e.g. Logopenic dementia, Vascular dementia, Frontotemporal dementia [Pick's Disease] and Dementia with Lewy bodies) and uncommon causes (Cerebral amyloid angiopathy, Progressive supranuclear palsy, Multisystem atrophy, Creutzfeldt-Jakob disease, Huntington disease, Cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy, Corticobasal degeneration) will be demonstrated.

Conclusions
Given the high burden of dementia, timely diagnosis is consequential. Neuroimaging plays an increasingly crucial role in the
evaluation of various types of dementia. Getting familiar with novel emerging techniques and functional imaging seems warranted for every neuroradiologist in daily practice.

1904

**Metabolic and Toxic Encephalopathy**

**B Baek**

*Chonnam National University Hospital, Gwangju, Chonnam*

**Purpose**

Brain imaging plays an important role in the diagnosis of metabolic and toxic encephalopathy from the various causes, especially in case of unknown or vague past history. To illustrate the various causes of acquired metabolic encephalopathy and toxic encephalopathy. To identify hiding etiology with radiologic findings of brain CT and MRI as well as clinical manifestations.

**Materials and Methods**

Here, we describe imaging features of acquired metabolic encephalopathy and toxic encephalopathy based on our experiences and a review of the literature.

**Results**


**Conclusions**

It is indispensable for the neuroradiologist to be aware of various metabolic and toxic encephalopathy on cross-sectional brain imaging. This awareness can help to raise the confidence of diagnosis and plan the optimal treatment strategy.
Middle Ear Masses: A Neuroimaging Pictorial and Educational Review of Benign and Malignant Lesions

D Martin, D McAllister, S Hashmi, T Massoud

Purpose
The middle ear (ME) cavity contains various nerves, vessels, and ossicles to facilitate mechanical transmission of sound. ME masses are uncommon, greatly varying in pathology, anatomy, and clinical manifestations. Neoplasms may be primary tumors of the ME, or tumors of adjacent structures that involve the ME cavity. CT and MRI are useful in defining the extent and nature of these lesions, but histologic analysis is often necessary for a definitive diagnosis. Full understanding of ME masses can present a significant challenge to neuroradiologists owing to the complex anatomy and small size of the ME. We provide a pictorial and educational review of these masses to aid in neuroimaging interpretation and patient management.

Materials and Methods
We comprehensively review the imaging findings of a wide spectrum of benign and malignant lesions of the ME categorized by etiology.

Results
We describe the imaging anatomy of the ME, and then review the imaging features of ME masses, including: 1) Vascular lesions (e.g. aberrant ICA, aberrant jugular bulb, glomus tumor, and capillary hemangioma); 2) Non-neoplastic masses (e.g. meningocele, arachnoid cyst, cholesteatoma, cholesterol granuloma, and gouty tophi); 3) Benign neoplastic lesions (e.g. adenoma, carcinoid tumor, osteoma, lipoma, meningioma, schwannoma, myxoma, salivary gland/glial choristoma, and eosinophilic/plasma cell granuloma); and 4) Malignant neoplasms (including squamous cell carcinoma (SCC), embryonal rhabdomyosarcoma, adenoid cystic carcinoma, and primary adenocarcinoma). In practice, the most common primary ME tumors are glomus tumors, followed by adenomas in adults and hemangiomas in children. Primary ME tumors may extend intracranially or into other parts of the temporal bone. Malignant ME tumors are rare, and SCCs are the most prevalent, usually occurring with neglected chronic infection of the ME. Benign ME tumors also may be locally destructive despite their favorable histopathology. Benign tumors of adjacent structures that may invade the ME include vestibular and facial nerve schwannomas, temporal meningiomas, and parotid tumors. We discuss management of these ME masses, including the indications for further imaging.

Conclusions
Prompt diagnosis and treatment of ME masses are necessary to prevent progression of audiologic, vestibular, and facial nerve dysfunction. This presentation will aid in neuroimaging interpretation and understanding of ME masses to improve patient management.

1701
Middle Meningeal Artery Embolization for the Treatment of Chronic Subdural Hematoma

J Asmar, S Ghosh

Purpose
To describe the available treatment options for chronic subdural hematoma (cSDH) including the relatively newer endovascular method for treating cSDH with middle meningeal artery (MMA) embolization.

Materials and Methods
We discuss the indications for each treatment option and focus on the advantages of MMA embolization for cSDH. Using data from our own institution and recently published studies, we highlight the success rates with MMA embolization.

Results
MMA embolization is an emerging minimally invasive endovascular technique for treatment of cSDH in patients who are poor surgical candidates or who have refractory cSDH. cSDH is estimated to be the most common neurosurgical diagnosis in adults within the next decade (1). Often bilateral, cSDHs can be very disabling to patients, causing stroke symptoms such as speech impairment and weakness, chronic headache, or reversible dementia. In general, conservative management of a cSDH is favored if the patient is asymptomatic, has minor symptoms, and has a cSDH measuring < 10mm in thickness with < 5mm of midline shift (2). Surgery is favored if symptoms are severe or if the cSDH is large. Surgery presents a number of challenges, however. In addition to patients often being poor surgical candidates, stroke prophylactic therapy has to be discontinued and repeat intervention may be necessary to address SDH recurrence. MMA embolization is an appealing alternative as it may allow the patient to continue stroke prophylactic therapy and it can serve as primary or adjunct therapy to surgical intervention for a cSDH. The MMA can be embolized with PVA particles, Onyx, n-BCA glue, and/or a coil. 9 cases of MMA embolization performed at our institution for cSDH had no procedural complications. MMA embolization was favored as the preferred therapeutic option for cSDHs based on a retrospective study by
Okuma et al and in a meta-analysis study conducted by Srivastan et al. There was a lower reported recurrence rate of cSDH following MMA embolization in comparison with conventional management (3,4).

Conclusions
Middle meningeal artery embolization offers an effective alternative to treat chronic subdural hematomas, especially in high risk patients for whom surgical management is more challenging. As the popularity of the intervention continues to grow, we expect further trials to highlight its utility for treatment of chronic subdural hematomas.

(a) Lateral view of a selective DSA of the middle meningeal artery. (b) Frontal view of the selected middle meningeal artery injection demonstrates opacified meninges separated from the inner table of the calvarium by the chronic subdural hematoma.

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1583

Mimics of Perineural Spread in the Head and Neck

M Tanwar¹, B Branstetter²
¹University of Pittsburgh, Pittsburgh, PA, ²UPMC, Wexford, PA

Purpose
Perineural spread (PNS) is an important potential complication of head and neck malignancies, as it is associated with decreased survival and a higher risk of local recurrence and metastasis. Most cases of PNS occur in patients with squamous cell carcinoma because of its highest incidence. But adenoid cystic carcinoma has the highest relative incidence of PNS, with rates over 50%.

Accurate assessment of PNS is a critical task for head and neck radiologists, and there are many review articles focused on the imaging findings of PNS. However, a false positive diagnosis of PNS can be just as harmful to the patient as an overlooked case of PNS. In this educational exhibit, we delineate and classify various imaging mimics of perineural spread.

Materials and Methods
Review of case material from a single institution, with accompanying literature review.

Results
Mimics can be divided into the following categories: - Normal variants, including vascular structures - Infectious - Inflammatory, including granulomatous - Demyelination - Neoplastic - Hereditary - Treated tumor
Conclusions
Accurate assessment of perineural spread can be critical in head and neck malignancy management. A knowledge of potential mimics of PNS will prevent false-positive imaging interpretation.

Minimally Invasive Methods for Deep Brain Stimulation

A Shrigiriwar¹, T Garg²
¹Seth GS Medical College & KEM Hospital, Mumbai, Maharashtra, ²Seth GS Medical College & KEM Hospital, Mumbai, India

Purpose
1. Learn about various treatment modalities available for neurostimulation 2. Compare and contrast between surgical deep brain stimulation(DBS), endovascular DBS, gamma knife radiosurgery and focused ultrasound 3. Learn about the numerous systems proposed for endovascular DBS

Materials and Methods
Use of DBS has been approved for a number of ailments such as Parkinson’s disease, epilepsy, essential tremor, etc due to its proven effectiveness. Currently, MRI is used to map and locate the area of the brain where the electrode is to be placed. The electrode is then placed in the brain via craniotomy (awake/unconscious) and post-placement electrode recordings are obtained and utilized to assess the location of the placed electrode. Due to the need for craniotomy, surgically placed DBS systems are associated with many complications which has warranted the need for a safer and effective procedure.

Results
Non-incisional alternatives to DBS such as focused ultrasound and Gamma Knife Radiosurgery are therapeutically effective with advantages such as highly precise targetting and no need for subsequent visits to replace batteries/broken wires as required in surgically placed electrodes. However, they are associated with transient and permanent neurological deficits. Endovascular techniques are the standard of care for aneurysm management, thrombectomy and other cerebral diseases due to minimal associated complications. Presently, a wireless cardiac pacing system with intravascularly placed leads has been patented, indicating that there is scope for intravascularly placed electrodes in the brain for neuromodulation. Capillaries reach up to all aspects of the brain, therefore the development of electrodes less than 10µ in thickness can virtually reach anywhere. Numerous patents listed for minimally invasive endovascular cranial lead insertion include stent-based lead anchors and disease-specific systems. Endovascular stent placement enables multicentric stimulation which when recorded mimics a normal brain response. Limitation of the endovascular approach is vessel injury and thrombosis which can be overcome by using small devices, prescribing antiplatelet therapy, and stent coating.
Conclusions
Minimally invasive DBM has tremendous scope in the future because of its easy feasibility, fewer associated complications and faster recovery time.

1516

Moguls of the Skull Base Slope - A Pictorial Review of Pathological Processes Involving the Clivus

A Wrubel1, D Noujaim2, S Patel3, B Griffith2
1Henry Ford Health System, Birmingham, MI, 2Henry Ford Health System, Detroit, MI, 3HENRY FORD HOSPITAL, DETROIT, MI

Purpose
A wide spectrum of pathology can involve the clivus from metastatic tumors and invasive tumors, to primary and hematopoietic neoplasm. Given clinical findings are nonspecific, if present, imaging is required for identifying and characterizing lesions affecting this region. However, given the breadth of pathology involving the clivus, classifying the lesion can be challenging, requiring localization of the center of the mass and knowledge of signal characteristics of potential pathology. In this pictorial review, we will discuss the normal anatomy of the clivus and surrounding structures, along with key differentiating imaging features of various pathological conditions involving the clivus.

Materials and Methods
• Using diagrams, MRI, and CT we will discuss the anatomy of the clivus, particularly its relationship to surrounding anatomic structures. • Using representative case files, we will review a variety of common and uncommon pathologies affecting the clivus including: invasive pituitary macroadenoma (Fig 1A), plasmacytoma (Fig 1B), chordoma (Fig 1C), chondrosarcoma (Fig 1D), giant cell reparative granuloma, clival metastasis, fibrous dysplasia, multiple myeloma, lymphoma, intraosseous meningioma, ecchordosis physaliphora, sphenoid sinus mucocele, invasive nasopharyngeal carcinoma. • We will discuss imaging features that can help in differentiating the pathology within these spaces and in formulating an appropriate differential diagnosis.

Results
Key Learning Points: • Differential diagnoses and features of pathology of the clivus using a case-based approach, including their imaging appearance. • Normal anatomy of the clivus and surrounding structures will also be reviewed.

Conclusions
Evaluating clival pathology on imaging requires an understanding of the surrounding anatomy and pathology involving those structures, in addition to intrinsic disease processes. This exhibit will provide viewers with an in-depth pictorial review of both common and uncommon pathologies affecting the clivus, differential diagnoses, and how to differentiate lesions involving this region on imaging with emphasis on key differentiating imaging features.
MRI and PET/CT Findings in Creutzfeldt-Jakob Disease: Differentiating Between Different Forms

**W Calderon Miranda**, P Puac Polanco, M Boll Woehrlen, J Balderrama, A Rovira, M Castillo, P Naval-Baudin

1Hospital Universitari Vall d’Hebron, Barcelona, Spain, 2University of Ottawa, Ottawa, Ontario, 3Instituto Nacional de Neurología y Neurocirugía, Mexico city, Mexico city, 4University of North Carolina at Chapel Hill, Chapel Hill, NC, 5Bellvitge Hospital Universitari, Hospitalet de Llobregat, Barcelona

**Purpose**

Creutzfeldt-Jakob Disease (CJD) is a catastrophic neurodegenerative disorder caused by prion infection that leads to spongiform degeneration of the brain. It is estimated that the annual incidence is approximately 1 per 1 million population. CJD may be classified into 3 groups: sporadic, genetic or acquired. MRI is the mainstay in the neuroimaging assessment of CJD. Diffusion-weighted imaging (DWI) detects abnormalities much earlier than conventional sequences. Widespread brain hypometabolism is the main finding detected on PET/CT. In this exhibit, we illustrate the imaging findings of CJD on MRI and PET/CT.

**Materials and Methods**

Participants will be able to recognize MRI and PET/CT manifestations of CJD and understand the usefulness of DWI in the diagnosis and follow up of this entity as well as describe other conditions that may mimic CJD.
Results
We discuss the epidemiology, pathology and classification of prion diseases, molecular subtypes of CJD, imaging findings including patterns of involvement, diagnostic criteria and differential diagnosis.

Conclusions
CJD is a rare cause of rapidly progressive dementia with most patients dying within one year of onset. Knowledge of imaging patterns and diagnostic criteria helps in early diagnosis and appropriate management of these potentially infectious patients.

MRI Findings of Secondary Neuronal Degeneration

E LEE

1Dongguk University Ilsan Hospital, Goyang-si, Gyeonggi-do

Purpose
1. To review the pathophysiology of neuronal degeneration. 2. To show their neuronal pathway diagrams, clinical presentation, and important MR imaging features. 3. To help the radiologist recognize and understand secondary neuronal degeneration that is caused by intracranial abnormalities.

Materials and Methods
1. Introduction and general overview of secondary neuronal degeneration 2. Review of various types and their neuronal pathways of secondary neuronal degeneration - corticospinal tract, pontocerebellar fiber, corpus callosum, limbic system, crossed cerebellar diaschisis/atrophy, hypertrophic olivary degeneration, retrograde thalamic degeneration, and visual pathway. 3. Role of MR imaging including diffusion weighted imaging

Results
Intracranial lesions often lead to changes in neurons remote from the site of the primary abnormality. This secondary degeneration of white matter fibers should not be misinterpreted as a primary ischemic, traumatic, or neoplastic process. Secondary white matter degeneration is classically divided into retrograde and anterograde (or Wallerian) degeneration. These abnormalities can be clearly demonstrated by MR imaging. Diffusion weighted imaging can help detect early Wallerian degeneration. The use of diffusion tensor imaging maps can assist in diagnosing and determining the extent of diseases that cause fiber damage and neuronal degeneration.

Conclusions
Intracranial lesions often produce remote physiologic and anatomic abnormalities because the lesions affect the complex neuronal connections. The ability to investigate secondary degeneration noninvasively would be valuable not only to improve diagnosis of many neurological diseases, but also to facilitate the study of human functional neuroanatomy. Knowledge of cranial pathways and imaging findings of secondary degeneration can prevent misdiagnosing them as separate primary abnormalities.
MRI guided laser ablation for epilepsy - What a radiologist needs to know?

M Kuruva¹, J Allen², J Willie³, R Hu²
¹Emory University School of Medicine, Atlanta, GA, ²Emory University, Atlanta, GA, ³Emory University School of Medicine, ATLANTA, GA

Purpose
MRI guided laser ablation (MGLA) is relatively new technique and is being increasingly used to treat various intracranial pathologies which include mesial temporal sclerosis, cortical dysplasias, hamartomas and gliomas. Knowledge of these imaging findings is important to avoid pitfalls and to provide accurate interpretation. However, limited literature exists in radiology about the imaging findings post MGLA. In this exhibit we aim to briefly review the indications, expected imaging findings and also provide few examples of complications and pitfalls post MGLA.

Materials and Methods
N/A

Results
The most common indications MGLA was performed were for mesial temporal sclerosis, EEG positive seizure focus with or without imaging correlates, low grade gliomas, metastases and cortical dysplasias. Common findings post ablation were diffusion restriction in and around ablation zones, FLAIR hyperintensity, post contrast enhancement (image 1 and 2). Most common complication was trace subdural hemorrhage, followed by intra ablation zone petechial hemorrhage. However an unique artifact was noted on FLAIR images as FLAIR non suppression of signal in sulcal spaces (due to heating induced alterations of T1 relaxation time) (image 3). Rare complications were facial nerve palsy with imaging features of asymmetric enhancement of facial nerve (image 4).

Conclusions
Familiarity with indications, expected imaging findings, complications helps radiologists to provide accurate interpretation of imaging post MRI guided ablation.
Multi-modality Imaging of Hereditary Paraganglioma-Pheochromocytoma Syndrome in the Head and Neck

Y Ota¹, T Moritani¹, S Naganawa¹, A Capizzano¹, J Kim¹, A Srinivasan¹
¹University of Michigan, Ann Arbor, MI

Purpose
In order to review multi-modality imaging of hereditary paraganglioma-pheochromocytoma and types of genetic mutations

Materials and Methods
There is a wide range of genetic mutations associated with intra-and extra-adrenal paragangliomas so called hereditary paraganglioma-pheochromocytoma syndrome. Since paragangliomas (PGLs) can be hormonally active with excess catecholamine secretion, early radiological diagnosis is important to prevent potentially fatal untreated malignant hypertension and cardiac arrhythmia. We present typical radiologic patterns of head and neck PGLs associated with genetic mutations. SDH enzyme complex comprises four subunits and each encoded by separate genes (SDHA, SDHB, SDHC, and SDHD). The fifth gene encodes the separate SDHAF2 factor. Mutations in any of these genes result in deactivation of SDH enzyme, accumulation of succinate, and increased production of oxygen.
free radicals which lead to tumor formation. The cumulative risk of unaffected carriers of SDHB, SDHD, and SDHC developing PGLs by the age of 60 years was not low, which supports the need for lifelong surveillance of asymptomatic carriers.

Results
Typical appearance of head and neck PGLs on CT and MRI is well-circumscribed heterogeneous highly vascular tumors with intense contrast enhancement. CECT offers excellent contrast and spatial resolution. CTA demonstrates vascular relationship to the tumor for surgical planning. MRI including whole body MRI offers better soft-tissue contrast which is useful for the long-term surveillance. DWI/ADC helps to distinguish benign from malignant tumors. Lower ADC values suggest malignant lesions. DCE-MRI has been used for tumor characterization. Malignant tumors tend to show strong initial signal increase followed by washout effect, whereas benign lesions demonstrate slow initial signal enhancement combined with continuous signal increase. US is the first study performed for a cervical PGLs showing well-circumscribed hyperechoic heterogeneous ovoid mass. Color Doppler US shows marked hypervascularity and intratumoral vessels. MRS can detect a succinate peak with SDH mutations. 123I-MIBG SPECT/CT is the widely used functional imaging for assessment of sympathetic PGLs. 68Ga-Dotatate PET is highly sensitive for the detection of PGLs.

Conclusions
We reviewed multi-modality imaging of hereditary paraganglioma-pheochromocytoma syndrome and types of genetic mutations. Radiologists should be aware of the characteristic imaging findings and genetics.

(Multispatial Necrotizing Cellulitis of the Floor of Mouth (Ludwig's Angina). Imaging Findings and Pathophysiology

K Sullivan1, C Li1, M Goldberg1, M Spearman1, A Sohn1, C Wanamaker1, M Kulzer2, W CHANG3
1Allegheny Health Network, Pittsburgh, PA. 2Allegheny Health Network, PITTSBURGH, PA. 3ALLEGHENY HEALTH NETWORK, PITTSBURGH, PA

Purpose
Ludwig's Angina is a diffuse, rapidly progressive and potentially life-threatening multispatial abscess/cellulitis involving the soft tissues of the neck. Early recognition is essential to ensure successful treatment and the radiologist plays a key role in the primary detection of this infection and its potential complications. The most common etiology of Ludwig's Angina is odontogenic infection that leads to a floor of mouth cellulitis, most commonly from the roots of the second or third mandibular molars. Rapid spread to the surrounding tissues associated with severe edema can lead to devastating consequences, including airway compromise and descending mediastinitis. However peritonsillar abscess can lead to a similar clinical course.

Materials and Methods
In this exhibit, we will discuss the typical clinical history, physical exam findings, and laboratory values in patients with the clinical diagnosis of Ludwig's Angina. Subsequently, we will review the pertinent imaging findings, including cases of both odontogenic and...
peritonsillar origin. We will also discuss the pathophysiology and paths of spread of infection, discuss the normal anatomy of the spaces of the suprahoid neck and discuss potential treatment options.

Results
Ludwig's Angina from odontogenic origin is typically a result of odontogenic infection involving the 2nd and 3rd mandibular molars extending below the mylohyoid muscle into the submandibular space resulting in cellulitis and/or abscess with subsequent extension to the sublingual and submental spaces, resulting in trismus, dysphagia, and potential airway compromise. Airway compromise is usually related to the sublingual space infection which results in tongue displacement, airway narrowing/edema and increased secretions. Less commonly, a peritonsilar abscess could extend to the parapharyngeal space and subsequently to the submandibular, sublingual, and submental spaces, resulting in a similar presentation. In each case, the aggressive nature of this infection can result in life threatening airway compromise if prompt treatment is not initiated.

Conclusions
Ludwig's angina is a severe and potentially life-threatening infectious cellulitis involving the soft tissue spaces of the neck most commonly arising from odontogenic disease involving the mandibular molars but also from oropharyngeal abscess. Due to the aggressive nature of this infection, and its potential for devastating consequences, early radiologic detection is essential to ensuring prompt diagnosis and treatment.
Figure 1: a-b) Axial CT images showing hypodense fluid collections in the peritonsilar and parapharyngeal spaces (green asterisk) extending to the submandibular (purple asterisk) and sublingual spaces (red asterisk) compatible with multispatial abscess, likely of peritonsilar origin. c-d) Axial CT showing recent tooth extraction, with hypodense fluid collections in the parapharyngeal (green), submandibular (purple), parotid (yellow asterisk), and sublingual (red) spaces, compatible with multispatial abscess of odontogenic origin. (Filename: TCT_1625_ludwig5.jpg)

Neck post radiation changes: Spectrum of imaging findings
H Al-Jadiry1, T Shestopalova2, R Chaudhary1
1University of Texas Medical Branch, Galveston, TX, 2UTMB, Galveston, TX

Purpose
Radiotherapy is an essential treatment modality for head and neck cancers. Patients who have been irradiated are often followed up with cross sectional imaging for surveillance of their treated disease. Being aware of post radiation changes and differentiating it from tumor recurrence or treatment complications is crucial in management of these patients. In this educational exhibit, we will outline the imaging findings of early and late post radiation changes which would be a helpful tool for radiology practice.

Materials and Methods
The presentation is summarizing early and late effects of post radiation. The exhibit includes cross sectional imaging with discussion of imaging findings, differential diagnoses and distinguishing features, final diagnosis as well as risk and timing of post radiation changes.

Results
The list of post radiation changes included in the presentation: 1) Early post radiation changes - Postradiation skin and soft tissue changes, - Major salivary glands changes - Pharyngeal and parapharyngeal post radiation changes 2) Late post radiation changes - Salivary glands changes - Thyroid gland changes - Radiation induced chondronecrosis and osteoradionecrosis - Large vessel radiation induced changes

Conclusions
Radiotherapy can cause several soft tissue changes which might be confusing for disease recurrence or treatment complications. Awareness of these changes in the absence of detailed history will improve report quality and impact patient's management.

2657

Necrotizing lesions of the pediatric brain.

A Jaju1, A Brahmamdam2, M Ryan3, S Palasis4
1Ann & Robert Lurie Children's Hosp of Chgo, Chicago, IL, 2Northwestern University Feinberg School of Medicine, Chicago, IL, 3ANN & ROBERT H. LURIE CHILDREN'S HOSPITAL OF CHICAGO, CHICAGO, IL, 4ANN AND ROBERT H. LURIE CHILDREN'S HOSPITAL OF CHICAGO, Chicago, IL

Purpose
Multiple non-neoplastic pediatric disease processes such as infections, autoimmune inflammatory conditions, demyelination, vasculitis and treatment-related changes, can cause rapidly progressive brain parenchymal injury with necrotic changes. These diseases typically have widespread parenchymal involvement, with fulminant clinical course, severe neurological sequelae and high mortality. The imaging features often overlap, however there can be some helpful clues. The laboratory features are non-specific and brain biopsies can be inconclusive as well. A combination of clinical, laboratory, radiological and neuropathological features is required to arrive at a definite diagnosis. MRI is often performed early in the course of disease, and is pivotal in guiding further clinical management and differentiating non-neoplastic versus neoplastic process. Learning Objectives: 1. To understand the non-neoplastic pathologies that can cause fulminant necrotic brain injury in children 2. To understand the specific imaging features that can point to a more specific diagnosis and differentiate these conditions from aggressive or cystic neoplasms.

Materials and Methods
N/A

Results
The pathologies leading to rapidly progressive, necrotic lesions of the pediatric brain typically present with expansile T2 hyperintensities with patchy post contrast enhancement, that can progress to cavitory lesions with ring enhancement. On histopathology, these lesions may show edema, petechial hemorrhage and necrosis with presence of disease-specific changes such as inflammatory cells, demyelination, immune cell proliferation and vasculitis. MRI of the spine can add valuable additional information. The imaging features of the following conditions will be discussed with reference to laboratory and histopathological findings as relevant. 1. Infectious: Herpes simplex virus (HSV) and other viral, bacterial and fungal infections 2. Inflammatory and autoimmune: Acute necrotizing encephalopathy of childhood which could related to preceding viral infection, or the familial form associated with RANBP2 gene mutation; hemophagocytic lymphohistiocytosis (HLH) – primary or secondary; other idiopathic inflammatory conditions 3. Demyelination: Tumefactive type – isolated or associated with multiple sclerosis; neuromyelitis optica spectrum or anti myelin oligodendrocyte glycoprotein (MOG-IgG); acute hemorrhagic leukoencephalitis 4. CNS vasculitis: Primary CNS angiitis and other forms 5. Treatment-related: Radiation necrosis

Conclusions
N/A
Fig a & b- Axial T2 weighted images showing large expansile lesions in bilateral posterior white matter on the initial study (a) that progressed to necrosis one week later (b). The biopsy showed neutrophilic inflammation.

Fig c&d- Axial T2 weighted and axial post contrast T1-weighted images show expansile, partially cystic/necrotic left frontal lobe lesion with ‘incomplete ring-like’ enhancement. The biopsy showed demyelination and no evidence of neoplastic cells.

(Filename: TCT_2657_ASNR2.jpg)
Neurocysticercosis Endemic in the Borderland: Imaging Utilization for Diagnosis of Disease Spectrum

A Rohana¹, K El Salek², C Mullins³, J Gavito-Higuera⁴
¹Texas Tech University Health Sciences Center El Paso, El Paso, TX, ²Texas Tech, El Paso, TX, ³Texas Tech University Health Sciences Center, El Paso, TX, ⁴Texas Tech University El Paso, El Paso, TX

Purpose
1. Discuss the epidemiological significance of cystercosis. 2. Review of the disease course of neurocysticercosis and infecting agent. 3. Discuss the spectrum of imaging characteristics and classification of neurocysticercosis.

Materials and Methods
N/A

Results
N/A

Conclusions
Neurocysticercosis (NCC) is one of the major parasitic diseases of the central nervous system that classically presents with seizures and other non-specific clinical symptoms, deeming medical diagnostic imaging a crucial part of diagnosis. Typically encountered in developing countries and endemic areas, globalization has resulted in the spread of the disease outside of these regions. It has proven to be seen at particularly higher rates within borderland towns where there is daily travel and international commerce. Cysticercosis is a result of fecal-oral transmission of eggs of the tapeworm Taenia solium. The eggs lodge in the capillaries of muscle and brain tissue and over a three-month course evolve from immature cysts to larval cysts. There is no inflammatory response as long as the wall of the cyst remains intact. When the parasite dies, an inflammatory response with perilesion edema supervenes and ultimately a calcified lesion forms.¹ The Center for Disease Control (CDC) named NCC to be one of the Neglected Parasitic Infections (NPIs), a group of five parasitic diseases that have been targeted by CDC for public health action based on number of people infected, severity of the illnesses, and ability to prevent and treat them.² There are both intra-axial and extra-axial locations where the infection can manifest: subarachnoid space, parenchymal, with the ventricles, and a spinal form. Additionally there are multiple different stages in which the infection can present, noncystic, vesicular, colloidal vesicular, granular nodular and nodular calcified.¹ With these varying locations and each of these stages having their own unique imaging characteristics, diagnosis can be challenging. The aim of this presentation is to retrospectively examine multiple imaging cases within our border town hospital at different stages of the disease to raise awareness among physicians about NCC in hopes of achieving early diagnosis and appropriate management.
Neuroendovascular Devices: A Primer for the Diagnostic Radiologist

J Henain¹, J Henain¹, C Chung¹, M Zygmont¹, B Awad², J O'Keefe¹, B Howard¹, R Peterson³
¹Emory University School of Medicine, Atlanta, GA, ²Drexel, Airmont, NY, ³EMORY UNIVERSITY SCHOOL OF MEDICINE, NORCROSS, GA

Purpose
In recent years, innovations in the neuroendovascular field have introduced multiple novel devices and techniques, greatly expanding the neurointerventionist's armamentarium. The emergence of novel treatment strategies, such as flow diversion and flow disruption for treating intracranial saccular aneurysms, has improved the versatility and feasibility of treating complex cases endovascularly. As such, endovascular approaches have evolved to become the mainstay of treatment for various cerebrovascular conditions. With the different types of interventions available, it is critical for the diagnostic radiologist to have a current and intimate knowledge of the devices used, including their gross appearance, radiographic appearance immediately post-intervention, and expected evolution over time.

Materials and Methods
Describe and discuss the expected and unexpected radiographic appearance of neuroendovascular devices used in the treatment of conditions such as cerebral aneurysms, arteriovenous malformations/fistulas, atherosclerotic disease, and ischemic stroke.

Results
This educational exhibit systematically introduces devices commonly used to by the neurointerventionist including coils, stents, Pipeline embolization device (PED), Woven Endobridge (WEB), liquid embolics/particles and stentriever. We show photographs of the devices ex vivo and discuss their underlying treatment principles. Radiographic appearance immediately post-intervention and evolution over time are highlighted. Case-based examples are used to demonstrate unexpected findings and post-treatment complications.

Conclusions
Imaging plays a critical role in evaluating the success of endovascular therapy for cerebrovascular conditions and assessing unforeseen complications following intervention. Up-to-date knowledge of the various devices and their appropriate radiographic appearance over time is essential for the diagnostic radiologist, such that potential post-intervention complications can be promptly and accurately recognized.

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Neuroimaging for Mechanical Thrombectomy in Early- and Late-Window Ischemic Stroke: What the On-Call Radiologist Needs to Know.

D Wolman¹, J Heit¹
¹Stanford University Hospital, Stanford, CA

Purpose
To provide a practical overview of the evidence-based neuroimaging methods of evaluating thrombectomy candidacy in patients presenting with acute ischemic stroke in the early- and late-window.

Materials and Methods
This educational exhibit provides a step-by-step discussion of how to utilize the latest neuroimaging techniques when evaluating a patient for thrombectomy candidacy. The goal of the presentation is to provide a practical and clinically focused description of the following topics: 1. Mechanics of acute ischemic stroke and fate of ischemic tissue 2. Goals and methods of stroke management and reperfusion 3. Checklist for the evaluation of large-vessel ischemic stroke 4. Fundamentals of perfusion imaging 5. Pre-treatment imaging of early-window ischemic stroke 6. Pre-treatment imaging of late-window ischemic stroke

Results
The goal of mechanical thrombectomy in the treatment of large-vessel occlusive acute ischemic stroke is to rescue the greatest volume of penumbral tissue. Pre-interventional neuroimaging evaluates patient candidacy on the basis of four critical parameters; (1) the presence of a large-vessel occlusion, (2) the presence of a small core infarct, (3) the presence of salvageable penumbral tissue, and (4) the absence of cerebral hemorrhage1. Multiple methods are available to accurately evaluate each of these parameters using either CT or MRI, with differing requirements in the early- (0-6 hours) and late-windows (6-24 hours)2-4. Early-window evaluation can be safely performed in the absence of perfusion imaging, however all late-window evaluations necessitate the use of perfusion imaging, which is a unifying technique in the modern evaluation of large-vessel occlusive stroke. Each potential method is reviewed in detail in this exhibit.

Conclusions
Evaluation of patient candidacy for endovascular thrombectomy can be performed using CT or MRI, requiring only parenchymal and vascular assessment in the early-window, while evaluation of all late-window patients requires perfusion imaging. This educational exhibit provides a simple, evidence-based methodological overview for the on-call radiologist to accurately evaluate patients presenting with large-vessel occlusive acute ischemic stroke.
Neuroimaging in Coma, Brain Death and Related Conditions

E Zamora¹, C Zamora²
¹Montefiore Medical Center, The Bronx, NY, ²University of North Carolina at Chapel Hill, Chapel Hill, NC

Purpose
Present an overview of the pathophysiology leading to alterations of consciousness and discuss the role of various neuroimaging modalities in the evaluation of coma, brain death, and associated conditions.

Materials and Methods
This image-rich educational exhibit will discuss various conditions that result in coma and other alterations of consciousness based on our experience across two large academic institutions.

Results
Coma is a prolonged state of unarousable unresponsiveness to outside stimuli frequently seen in critical care patients. Different terms have been variably used to describe states between alertness and coma, including, stupor, lethargy, and obtundation. The causes of coma are varied and include direct injury to the ascending reticular activating system (which has a primary function in arousal and consciousness), bilateral and diffuse involvement of the cerebral hemispheres (e.g. drugs, toxic, metabolic, and infectious etiologies), or unilateral lesions that are large enough to exert mass effect on the contralateral hemisphere or brain stem (patients with horizontal displacement of septum pellucidum > 13 mm are usually comatose). Importantly, there are conditions that may mimic coma but where patients have preserved consciousness: locked-in syndrome (injury to the basis pontis), akinetic mutism, and psychogenic unresponsiveness, all of which warrant a careful neurological examination. Computed tomography is usually the first imaging modality in patients with acutely altered mental status and often reveals space occupying or diffuse cerebral lesions, however MRI is the gold standard to evaluate the extent of abnormalities and to further narrow the differential diagnosis. Metabolic nuclear imaging methods are also available for evaluating other coma-like states, including epilepsy or neurological syndromes such as persistent vegetative states. 18F FDG PET has a role in the evaluation of seizures as well as persistent vegetative states while other methods such as 99mTc-HMPAO SPECT brain perfusion or brain blood flow using 99mTc-DTPA are used in the determination of brain death.

Conclusions
This educational exhibit is an overview of the contribution of neuroimaging in the evaluation of coma-like states and associated pathologies. Clinical examination is often limited and neuroimaging serves as a tool for diagnosis, management and patient prognosis.
Neuroimaging of Sickle Cell Disease and the Complications of its Treatment

D Mallon¹, M Singh², L Dixon², A Gontsarova², W Jan², O Kirmi³, F Tona³
¹Imperial College London/Imperial College Healthcare NHS Trust, London, United Kingdom, ²Imperial College Healthcare NHS Trust, London, United Kingdom, ³Imperial College Healthcare NHS Trust, London, United Kingdom

Purpose
Sickle cell disease (SCD) is the most prevalent hereditary anemia and is characterized by abnormal erythrocyte development. Distorted erythrocytes predispose to vascular occlusions that most commonly affect the bone, lungs and brain. The cerebral manifestations of SCD are particularly important due to their association with significant functional disability and cognitive impairment. The interpretation of neuroimaging in this patient cohort is often challenging because acute and chronic manifestations of SCD and the cerebral complications of its treatment have overlapping imaging features and often coexist.
Materials and Methods
This review provides a broad range of cases to help navigate the complex task of differentiating between these entities.

Results
Case discussion
Acute cerebral manifestations of SCD:
- Ischemic and hemorrhagic stroke
- Intracranial venous thrombosis
- Posterior reversible encephalopathy syndrome (PRES) (Figure 1A)
- Calvarium bone infarction (Figure 1B)
- Fat embolism syndrome (Figure 1C)

Chronic cerebral manifestations of SCD:
- Silent cerebral ischemia
- Moyamoya-like vasculopathy (Figure 1D)

Complications of SCD therapy:
- Brain iron accumulation following recurrent blood transfusions
- Failure of arterial bypass for moyamoya-like vasculopathy
- Intracranial infections in immunosuppressed patients following bone marrow transplant (BMT)
- Acute hemorrhagic leukoencephalitis in a pancytopenic patient following BMT
- CMV vasculitis in immunosuppressed patient following bone BMT.

Conclusions
This review of a large series of cases will aid the neuroradiologist in identifying and distinguishing between the acute and chronic manifestations of sickle cell disease and the cerebral complications of SCD treatment.

(Filename: TCT_2230_figure_1.jpg)

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Neurometabolic Diseases In Children: An Update In The Era Of Genomics

M Raja¹, M Osman², J AlRayahi³

ASNR20 Virtual Proceedings Page 189
Purpose
To present an update on the current classification of neurometabolic diseases in children in relation to neuroimaging To discuss the role of imaging in metabolic diseases in children following the recent accelerated advancements in the field of neurometabolic genomics

Materials and Methods
This review is based on our experience at a single-centered pediatric tertiary care hospital in a region that has a high prevalence of neurometabolic diseases. Herein, we aim to review the wide variety of neurometabolic diseases, ranging from the pathognomonic to the uncommon, along with typical examples of each. - To discuss the different current neurometabolic classifications based on pathophysiology, pathological changes & pathogenetic mechanisms - To discuss the pros and cons of neuroimaging versus genomic evaluation of neurometabolic diseases - To discuss the role of neuroimaging in the detection, diagnosis and follow up of neurometabolic disorders - To reemphasize and expand upon the pattern recognition approach in the evaluation of neurometabolic disorders

Results
The introduction of whole exome sequencing in 2005 has brought a surge in the understanding of pathogenetic mechanisms of several neurometabolic disease, giving rise to newer classifications, resulting in a drop in the percent of leukodystrophies with unknown etiology from 50% to 20% between 2010-16. Meanwhile, concerns about the significance of neuroimaging in comparison to genetic workup have risen. Neuroimaging plays a paramount role as the first line in evaluation of patients with suspected neurometabolic disease. This is as follows: 1)Confirming the suspicion of neurometabolic disease, 2) Utilizing the pattern recognition approach in the evaluation of neurometabolic diseases to "special" imaging and clinical lower features & 3) concluding whether the findings are a)pathognomonic of one disease, b)suggestive of a group of diseases or c) non-specific. This will aid in early management and in deciding for further genetic testing - i.e. gene panel versus WES

Conclusions
Neurometabolic diseases in children are highly heterogeneous, manifesting in people of all ages and most commonly with a progressive course. Some neurometabolic disorders, however, show response to treatment in the early stages which makes early diagnosis all the more important. Here we highlight the role of neuroimaging as the first line of evaluation & emphasize the importance of creating a multidisciplinary metabolic team along with neurologist and the genetic pathologist.
Neuroradiology Big Wigs-Part 2 Brain and Spine

C Tournade¹, F Boucher¹, B Yaldoo¹, J Kim¹, T Moritani¹
¹University of Michigan, Ann Arbor, MI

Purpose
Throughout medicine, and specifically within the field of neuroradiology, eponyms remain intertwined within anatomy and pathology. An eponym is a word or phrase derived from a person's name. Medical eponyms often acknowledge an individual who played a major part in identifying or furthering knowledge related to a particular anatomic or pathologic process. Eponyms can be useful in providing a concise description of a complex disease process, such as Parkinson's disease or Creutzfeldt-Jakob disease where more descriptive terminology can be cumbersome. However, eponyms may also be confusing or misleading.

Materials and Methods
Representative images were retrieved from the University of Michigan imaging archives to illustrate 36 specific neuroradiologic eponyms of the brain and spine.

Results
Brain:
- Aguecheek disease
- Alzheimer disease
- Balo concentric demyelination
- Bing-Neel syndrome
- Bourneville disease
- Canavan disease
- Creutzfeldt–Jakob disease
- Farh syndrome
- Hallervorden-Spatz syndrome
- Huntington disease
- Joubert syndrome
- Lazarus complex
- Leigh syndrome
- Louis-Bar syndrome
- Machiafava Bignami syndrome
- Ondine's curse
- Parkinson disease
- Sturge Weber syndrome
- von Hippel-Lindau disease
- von Recklinghausen disease
- Wallenburg syndrome
- Wernicke-Korsakoff syndrome
- Wilson disease

Spine:
- Baastrup syndrome
- Brown-Sequard syndrome
- Chance Fracture
- Devic disease
- Foix-Alajouanine syndrome
- Coup de poignard of Michon
- Gibbus deformity
- Hirayama disease
- Holdsworth fracture
- Jefferson fracture (Atlas)
- Klippel–Feil syndrome
- Kümmell disease
- Pott disease
- Scheuermann disease

Conclusions
Given the continued common use of eponyms within the field of neuroradiology, familiarity with these terms and their pathologic significance can benefit the neuroradiologist in succinctly communicating within their clinical colleagues.
Non-large-vascular-territory-ischemia: from Moyamoya to Hypereosinophilia and Everything In Between

**J Starkey**¹
¹N/A, N/A

**Purpose**
- Ischemia conforming to a large vascular territory is easily recognized, but radiologists often encounter ischemia that does not conform to a particular vascular territory
- Radiologists should understand the etiologies and mechanisms underlying ischemia that does not conform to a single vascular territory
- Radiologists should recognize specific imaging features that can either narrow the differential or provide specific diagnosis in such cases

**Materials and Methods**
- Detailed review of large and small vascular territories using CTA, MRA, and angiogram, with illustrations
- Review of watershed territories (cortical watershed and internal watershed), with a review of alternative terminologies (e.g. "border zone")
- Case based review and discussion of infarctions - MELAS - Moyamoya - CADASIL - CAROSIL - Cardiac bypass (with review of literature regarding air microemboli) - Hypereosinophilia - Trousseau syndrome - Sickle cell - Hypotension - Hypoxemia - Punctate infarct (differential) - Mimics - Review

**Results**
NA

**Conclusions**
Ischemia that does not conform to a vascular territory is common and often specific findings combined with history allows specific diagnosis.

![CADASIL Image](TCT_2622_non-vascularterritoryischemia.jpg)

Normal Variation of the Subarcuate Canal: A Rare Important Nonpathologic Structure in the Temporal Bone

**P Couture**¹, **D RAY**²
¹Vanderbilt University Medical Center, Nashville, TN, ²Vanderbilt, Brentwood, TN

**Purpose**
The purpose of the educational exhibit will be to educate radiologists on the existence and imaging appearance of the subarcuate artery and its related canal. Specifically, this exhibit will impart knowledge regarding the rare normal variants that can often be puzzling to the unaware radiologist or otologist.
Materials and Methods
In this image rich educational exhibit, the anatomy and bony landmarks of the temporal bone will be reviewed utilizing CT and MRI. A brief visual review and definition of the subarcuate canal also described in the literature as the petromastoid canal. A literature review describing the available information published on the normal anatomical variations will be summarized. The development and contents of the subarcuate canal will be reviewed followed by a discussion of the significance of properly identifying the subarcuate foramen as a normal structure uncommonly seen.

Results
Variations in the path of the subarcuate canal is an uncommon entity on routine temporal bone imaging. This canal connects the mastoid antrum with the intracranial contents. Housing the subarcuate artery, it supplies the otic capsule of the semicircular canals, vestibule, facial nerve canal, and mastoid antrum with numerous vascular anastomoses. Often, this canal regresses as one ages into adulthood. When enlarged, this entity can be easily confused as pathologic given its appearance.

Conclusions
Variations and prominence of the subarcuate foramen is uncommonly seen in the temporal bone that may generate confusion to those unfamiliar with this entity. This foramen is commonly confused for an enlarged vestibular canal, fracture plane, bony dehiscence of a nearby structure or pathological entity extending between the crures of the semicircular canals. Adequate knowledge of this lesser known structure will help ensure radiologists and our clinical colleagues do not mistake this normal structure for something more sinister.

(Filename: TCT_1979_ASNRPatrickCoutureDavidRay.jpg)

2008

Not Just Down and Out: Oculomotor Nerve Pathologic Spectrum

A Condos¹, E Bahorik¹, E Prokopovich¹, D Hawley¹, A Cho², M Cathey¹

¹Naval Medical Center San Diego, San Diego, CA, ²Naval Medical Center San Diego, san diego, CA

Purpose
The purpose of this exhibit is: -Review and understand the anatomy of the oculomotor nerve on high-resolution 3T MRI. -Understand the function of the oculomotor nerve. -Understand the clinical entities relative to the location of a lesion along the course of the oculomotor nerve.

Materials and Methods
Retrospective review of 3T MR and CT examinations performed for oculomotor nerve palsy or paresis over the last 5 years. A variety of oculomotor nerve palsy cases are presented which clearly demonstrate the pertinent imaging findings on high resolution cross-sectional imaging. Relevant anatomy is reviewed. Additionally, a literature review on oculomotor nerve palsy was completed.

Results
Review oculomotor nerve anatomy by dividing the nerve into 7 distinct segments: supranuclear, nuclear, fascicular, cisternal, cavernous sinus, superior orbital fissure, and orbital lesions using a case based approach. This presentation highlights neuroanatomy pertinent to the specific level of oculomotor pathology, emphasizing how the clinical presentation can drive the differential diagnosis.
Lastly, review oculomotor nerve synkinesis and the importance of understanding that this abnormal response can result in mislocalization.

Conclusions

Etiology and clinical presentation of CN III palsy varies depending on the level of the lesion or injury. An accurate diagnosis is predicated on a detailed understanding of the anatomy and CN III pathologic spectrum. Classic CN III injury can be classified partial (paresis) or complete palsy with or without pupillary involvement. Pupillary involved CN III palsy is more often caused by compression, which can be related to aneurysm and requires vascular imaging. Cavernous sinus or superior orbital fissure lesions typically result in multiple cranial nerve palsies. Oculomotor synkinesis is an abnormal response to firing of the oculomotor nerve, resulting in unwanted muscular contraction. Radiologists must be familiar the spectrum of oculomotor dysfunction to avoid lesion mislocalization and/or premature exclusion of CN III pathology.

OFF THE BEATEN PATH: A collection of primary CNS tumors that posed a diagnostic dilemma

S Ramji1, A Gontsarova2, F D'Arco3, C Soh4, R Adas5, W Jan6

1Charing Cross Hospital, Imperial College NHS trust, London, United Kingdom, 2Imperial College Healthcare NHS Trust, London, United Kingdom, 3Great Ormond Street Hospital for Children, London, London, 4Central Manchester Foundation trust, Manchester, Manchester, 5King Abdul Aziz Medical City, Jeddah, Jeddah, 6Imperial college healthcare NHS trust, London, London

Purpose

The timely and correct diagnosis of a brain tumour is crucial to maximising outcome and is heavily dependent upon imaging. The neuro-radiological approach to tumours relies upon multiple parameters in reaching a provisional diagnosis. Of these, location, signal characteristics and post contrast enhancement pattern are factors that help narrow the differential diagnosis. However, tumours can present in unusual ways that baffle even the most experienced neuro-radiologist and result in delays in diagnosis or incorrect initial management.

Materials and Methods

In this exhibit, we describe cases of various primary central nervous system (CNS) tumours which proved to be a diagnostic challenge. The cases are collected from various eminent tertiary neuroscience centres in the United Kingdom and Saudi Arabia.
Results
Our cases span both the pediatric and adult age groups and include a range of histologically proven diagnoses, such as high grade gliomas, chordomas, meningiomas, cavernous haemangioma, ATRT and pilocytic astrocytoma (see image). We have categorised the cases into two subgroups- 1. primary CNS tumours presenting in an unusual location and 2. primary CNS tumours presenting with unusual imaging features. Figure 1 a) Axial contrast enhanced T1W image demonstrating nodular leptomeningeal enhancement, eventually diagnosed as leptomeningeal GBM. b) Sagittal T1W image of the sacrum showing a subcutaneous extraspi
ependymoma c) Sagittal T2W image showing a deep vermian pilocytic astrocytoma in a case of rhombencephalitis. d) Mixed signal T1W image of midline posterior fossa tumour with multiple venous lakes and a gradual pattern of enhancement (not shown), proved to be cavernous haemangioma.

Conclusions
Atypical imaging presentation of CNS tumours can diagnostic confusion and delay. This exhibit focuses on important unusual variants of primary CNS tumours and the valuable lessons learnt from diagnostic dilemmas. Awareness of atypical presentations in neuro-oncology is valuable in aiding better management in a patient cohort who often have limited survival.

Figure 1
(Filename: TCT_2237_Imageforabstract.JPG)

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One-Stop-Shop: A Single Modality to Diagnose, Triage, and Treat Ischemic Stroke for Revascularization

K Capel1, B Aagaard-Kienitz2, A Ahmed3, D Niemann3, J Garrett4, Y Li3, K Li3, C STROTHER5, G Chen3, L Eisenmenger6
1UW Health Hospitals and Clinics, Madison, WI, 2N/A, N/A, 3UW Madison, Madison, WI, 4UW Madison -Department of Radiology, Madison, WI, 5UW Madison, MADISON, WI, 6University of Wisconsin - Madison, Madison, WI

Purpose
In acute stroke patients, time from imaging to groin puncture highly correlates with outcome and often accounts for significant time delay between hospital arrival and start of endovascular therapy (1). The purpose of this exhibit is to outline a "One-Stop-Shop" workflow where selected stroke patients transfer directly to the angiography suite for comprehensive imaging and treatment.

Materials and Methods
To make the "One-Stop-Shop" workflow feasible, there must be: • A multidisciplinary consensus on inclusion criteria (i.e. NIH stroke score of >8, outside noncontrast CT head) • An adequate NIH stroke score pre and post-transfer to ensure no interval changes •
Improved cone beam CT (CBCT) imaging performed in the angiographic suite (i.e. non-contrast, CTA, CT perfusion imaging techniques, and reconstruction methods) • Automated imaging data transfer, CBCT image reconstruction, and timely perfusion post-processing • A comparison of CBCT diagnostic quality versus current standard multidetector CT (MDCT) perfusion

Results
A "One-Stop-Shop" workflow relies on a multidisciplinary triage and treatment approach with efficient and accurate clinical evaluation to ensure appropriate selection of patients with large vessel occlusion. From the imaging prospective, our SMART-RECON has improved temporal resolution (<2 sec/frame), reduced artifacts (noise streaks and level, beam hardening, and scatter artifacts) allowing for more accurate detection of intracranial hemorrhage and assessment of CBCT brain perfusion (core infarct and penumbra). It also attains a one-minute reconstruction speed for processing and display of images, eliminates limited-view and temporal-average artifacts, and lowers radiation dose (~1-2 mSv) enabling repeat perfusion imaging after intervention (2,3). Our preliminary data demonstrates CBCT can provide non-inferior perfusion imaging compared with MDCT with added diagnostic benefits of colorized time-resolved CTA images. Our automated pipeline ensures images arrive to PACS with RAPID post-processing ~11-15 minutes after the data acquisition.

Conclusions
Through development of our One-Stop-Shop acute stroke workflow, direct transfer to the angiography suite for comprehensive imaging and treatment is now feasible. Ongoing clinical studies will evaluate attainability and outcomes of One-Stop-Shop workflow in patients presenting with acute stroke. Our hypothesis is that our intervention will result in better neurological outcomes due to decreased time between stroke onset and intervention.

Ophthalmologic Jargon and You

B Hansen¹, J Leever¹
¹University of Kansas Medical Center, Kansas City, KS

Purpose
1. Familiarize the radiologist the specific clinical ophthalmologic diagnoses 2. Educate on the abbreviations for ophthalmologic diagnoses used in clinical notation 3. Enhance radiologic interpretation when approached for ophthalmologic exam

Materials and Methods
Abbreviations are ubiquitous in medical documentation. Ones related to ophthalmology tend to be specific without crossover into other specialties. This can act as a barrier for radiologists who do not encounter ophthalmologic cases routinely. This electronic educational exhibit will convey a clinical and/or radiologic appearance of one distinct ophthalmologic entity per electronic slide. To
enhance the presentation and further the reader's knowledge, the entity's unique ophthalmology abbreviation used in clinical notation will be included on the slide. This simultaneous depiction of clinical appearance with abbreviated clinical documentation is not achievable by the radiologist in daily practice without recurrent interruptions for inquiry.

Results
The ophthalmologic entities will be those conveyed by imaging alone or clinical findings with an etiology which can be conveyed by imaging. There will be imaging abnormalities of the globe itself, such as rhegmatogenous retinal detachment or globe rupture. Commonly encountered post-surgical findings such as silicone oil or scleral bands will also be included. Different forms of strabismus will be shown, such as the difference between esophoria and esotropia. Lastly, extrinsic orbital abnormalities such as infectious or intracranial pathology.

Conclusions
It is important know what the referring clinician is wanting to evaluate. Ophthalmologic jargon can be challenging to decipher for the non-ophthalmologist; this jargon is compounded by specialty-specific abbreviations used in clinical notation. For radiologists, this is encountered in the form of radiology exam requests. This electronic exhibit will be of service in order to interpret the imaging adequately as well as tailor the imaging protocol appropriately.

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1579

Orbital Inflammatory Disease: Much More Than “Pseudotumor”

A Callen¹, N Rasool¹, C Glastonbury¹
¹UCSF, San Francisco, CA

Purpose
The characterization and accurate diagnosis of orbital inflammatory disease (OID) present unique challenges to neuroradiologists due to nonspecific and overlapping imaging findings. Additionally, the clinical presentation in OID can be perplexing. Emerging clinical markers and laboratory technologies can aid in this contextualization, and when used alongside appropriate imaging protocols and a systematic approach to imaging evaluation, can augment radiology reports characterizing OID. The purpose of this educational exhibit is to characterize the clinical and imaging findings associated with OID, and describe an approach to orbital imaging studies.
Materials and Methods
The imaging modalities and disease-specific protocols to evaluate OID are reviewed. The imaging characteristics of OID and their newly understood corresponding clinical and laboratory markers are described.

Results
OID comes in many forms and can localize to various orbital tissues. In many cases the differential diagnosis for OID are lumped together as "pseudotumor versus IgG4 disease versus lymphoma". Further elucidation of a specific diagnosis requires an understanding of the patient's clinical history, including systemic diseases, prior drug use, or prior illnesses. Additionally, the presence of enophthalmos or sinonasal disease are important clues guiding the differential diagnosis. Some imaging findings can be helpful to direct clinical testing towards specific diagnoses, such as the presence of chronic destructive sinonasal inflammation in granulomatosis with polyangiitis (GPA). GPA may exist without elevated serum c-ANCA. Therefore, imaging findings may be the only feature guiding a diagnosis. Many times, despite imaging providing a narrow differential diagnosis, biopsy will often still be required. More recent molecular diagnostic work has shown specific gene expression profiles in otherwise nonspecific OID which can distinguish inflammatory processes, and molecular work is progressing towards obviating tissue biopsy and instead testing of serum or tears.

Conclusions
There is much more that is now understood about the etiology and molecular nature of OID. Radiologists should look for specific features to arrive at a refined differential diagnosis, and to accurately monitor disease activity. We present an imaging algorithm, and combine the current understanding of the molecular nature of OID with critical imaging features in order to provide a useful approach to the orbital imaging report.

Osseous Maxillofacial Lesions: A Multimodality Approach

J Thelen¹, A Portanova¹
¹University of Rochester Medical Center, Rochester, NY

Purpose
Osseous lesions involving the maxillofacial skeleton are commonly encountered in neuroimaging both as a primary indication and as incidental findings. Because of the breadth of pathology and often atypical presentation, these lesions may pose a diagnostic dilemma. Nevertheless, a thorough understanding of maxillofacial anatomy, as well as characteristic presentations of both common and more rare maxillofacial lesions can allow for timely diagnosis, and provide insights which may significantly alter patient management. The goal of this exhibit is to review relevant osseous maxillofacial anatomy, as well as characteristic imaging findings for various osseous maxillofacial pathologies on multiple modalities, including computed tomography (CT), magnetic resonance (MR), positron emission tomography - computed tomography (PET/CT), and nuclear medicine scintigraphy.

(Filename: TCT_1579_Sample.jpg)
Materials and Methods
This exhibit will describe characteristic imaging findings for various common and rare osseous lesions of the maxillofacial skeleton using a case based approach.

Results
Cases to include: Ameloblastoma Apical periodontitis Arteriovenous malformation Chondrosarcoma Exostosis Fibrous dysplasia Intraosseous cavernous hemangioma Metastasis Multiple myeloma Odontogenic keratocyst Osteoid osteoma/Osteoblastoma Osteoma Osteomyelitis Osteonecrosis Osteosarcoma Stafne Cyst

Conclusions
Osseous maxillofacial lesions are a commonly encountered entity in neuroimaging, and an understanding of maxillofacial anatomy, as well as characteristic presentations of both common and more rare maxillofacial lesions on multiple imaging modalities can lead to accurate diagnosis, and positively alter patient management.

Case 1: 49-year-old female with breast cancer presenting with an ulcerated hard palate mass after zoledronic acid infusion

Perfusion and Diffusion-Weighted MR Imaging of CNS Lymphoma: Imaging Characteristics and Pitfalls with Pathological Correlations

S Jafri1, S Camelo-Piragua1, S Naganawa1, Y Ota1, J Kim1, A Capizzano1, T MORITANI2

1University of Michigan, Ann Arbor, MI, 2UNIVERSITY OF MICHIGAN, ANN ARBOR, MI

Purpose
- Review perfusion and diffusion weighted MR imaging findings of Primary CNS lymphoma (PCNSL) with pathological correlation.
- Discuss MR parameters and features that are most helpful in differentiating PCNSL from glioblastoma (GBM), tumefactive demyelination and metastasis. ■ Identify potential limitations and pitfalls of perfusion and diffusion imaging in the setting of PCNSL evaluation.
Materials and Methods
Overview of the complementary roles of perfusion and diffusion-weighted MR imaging in PCNSL ■ Dynamic susceptibility contrast (DSC) perfusion technique ■ Dynamic contrast enhanced (DCE) perfusion technique ■ Diffusion weighted imaging and ADC MR parameters and their utility in predicting PCNSL vs GBM ■ DSC perfusion parameters, including corrected and uncorrected rCBV, rCBF, K2, time intensity curve ■ DCE perfusion parameters, including AUC, Ve, Vp, Ktrans, time intensity curve ■ DWI and ADC value Limitations of perfusion and diffusion MR imaging in PCNSL

Results
Primary CNS lymphoma has increased in both immunocompetent and immunocompromised patients over the last few decades. MRI reliably demonstrates tumor localization and size, however accurate preoperative diagnosis remains a challenge. Differential often includes GBM, tumefactive demyelination, metastases and infection. Advanced MRI techniques such as diffusion and perfusion imaging can play complementary roles allowing for earlier diagnosis and management. PCNSL often demonstrates more restricted diffusion with lower ADC values compared to GBM or metastases. PCNSL also has less neovascularization with angiocentric tumor growth manifested as lower rCBV than GBM or metastases, but higher than tumefactive demyelination. Permeability parameters from DCE in tumor and peritumoral areas could help in discriminating lymphoma versus glioblastoma. Infiltration into the endothelium and vessel lumen is frequently observed, disrupting the blood-brain barrier and producing a larger degree of contrast extravasation. Limitations and pitfalls arise in interpreting DSC permeability parameters because of T1 and T2* leakage relaxation effects when contrast extravasates to the extracellular extravascular space.

Conclusions
Upon completion of this exhibit, the reader will become familiar with the technical aspects and role of MR perfusion and diffusion techniques in CNS lymphoma, imaging and pathology features in differentiating from tumor and tumefactive demyelination, and the limitations and pitfalls to make accurate diagnosis and assessment.
Periventricular Germinoma: A Case Series with Radiologic-Pathologic Correlation

S VERMA, T Shepherd
1NYU Langone Health, New York City, NY

Purpose
We present a case series of 4 patients with CNS germinomas with radiology-pathology correlation. We illustrate the wide variety of imaging presentations, including a rare case of germinoma presenting as isolated periventricular dissemination. Associated pathology images and discussion will also be provided for all cases.

Materials and Methods
N/A

Results
Germinomas represent the most common intracranial germ cell tumor, and comprise up to 3% of all brain tumors. Typical imaging manifestations of intracranial germinomas include masses in the midline areas, including the suprasellar and pineal region. Less commonly, they can occur in the ventricles and basal ganglia. 4 cases are presented in this series, including a case of suprasellar germinoma with subependymal spread, pineal region mass with subependymal spread, suprasellar and pineal region masses with subependymal spread, and a case of isolated subependymal spread of germinoma.

Conclusions
In the setting of suprasellar and pineal gland masses, the imaging diagnosis of CNS germinomas may be straightforward. However, germinoma can have an atypical presentation with isolated periventricular dissemination, creating a diagnostic dilemma, which may be misdiagnosed as other entities such as lymphoma. The radiologist should be aware of germinoma as a differential for subependymal hyperdense and enhancing nodularity.
Pictorial review of calcifying lesions and pseudolesions of the neuroaxis with focus on CAPNON.

R Zelaya¹, C Atkinson²

¹San Antonio Military Medical Center, Fort Sam Houston, TX, ²San Antonio Military Medical Center, San Antonio, TX

Figure 1, 2, 3 from Case 1 demonstrating midline masses and periventricular spread on both MR and CT imaging.

Figure 4 from Case 2 demonstrating isolated periventricular spread without associated masses. Images of midline structures will also be included showing absent midline masses.

(Filename: TCT_1823_Abstractimages.jpg)
Purpose
Many different intracranial lesions and pseudolesions demonstrate dense calcifications. Neuroimaging plays a vital role in lesion characterization and development of a differential diagnosis. The purpose of this educational exhibit is to offer a case based pictorial review of different calcified lesions and pseudolesions of the neuroaxis with an emphasis on the uncommon histologic entity called calcified pseudoneoplasm of the neuroaxis (CAPNON), a non-neoplastic lesion which is sometimes mistaken for more common neoplastic and non-neoplastic lesions.

Materials and Methods
A literature review was performed regarding CAPNON and other calcified lesions, and our teaching file was searched for cases demonstrating dense intracranial calcifications and calcified lesions. The imaging cases that will be displayed in this exhibit will demonstrate key differentiating characteristics of calcified intracranial lesions as a pictorial review.

Results
The histology/pathology, epidemiology and distinguishing imaging features of a variety of calcified lesions will be highlighted. Imaging characteristics such as patterns of contrast enhancement, vascularization, perilesional edema, diffusion restriction and anatomic considerations will be presented to narrow differential diagnosis. The cases will include a variety of examples of neoplastic, inflammatory, infectious, vascular, congenital and metabolic lesions. Case examples will include calcified meningioma, osteoma, oligodendroglioma, choroid plexus papilloma, ependymoma, craniopharyngioma, sarcoidosis, tuberculosis, neurocysticercosis, toxoplasmosis, CMV, cavernoma, AVM, Sturge Webber, tuberous sclerosis, neurofibromatosis, basal cell nevus syndrome, Fahr's syndrome, hyperparathyroid disease, calcified pseudoneoplasm of the neuroaxis (CAPNON), and amyloidosis.

Conclusions
It is essential that radiologists understand key distinguishing imaging features of various calcified intracranial lesions to narrow diagnostic considerations and help guide management decisions.

(Pictured: TCT_2575_Figure1.jpg)

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Pictorial Review of Hippocampal Anatomy, Pathology, and Treatment Methods for Mesial Temporal Lobe Epilepsy

K Werth, N Harn, J Bertsch, J Leever, L Ledbetter

1University of Kansas Medical Center, Kansas City, KS

Purpose
This pictorial review is created to assist in radiologic evaluation of hippocampal anatomy, pathology, and treatment methods for mesial temporal lobe epilepsy (MTLE). This is an important concept to understand to correctly identify normal anatomic structures and to accurately recognize abnormalities that may affect patient management.
Materials and Methods
Reviewing hippocampal anatomy and pathology on 3T MRI as well as patient selection criteria for treatment methods through literature and case review.

Results
Medication-resistant epilepsy is a disabling disease most frequently caused by MTLE. Over the years, targeted medical therapy has not improved the number of patients with MTLE suffering debilitating seizures (1). The mainstay of treatment in these patients has been surgical resection with either anterior temporal lobectomy (ATL) or selective amygdalohippocampectomy (SAH), which has demonstrated in a recent meta-analysis to result in seizure freedom in 75% of patients (2). Although there is the risk of permanent neurocognitive defects with surgical intervention, it is often performed without complications (3). Newer treatment methods, including stereotactic laser amygdalohippocampectomy (SLAH), are minimally invasive and have better risk profiles (4). It is imperative for the interpreting radiologist to be aware of normal hippocampal anatomy, common and uncommon hippocampal pathology, including mesial temporal sclerosis, malrotation, postictal changes, autoimmune and herpes encephalitis, DNET, ganglioglioma, sulcal remnant cysts, choroid fissure cysts, migrational anomalies, and sphenoid wing encephaloceles. It is also important for the radiologist to be familiar with patient selection criteria for different treatment methods for MTLE, including ATL or SAH, as well as newer technologies, such as SLAH.

Conclusions
The goal of this project is to provide a brief overview of hippocampal anatomy and pathology as well as review patient selection criteria for surgical treatment versus SLAH in MTLE. Accurate recognition of these findings and knowledge of treatment methods is important for further patient care.

(Pictorial Review of The Most Common Orbital and Ocular Trauma)

A Rohana¹, K El Salek², C Mullins³, J Gavito-Higuera⁴
Purpose
1- Imaging based anatomic review of the globe 2- Case based pictorial review of ocular trauma; Anterior vs Posterior chamber injury
3- Case based pictorial review of globe rupture. 4- Case based pictorial review of extra-ocular/intra-orbital trauma.

Materials and Methods
N/A

Results
N/A

Conclusions
Orbital imaging is a challenging but indispensable asset when evaluating for orbital trauma. It is particularly crucial in an emergency department setting when physical examination and history are often delayed while triaging more life threatening ailments. This educational exhibit will discuss a brief anatomic imaging review of the orbit and globe and perform a case-based review of the most common orbital and ocular injuries: anterior chamber injuries, injuries to the lens, open-globe injuries, ocular detachments, intra-orbital foreign bodies, carotid cavernous fistula, and optic nerve injuries. As an isolated level one trauma center with a large catch area we encounter complex and diverse array of orbital injuries which in certain cases exhibit very subtle imaging findings. However, prompt detection and management is paramount for prevention of long-term sequela. Computed tomography (CT) is the imaging modality of choice in an emergent setting due to its ability to detect ocular foreign bodies, fractures, and logistical superiority to magnetic resonance (MR) imaging. MR becomes useful after foreign bodies have been excluded in the evaluation of orbital soft tissues and visual pathways. By performing our pictorial review, we aim to familiarize radiologist with ocular trauma in addition to various mimics, pearls and pitfalls. Our exhibit will exclude orbital fractures to maintain focus on orbital injuries. We have systematically divided our cases based on the site of injury as follows: I- Ocular trauma: a. Anterior chamber injury b. Posterior chamber injury II- Globe rupture III- Extra-ocular, intra-orbital injury.

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Piecing it Together: Radiographic Diagnosis and Endovascular Treatment for Idiopathic Intracranial Hypertension

K Patel1, J Buckley1, N Akhtar2, W Holloway2, J Halpin2
1University of Missouri at Kansas City, Kansas City, MO, 2St. Luke's Hospital, Kansas City, MO
Purpose
1. Review the current understanding of Idiopathic intracranial hypertension (IIH) including pathophysiology and clinical presentation.
2. Discuss the imaging findings of IIH as well as potential pitfalls in diagnosis. 3. Illustrate intracranial venous anatomy on multiple modalities. 4. Discuss transverse sinus stenting including procedural indications, techniques, and potential complications.

Materials and Methods
Images from multiple diagnostic and/or interventional angiography cases from patients with IIH who underwent endovascular transverse sinus stenting for symptom relief, were used in this study from our institution for the purposes of this educational exhibit.

Results
1. Introduction to Idiopathic Intracranial Hypertension (IIH) 2. Clinical presentation, pathophysiology, and treatment options for IIH 3. Imaging features of IIH and potential pitfalls or mimics 4. Intracranial venous anatomy – MRV, CTV, venography 5. Transverse sinus stenting: indications, procedure, complications

Conclusions
Idiopathic intracranial hypertension (IIH) is a potentially debilitating condition most commonly affecting young women. Though the exact pathophysiology of IIH is not always clear, some cases are associated with transverse sinus stenosis. Endovascular treatment of transverse sinus stenosis via stenting has been shown to improve the debilitating symptoms of IIH in some patients. It is important for radiologists to be familiar with the imaging features of IIH as well as transverse sinus stenosis – a potentially treatable cause of the condition.

Posterior mediastinal masses in children: A pictorial review

C Olivas Chacon¹, M Aslam², S Guha Roy³, F Brown², H Otero³
Purpose
• To review the normal contents of the posterior mediastinum. • To compare and contrast the classic imaging features of neurogenic tumors in the posterior mediastinum, including nerve sheath tumors (schwannoma, neurofibroma), parasympathetic tumors (paraganglioma, chemodectoma) and sympathetic chain tumors (neuroblastoma, ganglioneuroma). • To demonstrate the imaging appearance of vascular and lymphatic malformations in the posterior mediastinum in children. • To compare and contrast the imaging characteristic of non-neurogenic tumors occupying the posterior mediastinum, including lymphoma, Ewing sarcoma, extraskeletal myxoid chondrosarcoma, and chordoma. • To illustrate the imaging characteristics of other lesions in the posterior mediastinum such as duplication cysts, extramedullary hematopoiesis, and meningoceles. • To provide imaging pearls and pitfalls which can be used when facing challenging cases.

Materials and Methods
We provide a pictorial review of posterior mediastinal masses in children for radiology trainees. Our aim is to illustrate the variety of disease processes that can be encountered in the posterior mediastinum in children and encourage trainees to perform organized thinking. Our objective is to present the myriad of imaging findings of common and uncommon masses in the posterior mediastinum, along with pearls and pitfalls which can be useful to narrow differential diagnosis when facing challenging cases.

Results
The posterior mediastinum contains neurogenic tissue, paravertebral fat and lymph nodes. The majority of masses encountered in the posterior mediastinum in children are neurogenic in origin. However a wide variety of other disease entities can arise in this region including vascular, lymphatic, congenital and malignant lesions.

Conclusions
Differentiating neurogenic tumors from other etiologies in the posterior mediastinum in children can be challenging given the subtleties and overlapping features of the different culprits. Knowing the classical imaging characteristics of different masses in the posterior mediastinum in children is key to provide adequate patient care. Entertaining accurate differential diagnosis is crucial to lead to appropriate treatment approaches.
Materials and Methods

The aging population has led to increased use of advanced diagnostic imaging, such as CT and MRI, leading to increased costs, potentially being harmful. To help decrease costs, Congress has examined prior authorization, yet it has scarce effectiveness. CDS is a tool to help clinicians order appropriate imaging based on appropriateness criteria. Overall, CDS will help enhance evidence-based practice, decrease delays in healthcare, decrease healthcare costs, and avoid replacing physician judgement. There is resistance by clinicians to CDS, predominantly due to the lack of understanding of the potentially meaningful role of CDS in improving healthcare. It has also been suggested that perceived lack of impact of CDS may be related to absence of any real consequences to ordering providers for ignoring recommendations or, conversely, any benefits for adhering to the recommendations presented in CDS alerts. PAMA was passed to help ensure CDS use so that ultimately there will be no reimbursement for advanced imaging by CMS if CDS is not consulted.

Results

By avoiding pre-authorization, PAMA still allows for decreasing imaging costs, yet eliminates a third payer. This allows for no delay in care, so imaging is faster—there is no waiting for a third party to accept or reject the claim. By removing a third party, PAMA does not take the decision out of the patient-doctor relationship—CDS is decision support, not replacement, it does not replace physician judgement. By using evidence based guidelines, it helps educate the provider and guide physicians. It can also help identify outliers and inform them. Also, if the CDS is not consulted, there will be no creation of competition among providers, since no providers will be reimbursed.

Conclusions

Overall, PAMA will not only help decrease costs of imaging and healthcare, however may also set an example for other private insurance companies, leading to more widespread use of CDS. This will lead to decreased use of inappropriate/unnecessary imaging thus decreasing healthcare costs.

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Quantitative Susceptibility Map Based Subthalamic Nucleus Delineation for Deep Brain Stimulator Targeting

C Smith1, N Bentley1, B Guthrie1, J Kim1

1University of Alabama at Birmingham, Birmingham, AL

Purpose

Deep brain stimulation (DBS) is effective in improving the motor complications of Parkinson's disease (PD), and the sensorimotor subregion of subthalamic nucleus (STN) is accepted as the most optimal locus. However reliable anatomical mapping of STN based on traditional MRI sequences is often challenging. Quantitative susceptibility mapping (QSM) is a recently developed MRI technique that provides excellent contrast between iron-rich deep gray matter nuclei and surrounding tissues. In this work, we demonstrate how QSM obtained for routine presurgical MRI studies provides superior STN delineation and its feasibility in stereotactic application.

Materials and Methods

We obtained brain MRI scans of sixty one patients (age range 46-87 years) with movement disorder (Dec. 2018 -Oct. 2019). All scans were performed on a 3T MR scanner with 64 channel head coil. Presurgical mapping MR protocol included axial 3D fluid and white matter suppression (FLAWS) with MP2RAGE, and axial 3D single echo GRE (TE=30 msec) in 1x1x1 mm isotropic resolution. QSM images were reconstructed in real time within scanner image reconstruction computer using GPU (NVIDIA K80) accelerated total generalized variation (TGV) method. QSM images were upsampled to 0.5x0.5x0.5 mm resolution with cubic spline interpolation and applied with edge enhance filter.

Results

Figure 1 demonstrates a representative case of STN visualization and delineation with QSM (right) and presurgical atlas-based targeting on StealthStation Surgical Navigation System (left). We demonstrate improved anatomical delineation of STN using QSM. We will discuss feasibility of QSM scan in routine clinical exam, and the efficacy and reliability of QSM based STN DBS targeting.

Conclusions

QSM provides improved anatomical delineation of STN. We will discuss feasibility of QSM in routine clinical exam, and the efficacy and reliability of QSM based STN DBS targeting.
Rat Lungworm Infection: A Review of the Findings and Comparison with Other Parasitic Infections

L Mitchell

Kaiser Permanente Hawaii Region, Aiea, HI

Purpose
To review the imaging findings associated with Angiostrongylus cantonensis (Rat lungworm) infection and compare these findings with those of other central nervous system parasitic infections.

Materials and Methods
Review of one recent case of rat lungworm infection and compare with other parasitic infection cases acquired over 10 years of practice.

Results
Rat lungworm infection has features that are both similar to and different than several other parasitic CNS infections. While most active parasitic and bacterial infections will show enhancement, our case highlights the use of susceptibility imaging to demonstrate characteristic tracks taken by the parasite that will persist after treatment and in the absence of contrast enhancement. Other examples of parasitic infections, for example Schistosomiasis, may have susceptibility findings in the absence of contrast enhancement but will do not often have the appearance of tracks.

Conclusions
Rat lungworm infection, while historically centered in Asia and Hawaii, is starting to be seen in the coastal United States.
Recognizing the susceptibility findings in addition to other findings suggesting infection may assist in the diagnosis for those cases that may be laboratory negative.

2810

Representative Cases of MR-Guided Focused Ultrasound Ablation for the Treatment of Neurological Disorders

T Miller¹, D Gandhi²
¹University of Maryland, BALTIMORE, MD, ²University of Maryland School of Medicine, Baltimore, MD

Purpose
MR guided focused ultrasound (MRgFUS) is emerging as a safe and effective method of producing structural and functional changes in the brain. The technique is being investigated for the treatment of several neurological disorders, including essential tremor, advanced idiopathic Parkinson’s disease, and neuropathic pain. Preliminary results have been promising and our center has participated in several clinical trials exploring the safety and feasibility of MRgFUS for the treatment of neurological conditions.

Materials and Methods
We present representative cases of MRgFUS ablation performed at our institution for each disease entity. The pre-procedure planning for each case is reviewed, including patient screening, pre-procedure imaging, and target localization. Next, we detail the technique of MRgFUS ablation for each condition, including specific targets such as the ventral intermediate nucleus for essential tremor and the globus pallidus interna for Parkinson’s disease. Potential technical challenges and complications are also discussed, including non-target ablation of adjacent eloquent structures. Finally, we briefly review patient follow up care and post-procedure imaging.

Results
MRgFUS treatments of essential tremor, advanced Parkinson’s disease, as well as chronic neuropathic pain are presented. In addition, we review a case of MRgFUS disruption of the blood brain barrier in the setting of glioblastoma multiforme intended to improve therapeutic drug delivery.

Conclusions
MRgFUS is a promising, non-invasive technique for the treatment of neurological disorders. Further investigation is warranted.

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Review of Intraventricular Lesions and their Mimics

J Castaneda-Panuco¹, C Liu¹
¹Keck Medical Center, University of Southern California, Los Angeles, CA

Purpose
To review ventricular anatomy to understand origin of common lesions. Review common intraventricular lesions and key patient demographics to provide a succinct differential diagnosis. Identify mimics of intraventricular masses and discuss key findings to help distinguish an intraventricular lesion from a parenchymal mass.

Materials and Methods
Intraventricular lesions are uncommon tumors seen in clinical practice. Knowledge of cell types making up the ventricular system can help in formulating a useful diagnosis. Many lesions occurring around the ventricles are easily identifiable as intraventricular in location. However, some are more difficult to localize as they may arise from adjacent structures and secondarily invade into the ventricle. We review commonly encountered intraventricular masses, their mimics and key imaging findings to help you identify site of origin.

Results
We present a detailed illustration of the ventricular system, surrounding anatomy and types of cells found at different locations. We then discuss key imaging characteristics for commonly seen ventricular lesions (e.g. meningiomas, choroid plexus papilloma, neurocytomas, colloid cysts, subependymoma) both on CT and MRI with example images. Finally, we review commonly seen lesions invading the ventricles that can mimic an intraventricular mass and discuss helpful imaging findings to distinguish a mass arising from the ventricular system versus a mass invading into the ventricles.

Conclusions
The goal of this educational exhibit is to help familiarize the radiologist with common intraventricular lesions and mimics of intraventricular lesions. Location of the intraventricular lesion, patient demographics and imaging characteristics will help the radiologist provide a succinct differential diagnosis. Certain imaging characteristics can also help distinguish an intraventricular mass from those secondarily invading into the ventricles.
**Sag What? Distinguishing Between Spontaneous Spinal CSF Leak and Its Mimickers**

A Chen\(^1\), K Bond\(^1\), J Cutsforth-Gregory\(^1\), F Diehn\(^1\), D Kim\(^1\), J Benson\(^1\), C Carr\(^1\)

\(^1\)Mayo Clinic, Rochester, MN

**Purpose**
1. Review the imaging characteristics and radiologic workup of spontaneous spinal cerebrospinal fluid leaks (SSCSFL).
2. Discuss mimickers of SSCSFL - including Chiari Type I morphology, diencephalic-mesencephalic junction dysplasia, IgG4-related disease, and neurosarcoaidosis - and key differentiating characteristics.

**Materials and Methods**
N/A

**Results**
N/A

**Conclusions**
Spontaneous spinal cerebrospinal fluid leak (SSCSFL) is a rare condition often but not always caused by a small dural tear with resultant extradural leakage of CSF and a low CSF pressure state. It classically presents as an orthostatic headache but the presentation ranges from vague neurologic symptoms, cranial nerve palsies, to severe encephalopathy. Timely identification of this condition is valuable because treatment with a fibrin epidural blood patch or surgical closure of the dural defect can lead to significant improvement of symptoms and cure. Diagnosis and treatment of the condition is complicated by overlap in the clinical and radiologic presentation of SSCSFL with other neurologic conditions. Understanding the manifestations of SSCSFL and its mimickers is critical to making an accurate and expeditious diagnosis. The preferred initial diagnostic imaging modality is a brain MRI without and with gadolinium. The hallmark finding of SSCSFL is "brain sag," or a downward displacement of the brain resulting in flattening of the ventral pons, slumping of the midbrain, descent of the cerebellar tonsils, and effacement of the associated subarachnoid/cisternal spaces. Additional findings may include diffuse pachymeningeal thickening and enhancement, dural venous sinus engorgement occasionally complicated by thrombosis, atraumatic subdural hematomas or hygromas, pituitary enlargement, and superficial siderosis. Raising suspicion of SSCSFL based on the imaging findings may be challenging due to its similarities with other conditions. For example, Chiari Type I morphology or diencephalic-mesencephalic junction dysplasia may both appear similar to the "brain sag" of SSCSFL. Dural thickening associated with IgG4-related disease, neurosarcoaidosis, and a variety of inflammatory and infectious etiologies may mimic the pachymeningeal findings of SSCSFL. Conversely, SSCSFL may initially present in a non-classic fashion with a complication such as cerebral venous sinus thrombosis, pituitary engorgement and/or apoplexy, or superficial siderosis, and it is important to consider an SSCSFL as the underlying diagnosis.
Scalp Lesions: "What Is This Bump on My Head?"

S Kim¹, B Baek², Y Lee³
¹Chonnam National University Hawsun Hospital, Hwasun-gun, Jeollanam-do, ²Chonnam National University Hospital, Gwangju, Chonnam, ³Chonnam National University Hospital, GWANGJU, N/A

Purpose
The purpose of this educational exhibition is to illustrated diagnostic key CT and MR imaging features of various scalp lesions, according to their locations within the scalp.

Materials and Methods
We searched our teaching files over the past 10 years and collected illustrative cases of patients who presented with scalp lesions. In this exhibit we will describe the diagnostic key CT and MR imaging features of various scalp lesions according the their located layer within the scalp.

Results
Various scalp lesions are identified as palpable masses or incidental findings. They represent a challenge for clinicians and radiologists. This exhibit will include a detailed anatomic discussion of the scalp. We will explain how the five layers of scalp can be distinguished in CT and MRI, so that the exact location of various scalp lesions can be identified. Next, the typical imaging findings of scalp lesions will be reviewed. Scalp lesions include epidermoid cyst, trichilemmal cyst, pilomatricoma, skin tumor, lipoma, hemangioma, vascular malformation, caput succedaneum, cephalhematoma, subgaleal hemorrhage, dermoid cyst, Pott's puffy tumor, atretic cephalocele, and sinus pericranii.

Conclusions
By viewing this exhibit, the reader will enhance their understanding of the detailed anatomy of scalp layers and typical imaging features of a wide variety of scalp lesions.
Short term imaging course of drug induced hypophysitis in a patient with metastatic renal cell carcinoma treated with nivolumab electing to continue therapy

J Black¹, J PERCHIK², H Sotoudeh³
¹University of Alabama at Birmingham (UAB), Birmingham, AL, ²UNIVERSITY OF ALABAMA, BIRMINGHAM, BIRMINGHAM, AL, ³University of Alabama Birmingham, Birmingham, AL

Purpose
Idiopathic autoimmune hypophysitis is an immune-mediated inflammatory disorder involving immune cell invasion of the pituitary, causing mass effect and, therefore, symptoms ranging from fatigue and vision changes to pituitary apoplexy. The use of immune checkpoint inhibitors, such as ipilimumab, nivolumab, and pembrolizumab, have been described as a cause of this disorder. Nivolumab is an anti-programmed death 1 (PD-1) monoclonal antibody which inhibits the interaction of PD-1 and PD-1 ligands, enhancing T-cell response against malignant cells. This inhibition by Nivolumab results in hypophysitis with a reported incidence of <1%. Very few case reports of this condition have been published so far.

Materials and Methods
We report a patient with metastatic renal cell carcinoma with nivolumab induced hypophysitis and with persistent radiologic findings despite clinical improvement.

Results
The patient is a known case of metastatic renal cell carcinoma who presented to the emergency department with vision changes and dizziness following treatment two weeks after starting nivolumab. Imaging findings were consistent with hypophysitis, with edema and enhancement of the pituitary and infundibulum, as well as edema of the optic chiasm. Typically, patients who experience symptomatic drug induced hypophysitis discontinue the precipitating medication, however the patient's primary oncology team felt that nivolumab was the best chemotherapeutic agent in the patient's clinical setting. The patient elected to continue nivolumab with symptomatic management and repeat imaging. At three-month follow up, the patient's symptoms had resolved after completion of steroids but brain MRI showed persistent infundibulohypophysitis with resolution of optic chiasm edema.
Conclusions
This presentation suggests that imaging findings of drug induced hypophysitis persist in the setting of continued use of the inciting drug despite a patient's symptomatic improvement after management of the pituitary malfunction.

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Short vs. Long Spinal Cord T2 Lesions: Differential Diagnosis.

S Ferraciolli¹, T Miranda², L Araujo², K Terumi², E Agapito³, D Ehlers³, A Oliveira⁴, L Lucato⁵, C Leite⁶, C Zamora⁷, M Castillo⁸
¹InRad - HC- FMUSP, Sao Paulo, Brazil, ²Inrad, Sao Paulo, Sao Paulo, ³InRad, Sao Paulo, AK, ⁴InRad, Sao Paulo, Sao Paulo, ⁵N/A, ⁶N/A, ⁷N/A, Sao Paulo., ⁸Inrad, Sao Paulo, ⁹NCU, Chapel Hill, NC, ¹⁰Univ. Of North Carolina School Of Medicine, Chapel Hill, NC

Purpose
Our purpose is to review imaging findings and propose a step by step approach to helps us generate a differential diagnosis of short and long T2 hyperintense spinal cord lesions.

Materials and Methods
For this exhibit we searched the teaching files of two academic institutions for short and long T2 hyperintense spinal cord lesions on MRI. We propose a step by step approach for narrowing the differential diagnosis, also review and discuss the pertinent literature emphasizing distinguishing features for each entity.

Results
T2 hyperintense spinal cord lesions have a wide-range of differential diagnosis which include: MRI artifacts; trauma; compression myelopathy; primary and secondary neoplasms; radiation myelitis; congenital anomalies; demyelinating diseases (e.g. multiple sclerosis and optic neuromyelitis); subacute combined degeneration of the spinal cord (with B12 deficiency); drug toxicity (e.g. methotrexate); vascular causes (e.g. cord infarction and arteriovenous shunts); infective, post infective and granulomatous diseases (e.g. transverse myelitis, neurosarcoidosis, neurosarcoidosis, AIDS associated vacuolar myelopathy); and cavitary lesions (e.g. syringohydromyelia) among other less common causes. Correlation between clinical data and imaging characteristics of T2 hyperintense spinal cord lesions may help us generate a differential diagnosis which enables us to suggest the correct diagnosis. In this exhibit, we discuss imaging and clinical features that may aid to refine the differential diagnosis.

Conclusions
In this educational exhibit we describe short and long T2 hyperintense lesions, highlight the features that suggest the correct diagnosis, provide a short literature review as well as a diagnosis step by step approach.
Spaceflight Associated Neuro-ocular Syndrome: Decoding a New Medical Phenomenon using MRI

L. Kramer1, K. Hasan1, M. Stenger2, K. Marshall-Goebel3, B. Macias3
1University of Texas Health Science Center, Houston, TX, 2NASA, Houston, TX, 3KBR, Houston, TX

Purpose
Some astronauts with long-duration exposure to microgravity have reported altered visual acuity, commonly presenting as a hyperopic shift in vision. The clinical identification of choroidal folds, posterior globe flattening and optic disc edema in postflight astronauts has suggested elevated intracranial pressure (ICP) as a contributing factor. The purpose of this exhibit is to demonstrate how MRI has been used to study the intracranial and orbital effects of microgravity.

Materials and Methods
MRI orbital and intracranial findings from retrospective and prospective microgravity studies will be reviewed. The prospective study conducted MRI measurements from preflight baseline followed by 1, 30, 90, 180 and 360 days after landing. Evaluation of pituitary morphology, intracranial volumetry, aqueductal CSF velocity peak-to-peak velocity amplitude (CSFVp-p) and aqueductal stroke volume (ASV) was determined at each timepoint.

Results
Retrospective studies have demonstrated posterior globe flattening, optic disc protrusion, optic nerve sheath distention, and optic nerve sheath tortuosity, which support the hypothesis of increased ICP in microgravity. The more recent prospective study found that compared to preflight, 11 astronauts (mean age = 46 years) had a significant increase in intracranial volume (ICV) (P<0.001), ASV (P<0.01) and CSFVp-p (P<0.02) immediately post-flight. Six (55%) astronauts developed pituitary dome flattening or concavity, and average midline pituitary height decreased significantly from 5.9 to 5.3 mm (P<0.001). An example of quantitative change in pituitary mid-gland height from pre-flight baseline to immediately post-flight (1-3 days after landing) per eleven astronaut subjects is shown in the graph below. These prospectively derived findings are also supportive of elevated ICP.

Conclusions
1. Intracranial volume expansion within a rigid cranial compartment potentially increases ICP. 2. Acquired deformity of the pituitary gland is indirect evidence of elevated ICP. 3. Increased aqueductal velocity and stroke volumes are indicative of diminished intracranial compliance, which can accentuate ICP pulsatility. 4. Posterior globe flattening, optic nerve sheath dilatation, and optic...
disc edema are extra-cranial findings identified in retrospective studies, which support the hypothesis of elevated ICP physiology as a cause of visual changes in astronauts.

(Spectrum of Imaging Manifestations and Expected Post-Treatment Findings in Thyroid Orbitopathy)

I Saramago1, C Zamora1, M Castillo1
1University of North Carolina at Chapel Hill, Chapel Hill, NC

Purpose
Orbital involvement is the most common extrathyroidal manifestation of thyroid disease. The purpose of this exhibit is to highlight the range of typical and atypical presentations of thyroid eye disease as well as the expected appearance following medical therapy and surgical decompression.

Materials and Methods
For this exhibit we searched our teaching files over the past 10 years for cases of patients who presented with thyroid eye disease.

Results
Thyroid eye disease is thought to be an autoimmune process where antibodies target receptors of thyroid cells, extraocular muscles (EOM), and soft tissues of the orbit. Imaging manifestations consist of painless exophthalmos (i.e. proptosis), bilateral symmetric extraocular enlargement sparing the tendinous insertion in a predictable fashion (I'M SLO mnemonic - beginning with the inferior rectus muscle), fatty infiltration of EOM, increased retrobulbar fat, optic nerve compression, and rare involvement of the lacrimal gland. Treatment options consist of steroids, radiotherapy, and/or surgical decompression.

Conclusions
Thyroid disease is ubiquitous in medicine with a minority of patients suffering from orbital involvement. Clinical presentation and imaging appearance of thyroid orbitopathy are variable and form the basis for selection of optimal therapy.
Stuck in the middle!: How to deal with an abnormality in and around the 3rd ventricle.

R Hegde¹, P Kochar¹, S Smith¹
¹Yale New Haven Health-Bridgeport Hospital, Bridgeport, CT

Figure legend

Thyroid eye disease. (A) Axial noncontrast CT in a patient with Grave’s disease shows increased retrobulbar lipomatosis resulting in bilateral proptosis. (B) Axial noncontrast CT in a different patient demonstrates extrusion of orbital fat through superior orbital fissures (orange arrows) due to orbital crowding. (C) Coronal fat-saturated postcontrast T1 in a different patient shows extensive orbital enhancement due to active inflammation. (D) Coronal noncontrast CT in a different patient demonstrates postsurgical changes from bilateral medial and inferior orbital decompression osteotomies (blue arrows). Note fatty infiltration of the inferior rectus muscles.

(Filename: TCT_1439_FindingsinThyroidOrbitopathy.JPG)
Purpose
The 3rd ventricle is in the mid-line in the middle of the brain, with complex regional anatomy. Lesions may primarily arise within the 3rd ventricle or from the multitude of structures surrounding it. One should be familiar with the regional anatomy and key landmarks on various planes to be able to accurately characterize, describe the origin and extent of abnormalities in this region and come to an appropriate diagnosis or a sound list of differentials.

Materials and Methods
We review the imaging anatomy on CT/MRI of the 3rd ventricle and the surrounding structures. We present cases to demonstrate the varied pathologies that occur in this region.

Results
We review the CT/MR anatomy of the 3rd ventricle and its surrounding structures on various planes and highlight key anatomic landmarks. This includes the thalami laterally, the fornix and foramen of monro superiorly, the hypothalamus and brainstem inferiorly, the supraoptic and infundibular recesses anteriorly, the pineal region posteriorly along with the surrounding vasculature. We subsequently will depict a few 'Do not touch' lesions in this region such as cavum septum pellucidum and velum interpositum and pineal cysts. Then we depict common and uncommon masses in this region classifying them based on their site of origin and imaging appearance- anteriorly arising from sella/suprasellar region, posteriorly from the pineal region and tectum, superiorly from the foramen of monro and inferiorly from the hypothalamus. Other than masses, we depict cases with signal abnormalities in this region from metabolic, toxic and vascular etiologies.

Conclusions
Our exhibit aims to make the reader familiar with the imaging anatomy of the 3rd ventricle and structures surrounding it. Understanding the anatomy along with familiarity with common and typical abnormalities of this region helps develop an approach to the diagnosis.

Axial T2 (A) and T1 (B) MRI depict a large T1 hyperintense and T2 hypointense intraventricular mass in the third ventricle with obstructive hydrocephalus. Post contrast Coronal (C) and Sagittal (D) MRI show lack of internal enhancement in this case of a colloid cyst.
Subthalami Nuclei: Look at me! "A general approach to the differential diagnosis of the lesions in the subthalamic nuclei"

F Assunção¹, R Carmo¹, L Martins¹, T SCOPPETTA², L Freitas¹, L do Amaral¹, L Freitas¹, B Inada¹, C Campos¹, V Marussi¹
¹BP - A Beneficência Portuguesa de São Paulo, São Paulo, SP, ²Hospital São Camilo, São Paulo, SP

Purpose
To review the anatomy of the diencephalon with emphasis on the recognition of the subthalamic nuclei. To understand the physiology of the subthalamic nucleus and the symptoms related to its involvement in various diseases. To address the main differential diagnosis of subthalamic nuclei lesions including metabolic, vascular, infectious/inflammatory, and neoplastic diseases, highlighting the clues for the correct diagnosis considering relevant clinical and epidemiological context. To review the role of imaging modalities and correlation with a epidemiology, pathology and clinical context.

Materials and Methods
The authors reviewed the literature concerning the subthalamic nuclei pathologies and present the most common and/or relevant diseases classified in groups of causes. The discussion of each condition includes pathological, epidemiological and clinical descriptions, followed by a detailed discussion on the main imaging findings and the best clues to reach the correct diagnosis. The most illustrative cases of the authors' institutional databases were carefully selected to be included the presentation as examples of such pathologies.

Results
The subthalamic nuclei is a deep gray matter nuclei that can be affected by several pathologies. In the review of our database and the literature, the pathological conditions involving the subthalamic nuclei could be divided according to its origin (systemic or local) and its etiologic group (metabolic, inflammatory / infectious, vascular, neoplastic and miscellaneous conditions).

Conclusions
The subthalamic nuclei are an important anatomic site involved in a vast number of different diseases, and it is frequently neglected in the interpretation of brain imaging methods. The knowledge of the most common diseases affecting the subthalamic nuclei can provide important clues that point neurologists, neurosurgeons and radiologists in the direction of a correct diagnostic.
Techniques to Reduce MR Artifacts on Spine Imaging: An Educational Review

S Ghaderi Niri1, A Chiu1, N Bates1, T MASSOUD2, S Hashmi3
1Stanford University School of Medicine, Stanford, CA, 2STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA, 3N/A, N/A

Purpose
Many different artifacts can occur during spine MR imaging, either affecting diagnostic quality or resulting in simulation of pathology. Artifacts are classified as patient-related, signal processing-dependent, or hardware-related. They often plague spine MRI in the presence or absence of spinal hardware, and can pose a major limitation in evaluation of the spinal cord. Techniques to reduce spine MRI artifacts can enhance image quality and at times even convert a non-diagnostic study into a diagnostic one. We provide a pictorial and educational review of techniques to limit these artifacts to aid in neuroimaging interpretation and patient management.

Materials and Methods
We review and illustrate multiple spine MRI artifacts and their suppression techniques.

Results
We discuss artifact-reducing techniques to enhance spine MR image quality. For motion/ghosting artifacts, fast imaging is possible using GeneRalized Autocalibrating Partially Parallel Acquisitions (GRAPPA), a multicoil parallel imaging technique to limit imaging times by up to 70%. Respiratory gating may also be used to reduce motion artifact on short sequences such as diffusion-weighted imaging. 3T MRI scans demonstrate greater hardware-related signal loss when compared to 1.5T scanners, but the T2 technique Slice Encoding for Metal Artifact Correction (SEMAC) can be used on 3T scanners to reduce metal artifact. Chemical shift artifact, commonly seen on post-contrast T1 fast spin-echo sequence can be limited when FLAIR sequences are obtained instead. Gibbs or ringing/truncation artifact is a result of signal truncation at the border of the finite k-space. K-space data can be extrapolated beyond the defined measurements to allow for a reduction in Gibbs artifacts without compromising resolution. Use of iterative maximum-likelihood expectation maximization (MLEM) post-processing algorithm can also reduce Gibbs artifact. Adequate fat-suppression and field homogeneity remain essential in spine MR imaging but can be quite challenging to achieve. Iterative decomposition of water and fat with echo asymmetry and least-squares estimation (IDEAL), and mDIXON turbo spin-echo, are fat suppression technique that are less affected by magnetic field inhomogeneity and are superior to conventional fat suppression techniques.

Conclusions
Spine MRI artifacts can drastically limit diagnostic capability in neuroimaging. We review various artifacts and new suppression techniques that enable substantially improved spine imaging and better diagnostic yield.

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The Anatomy and Pathology of Epistaxis

S Strauss1, E Marin-Diez2, E EBANI3, J Lantos4, C Phillips5
1Weill Cornell Medical Center, Manhattan, NY, 2Hospital Universitario Marques de Valdecilla, Santander, Cantabria, SC, 3NEW YORK PRESBYTERIAN HOSPITAL - WEILL CORNELL, NEW YORK, NY, 4Weill Cornell Medicine/New York Presbyterian Hospital, Manhattan, NY, 5Weill Cornell Medical College, New York, NY

Purpose
Epistaxis is one of the most common otolaryngology emergencies, and approximately 8% of cases necessitate medical attention. The purpose of this educational poster presentation is to review the anatomy relevant to epistaxis and offer a case based review of underlying causes including traumatic, neoplastic and vascular etiologies.

Materials and Methods
In the following educational exhibit, we will review the anatomical considerations in the ontogenesis of epistaxis, present an image-based review of both common and uncommon causes of epistaxis, and provide an algorithm for diagnosis in the setting of epistaxis.

Results
Epistaxis is one of the most common otolaryngology emergencies, with an estimated lifetime incidence of 60%. The majority of cases of epistaxis result from disruption of the Kesselbach plexus, the anterior/inferior nasal septum blood supply. This includes the anterior and posterior ethmoidal arteries (Opthalmic artery), sphenopalatine artery (Internal maxillary artery), greater palatine artery (Internal maxillary artery) and superior labial artery (Facial artery). A minority of cases are caused by disruption of Woodruff plexus, the blood supply to the posterior, inferior, and lateral nasal septum, including branches from the sphenopalatine artery (Internal maxillary artery) and pharyngeal arteries (see attached sample slides). Although the majority of instances of epistaxis are benign, approximately 8% necessitate medical attention. Underlying causes for epistaxis can be broadly divided into traumatic/iatrogenic, neoplastic, and vascular etiologies. Traumatic/iatrogenic causes of epistaxis include septal perforation, foreign body, facial trauma, barotrauma and cocaine abuse. There are many neoplastic conditions which can result in epistaxis, including juvenile angiofibroma, nasopharyngeal carcinoma, paranasal sinus tumors, esthesioneuroblastoma, nasal melanoma, and hematolymphoid neoplasms, which will be highlighted in this presentation. Finally, vascular etiologies are often associated with other systemic manifestations, and include hereditary hemorrhagic telangiectasia, granulomatosis with polyangiitis, and venous malformation.
Conclusions
Understanding the vascular anatomy relevant to epistaxis can aid in diagnosis and treatment. While many cases of epistaxis are idiopathic, an identifiable cause is present in approximately 20% cases. Familiarity with the various entities that might cause epistaxis can aid in narrowing a differential diagnosis.

The brain stem encephalitis. The role of imaging in diagnosis.

H Sotoudeh1, E Sotoudeh2
1University of Alabama Birmingham, Birmingham, AL, 2Iranian Hospital in Dubai, Dubai, Dubai

Purpose
The brain stem encephalitis (BSE) is a rare challenging condition for diagnosis and management with mortality of about 20%. Even in well developed medical systems about 30% of the BSE remain unknown in etiology. Diagnosis of this condition on imaging is difficult since many different anthologies may present with relatively similar imaging findings. In this digital presentation we are going to review the imaging findings of different causes of BSE. We will review the imaging findings which can narrow the list of differential diagnosis.

Materials and Methods

Results
The main imaging findings of each group will be discussed and MR images of the most common disease in each group will be presented.

Conclusions
The imaging diagnosis of BSE remain challenging but we hope by this presentation the readers can narrow the list of differential diagnosis.
The Congenital Brainstem: A Pictorial and Educational Review of a variety of Congenital Abnormalities based on Neuroimaging with genotype correlation.

K GRAIES1
1PSMMC, RIYADH, SAUDI ARABIA

Purpose
The brainstem is a key anatomical structure as it gives rise to majority of cranial nerves with the subsequent main motor and sensory innervation to the face and neck as well as it is the pathway of the main white matter long tracts including the corticospinal tract, the posterior column-medial lemniscus pathway and the spinothalamic tract. The brain stem also plays an important role in the regulation of cardiac and respiratory function, consciousness and sleep cycle. A wide range of diseases can affect the brainstem and its surrounding structures in the posterior fossa. Congenital abnormalities constitute a relative large group in childhood which may result from inherited (genetic) or acquired (disruptive) causes. We review these and describe the spectrum of brainstem malformations and prenatal acquired anomalies taking advantage of magnetic resonance imaging (MRI) and correlation with genotype.

Materials and Methods
We review and present the neuroimaging findings in a wide spectrum of congenital pathologies originating from or involving the brainstem. Genotype specified in majority of cases.

Results
We first describe the imaging anatomy of the brainstem and its surrounding structures. We then present a pictorial review of wide ranging abnormalities that include congenital anomalies, e.g. Joubert syndrome/Molar Tooth Malformation, ponto-cerebellar hypoplasia, dystroglycanopathies/ Cobblestone malformations, tubulinopathies, horizontal gaze palsy with progressive scoliosis, brainstem disconnection syndrome, microcephaly with pontine and cerebellar hypoplasia (MICPCH) /CASK-related intellectual disability, Fetal retinoid syndrome with Mid-Hindbrain malformation…, and intrauterine acquired pathologies such as superficial siderosis with brainstem hypoplasia, and post ischemic or post infectious changes. The brainstem anomalies are either rarely isolated or frequently associated with cerebellar and/or cerebral anomalies.

Conclusions
We comprehensively review the imaging findings with the genotype correlation in a wide spectrum of brainstem congenital pathologies. This educational review will aid in the diagnostic approach of these pathologies and their characteristic imaging features so that the radiologists can provide the referring clinician with the appropriate differential, if not a definitive diagnosis to effectively and efficiently guide the next step in genetic work-up and management.

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The Destination Less Travelled To: A Case-Based Pictorial Review of Fourth Ventricle Lesions

H Rajebi1, B Tantiwongkosi1, A Singh1
1University of Texas Health at San Antonio, San Antonio, TX

Purpose
A heterogenous group of lesions arises from or involves the fourth ventricle. Although MRI plays the key role in characterization and localization of these lesions, given the similarities in signal intensities, accurate diagnosis is usually challenging. On other hand, clinical features, when present, are nonspecific. In this exhibit, we aim to review and discuss the lesions involving the fourth ventricle with a patterned approach of localizing the lesions first followed by analyzing the signal characteristics and eventually arriving at an appropriate diagnosis.

Materials and Methods
After a brief review of relevant embryology and anatomy, a comprehensive institutional case-based review of the fourth ventricle lesions will be presented. Diagnostic hints and pitfalls will be illustrated in each case. Finally, a systematic approach to narrow down the differential diagnosis will be hypothesized.

Results
Cases of infectious process (neurocysticercosis), various neoplasms (pilocytic astrocytoma, glioma, medulloblastoma, ependymoma, subependymoma, choroid plexus papilloma, dermoid cysts, epidermoid cysts, and metastasis), hemorrhage and vascular malformation in/around the fourth ventricle will be discussed in detail. Distinct imaging features of each entity will be explained, and pertinent negative findings will be discussed to exclude the other differentials.

Conclusions
Given the wide variety of the lesions involving the fourth ventricle, equivalent imaging patterns and nonspecific symptomatology, a thorough knowledge of the lesions around this potentially challenging location through a systematic approach seems warranted for every neuroradiologist.
The Glymphatic System: Current Concepts and Role in CNS Disease

D BHALLA¹, S Franczak², L Umfle², A KLEIN², M Agarwal²
¹University of Wisconsin - Madison, Menomonee Falls, WI, ²Medical College of Wisconsin, Milwaukee, WI, ³Medical College of Wisconsin, Milwaukee, WI

Purpose
To outline the current concepts of the glymphatic system and understand its role in CNS disease.

Materials and Methods
Appropriate figures and where possible radiographic images will be used to describe the current concepts of the glymphatic system of the brain. Explanatory images will be used to demonstrate the role of glymphatic dysfunction in CNS disease.

Results
Cutting edge research is tirelessly looking for new avenues to understand disease and ways to combat it. This has led to the discovery of glymphatic system in the brain, which is a glial dependent perivascular network serving a lymphatic function. The most central role of this system is believed to be the clearance of waste from the CSF. Age-associated decrease in arterial pulsatility can decrease glymphatic flow leading to inadequate clearance of amyloid beta and its accumulation in the brain. The causative role of similar mechanism of reduced glymphatic clearance and accumulation of toxic substances in neurodegenerative diseases such as Alzheimer's disease, is increasingly gaining attention. Glymphatic-directed therapies are not yet available but regular exercise and maintenance of healthy weight are known to prevent glymphatic dysfunction.

Conclusions
The newly discovered glymphatic system can possibly give us insights into the causation of neurodegenerative diseases and open up avenues for new therapies. This exhibit will outline the current concepts in the glymphatic system and its role in CNS disease.
Purpose
The hyoid bone (HB) is 'free floating' in the anterior neck. A wide spectrum of common and uncommon diseases may involve the HB directly, but clinical diagnosis is often delayed due to atypical disease presentation in this unusual location. The relative infrequency of focal HB pathology on CT and MRI can be challenging for the neuroradiologist.

Materials and Methods
We review the imaging manifestations of a wide spectrum of pathologies originating from or involving the HB, and we classify these entities according to their etiology.

Results
We first describe the imaging anatomy and embryology of the HB. We then present numerous imaging examples of abnormalities centered on the HB. These may be developmental, e.g. bilateral absence of the lesser horns, or partial ossifications of the horns with surrounding structures. The latter may be asymptomatic when the stylohyoid ligament is calcified or ossified, or symptomatic when contributing to the 'stylohyoid complex (Eagles) syndrome'. The greater horn of the HB can be long and dysmorphic, impinging on a vertebral lateral process to cause pain on head turning, or pain that is part of a 'hyoid syndrome', with impingement on the carotid sheath. Thyroglossal duct cysts may rarely become trapped into the pharyngeal arch components of the HB body. The HB is mobile and well protected by the protruded mandible and cervical spine; therefore, HB fractures are rare (0.002%), resulting from strangulation injuries and neck trauma. Importantly, HB fractures can potentially lead to fatal complications owing to upper airway edema. Dislocation of the symphysis between the greater horn and the body of the HB may also occur. We also review and illustrate reported neoplastic malignant HB lesions including chondrosarcoma, osteosarcoma, plasmacytoma, and metastases from breast, liver, or renal cancers; features of HB osteoradionecrosis following neck chemoradiation; and benign masses including aneurysmal bone cysts, chondromas, and osteomas. We discuss the differential diagnosis of a calcified mass in the hyoid region. Focal tuberculosis of the HB has also been described. Finally, we cover the many ways in which the normal or malformed HB can affect the adjacent carotid arteries causing stenosis, compression, dissection, pseudoaneurysm, and contributing to TIAs and stroke.

Conclusions
Focal HB pathology may be associated with or result in high morbidity. This presentation will aid in neuroimaging interpretation and understanding of HB lesions to improve patient management.

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The Hypoglossal Canal: Imaging Anatomy, Pathologies, Radiological approach and Diagnostic Pearls.

I Khan1, S Chng2, Y Sitoh3, B Purohit3
1National Neuroscience Institute, Singapore, Singapore, 2National Neuroscience Institute, Singapore, Singapore, 3National Neuroscience Institute, Singapore, Not applicable

Purpose
1. Review imaging anatomy of the hypoglossal canal. 2. Review differential diagnoses and imaging pearls of pathologies involving the hypoglossal canal.

Materials and Methods
This educational exhibit aims to identify and provide a broad overview of the varied CT and MR imaging appearances of hypoglossal canal pathologies, including the more common culprits like tumours and infection and less common but important lesions i.e dural AV- fistula around the hypoglossal canal causing nerve palsy.

Results
The hypoglossal canal is a bony passage located between the occipital condyle and jugular tubercle through which the hypoglossal nerve exits the posterior cranial fossa. The hypoglossal nerve provides somatic motor innervation to the intrinsic and extrinsic muscles of the tongue. Involvement of hypoglossal nerve produces characteristic clinical and radiological manifestations, of which unilateral tongue atrophy and deviation are most common. Lesions involving the hypoglossal canal are rare, usually benign, and often include hypoglossal nerve schwannomas and posterior fossa meningiomas. However, the hypoglossal nerve may also be affected by perineural tumour spread and skull base osteomyelitis. If fatty hemiatrophy of tongue is noted on a neck CT or MR, careful scrutiny of the posterior skull base and hypoglossal canal is important to exclude underlying pathology.

Conclusions
The diagnostic approach to patients with lesions involving the hypoglossal canal requires clinical correlation, knowledge of normal anatomy and imaging appearances.

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The Lord of the Nerves: A Case-based Review of the Anatomy and Pathology of the Trigeminal Nerve

H Rajebi1, A Singh1, A Gregorat1, B Tantiwongkosi1
Purpose
Trigeminal nerve has a long route from the nuclei to the peripheral branches passing through multiple foramina at the skull base. The knowledge about this path is crucial for the neuroradiologist to understand the associated underlying pathologies. In this exhibit, we aim to review the normal anatomy and imaging characteristics of various conditions involving the trigeminal nerve.

Materials and Methods
After a detailed review of the relevant anatomy of the trigeminal nerve and its branches, a comprehensive institutional case-based review of the primary and secondary pathologies involving the fifth cranial nerve will be illustrated. Diagnostic hints and pitfalls will be presented in each case. Finally, a systematic approach to narrow down the differential diagnosis will be hypothesized.

Results
Cases in multiple categories including but not limited to: neoplasms (Meningioma, Schwannoma, Lymphoma, Glioma, Atypical Teratoid Rhabdoid Tumor, Metastasis), inflammatory conditions (Multiple Sclerosis, Sarcoidosis, Chronic Lymphocytic Inflammation with Pontine Perivascular Enhancement Responsive to Steroids [CLIPPERS], Tolosa-Hunt syndrome), vascular-related (Stroke, Cavernoma, Internal carotid artery aneurysm and etc.), infectious process (Sinusitis, Abscess, Rhombencephalitis), and miscellaneous (Trigeminal Neuralgia, Perineural spread, Microvascular decompression and etc.) will be shown. Different MR sequences, distinct imaging features, and pertinent negative findings of each entity will be explained. A brief demographic feature of each condition and predisposing risk factors will also be reviewed.

Conclusions
Long course of the trigeminal nerve with complex skull base and foraminal anatomy yield to abnormal imaging findings in the context of multiple underlying pathologies. It is essential that neuroradiologists become familiar with the normal anatomy and various neuropathies involving the trigeminal nerve for early and precise diagnosis, given the limited role for physical examination.
Purpose
Describe and discuss expected post-operative appearance and unexpected findings of complications after neurosurgical procedures of the adult brain and spine.

Materials and Methods
This educational exhibit utilizes an interactive case-based format of presentations in the short and long term post-operative state. We emphasize post-surgical radiographic appearances and highlight the utility of multimodal neuroimaging strategies to better differentiate between expected and unexpected findings.

Results
Management in the post-surgical state relies heavily on imaging and its respective interpretation; however, interpretation can often be difficult in the immediate post-intervention period because expected postsurgical sequelae may mask underlying complications. Additionally, surgery alters anatomical planes and thereby the normal imaging characteristics of the brain and spine. Through this exhibit, we discuss imaging features of common and uncommon postsurgical complications in the immediate and long term. Surgical considerations, radiographic findings, imaging strategies and "red flags" will be highlighted to aid in identifying complications atypical from the expected post-surgical state. Surgical management of complications will be discussed. Selected examples of complications include: 1. Granulomatous reactions to retained surgical foreign bodies 2. Vascular injuries after intracranial ablation, pipeline stenting, transsphenoidal approaches, and spinal fusion 3. Granulomatous inflammation secondary to hydrophilic polymer embolization 4. Spinal CSF-pleural fistula 5. Pseudomeningoceles, tension pneumocephalus and CSF leaks 6. Infections 7. Post lumbar puncture subdural hygromas or intracranial hypotension

Conclusions
Recognizing imaging findings of post-operative complications is crucial to the timely diagnosis and treatment.

The Odontoid Arcade (OA): Anatomy and Clinical-Surgical Implications

E Supsupin

Purpose
The odontoid arcade (OA) provides arterial supply to the dens. Despite its crucial role in vascularizing the dens and its important clinical and surgical implications, the OA has gained very little attention and has been limitedly described in the literature. This presentation aims to review the anatomy of the OA and its relevance to traumatic injuries and surgical instrumentation of the dens.

Materials and Methods
This presentation aims to address the following: 1. Elucidate the anatomy of the OA 2. Describe the clinical relevance of the OA in
traumatic injuries to the dens and craniocervical junction. Illustrate how anatomic knowledge of the OA may prevent complications during cervical spine instrumentation.

Results
The arterial arcade supplying the dens is mainly formed by branches of the vertebral and ascending pharyngeal arteries. Traumatic disruption of the blood supply to the odontoid process may affect healing of dens fractures. The posterior ascending artery (PAA) is a branch of the vertebral artery that contributes to the formation of the OA. Because of its vascular contribution, injury to the PAA may affect healing of dens fractures. During cervical spine instrumentation, a wrong trajectory of the pedicle screw may lead to injury of the PAA and produce an epidural hematoma. Therefore, a thorough anatomic knowledge of the relationship of the PAA to the pedicle screw is crucial in avoiding these complications. The PAA also supplies important ligamentous structures at the craniocervical junction. Traction damage to the PAA in the traumatic setting may result in the formation of retroclival epidural hematoma. The OA may become an important collateral source in arterial occlusive disease, particularly in posterior circulation strokes.

Conclusions
The OA vascularizes the dens and may affect healing of fractures. A thorough anatomic knowledge of the OA is crucial in preventing potentially serious complications during placement of pedicle screws.

The Pterygopalatine Fossa: An Important Crossroad of Perineural Spread in Head and Neck Malignancies

R Patel1, S Khanpara1, E Supsupin1, A Kamali1
1The University of Texas Health Science Center, McGovern Medical School, Houston, TX

Purpose
1. To review detailed anatomy of the pterygopalatine fossa (PPF) on high resolution CT and MRI. 2. To review neurovascular contents of the PPF and its different communication in adjacent compartments/spaces using an illustrative step-by-step methodology. 3. To review direct and indirect radiological signs of perineural spread in head and neck.

Materials and Methods
Retrospective search of database of our tertiary hospital was performed from 2000 to 2019 with keyword search "Perineural Spread" "Head and Neck". Representative cases pertinent to spread across the pterygopalatine fossa were presented in a case based format.

Results
The pterygopalatine fossa (PPF) is a fat containing inverted pyramid shaped shape which is a very important major crossroad of the multiple neurovascular structures. Obliteration of this normal far should be considered as an important finding to look for pathology. This exhibit will give a detailed review on the anatomy of the PPF using an illustrative diagram showing major neurovascular structures and foramina linked to PPF which is most vital for understanding of perineural spread across the PPF. Any process involving the PPF may spread via several nerves in an antegrade as well as a retrograde fashion.

Conclusions
The PPF is a vital imaging landmark-space which involves in a wide range of pathologies of the head and neck. This exhibit will
provide a detailed overview of the perineural spreading pattern across the PPF which helps readers to get familiar with it which facilitates early detection of primary malignancy.

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The Spectrum of Imaging Findings of Low Grade Gliomas Treated with BRAF Inhibitors and MEK Inhibitors

E Al Ajmi1, P Krishnan2, M Shroff3
1University of Toronto, Toronto, Ontario, 2HOSPITAL FOR SICK CHILDREN, TORONTO, ontario, 3Hospital for Sick Children, Toronto, ON

Purpose
1. Discuss the recent advances in molecular characterization of RAS/RAF/MAPK pathway and its implications in the treatment of low grade gliomas (LGG) with molecular targeted therapy. 2. List some of BRAF inhibitors and MEK inhibitors and their emerging role in the treatment of LGG in children. 3. Present case-based examples to show the treatment effects of BRAF inhibitors and MEK inhibitors in LGG.

Materials and Methods
Case-based presentation from our database emphasizing the difference in imaging response among patients with LGG with BRAF fusion or BRAFV600E mutation who are on BRAF inhibitors and MEK inhibitors.

Results
Low-grade gliomas (LGGs) are a diverse group of tumors that accounts for about 30% of CNS primary tumors in children. Management of these tumors, which include surgery and adjuvant chemotherapy, depend largely on the age of the patient and location of these tumors. Recent advances in molecular characterization of RAS/RAF/MAPK pathway have improved our understating of these tumors and provided promising results for treatment. Ninety percent of pilocytic astrocytoms have BRAF-KIAA1549 fusion gene while 10% show BRAFV600E mutation. Other glioneuronal tumors like gangliogliomas and pleiomorphic xanthoastrocytomas harbor also the BRAFV600E mutation. In our case-based presentation we will show that the presence of BRAFV600E mutation results in favorable response on imaging compared to those cases with BRAF fusion when treated with BRAF inhibitors and MEK inhibitors. The treatment response manifests with reduction in the size of the tumor, decrease in its T2 signal intensity and reduction in enhancement. Some tumors show interval reductions in the size of their cystic components while others show persistent or interval development of small cysts. The imaging response is quite early and dramatic after the initiation of therapy in tumors with BRAFV600E mutation.

Conclusions
Recent advances in molecular targeted therapy have resulted in promising results in the management of LGG in children. Despite the remarkable imaging response in patients with BRAFV600E mutation, longer follow up and more studies are required for better evaluation of the clinical outcome and long term effects.
Fig. 1. 7 year-old boy with hypothalamic pilocytic astrocytoma with positive BRAF V600E mutation which progressed on vinblastine. He was started on trametinib. (A) Axial T2 showing the tumor prior to the initiation of trametinib therapy. (B) After three months of therapy, the tumor shrank significantly in size with reduction of its T2 signal intensity and development of small cystic components.

Fig. 2. 11 year-old boy with medullary ganglioglioma which is BRAF V600E mutant. (A) The tumor at baseline with complex solid and cystic appearance. (B) The tumor and its cystic components reduced in size markedly with reduction of its T2 signal after 3 months of treatment with Debrafenib.
The Spectrum Of Post Cranial Radiotherapy Changes in the Brain Parenchyma: Common to the uncommon.

S Hiremath¹, U ERDENEBOLD¹, V Nair¹, N Zakhari¹, T Nguyen¹
¹The Ottawa Hospital, Ottawa, Ontario

Purpose
This educational exhibit aims to: - Review the basic concepts of radiotherapy planning and treatment - Describe the early and delayed imaging changes based on the duration post radiotherapy - Illustrate the findings in pseudoresponse, pseudoprogression, radiation necrosis, and tumor recurrence - Depict the uncommon presentations post-therapy including peri-ictal pseudoprogression (PIPG), stroke-like migraine attacks after radiation therapy (SMART) and post-radiation vasculopathy

Materials and Methods
The magnetic resonance imaging (MRI) appearances of brain lesions post radiotherapy will be described in a case-based format, illustrating the salient features. Special focus will be placed on the conditions posing a diagnostic dilemma, including pseudoresponse, pseudo-progression, radiation necrosis, and tumor recurrence. We will briefly discuss other less common conditions, including PIPG, SMART, post-radiation vasculopathy and other lesions involving brain parenchyma.

Results
We need to be aware of the basic concepts of radiotherapy, it's planning and treatment. The post-radiotherapy changes in brain are classified as acute, subacute and chronic depending on the time frame post-radiotherapy. Conventional MR imaging, along with advanced sequences, plays an essential role in predicting the likelihood of pseudoresponse, pseudo-progression, radiation necrosis, and tumor recurrence. This is of utmost importance as it may lead to stopping effective therapy (e.g., in pseudo-progression) or unnecessary therapeutic intervention (e.g., in radiation necrosis). We will demonstrate the role of advanced sequences, including a diffusion-weighted sequence (DWI), dynamic susceptibility contrast T2* perfusion along with MR spectroscopy in differentiating these entities. We will illustrate the utility of dynamic contrast-enhanced T1 and ASL perfusion as problem-solving tools in those with associated hemorrhage where the role of T2* perfusion and spectroscopy are limited. In addition, we will highlight the rare mimics of tumor recurrence compromising of PIPG and SMART along with illustration of vasculopathy and cerebral vascular malformations associated with radiation therapy. We will also demonstrate radiation-induced leukoencephalopathy and some radiation-induced tumors.

Conclusions
There is a multitude of changes that occur in the brain post-radiotherapy. As radiologists, we need to be aware of their common and uncommon manifestations to facilitate early diagnosis and initiation of appropriate management.
There is a Neurovascular Contact! Wait a Minute... It is in the Asymptomatic Side!: How to Deal with Imaging Findings in Trigeminal Neuralgia

P Puac Polanco¹, S Chakraborty¹
¹University of Ottawa, Ottawa, Ontario

Purpose
To review the imaging findings of neurovascular contacts in the trigeminal nerve. To discuss the interpretation of these imaging findings in symptomatic vs. asymptomatic patients according to the evidence.

Materials and Methods
Vascular compression of the trigeminal nerve is the most common factor associated with the etiology of trigeminal neuralgia (TN). Nevertheless, anatomical and imaging studies have also reported neurovascular contact in trigeminal nerves of individuals without TN making the diagnosis challenging. We will review the most useful imaging sequences on MRI to evaluate neurovascular contacts of the trigeminal nerve and discuss the appropriate imaging approach for this condition. Clinical characteristics and imaging-based predictors of outcomes after microvascular decompression will also be discussed.

Results
A discussion about radiologic anatomy of the trigeminal nerve, clinically types of TN, the prevalence of neurovascular contacts in symptomatic vs. asymptomatic nerves, and types of treatment will be shown. Imaging findings in neurovascular contacts will be approached according to location of the contact, type of vessel, degree of compression, and presence of atrophy in the nerve.

Conclusions
Neurovascular contacts in the trigeminal nerve are commonly found during imaging workup of patients with TN; however, this is also a frequent finding in asymptomatic patients. Knowing the approach of imaging findings in TN based on scientific evidence and this correlated with the clinical scenario is key to elucidate the clinical question.

(Filename: TCT_2176_Graphicfile.jpg)

To the Left, To the Left…Unilateral Internal Cerebral Vein Thrombosis is To the Left

A Hu¹, M Thomas², S Chaudhary³, G Hathout¹
¹UCLA Medical Center, Los Angeles, CA, ²OLIVE VIEW-UCLA MEDICAL CENTER, LOS ANGELES, CA, ³Huntington Memorial Hospital, Pasadena, CA

Purpose
Deep cerebral vein thrombosis is a potentially lethal disease process, typically affecting the thalami and sometimes the basal ganglia. The typical presentation is bilateral thalamic edema, with possible infarction and hemorrhage, secondary to bilateral internal cerebral vein thrombosis. The purpose of this exhibit is to present a much rarer variant of deep cerebral vein thrombosis: unilateral internal cerebral vein thrombosis (UICVT). This entity is so rare that only a few cases have been published in the medical literature. Moreover, because of its rarity, UICVT is often initially misdiagnosed, delaying critical therapy. In this exhibit, we will present two cases of UICVT, and use these cases to: review the typical radiologic appearance of UICVT; understand the clinical presentation; provide a differential diagnosis when presented with a unilateral thalamic lesion; and discuss current literature findings of internal cerebral vein thrombosis.

(Filename: TCT_2480_Graphicfile.jpg)
Materials and Methods
We reviewed two cases of UICVT gathered by our authors. The first was a 63-year-old female who presented with dysarthria and right hemiparesis. The second was a 49-year-old female who presented with right hemiparesis and aphasia.

Results
In this exhibit, we will go over the typical appearance of UICVT, including parenchymal and vascular findings. Parenchymal findings most commonly include unilateral thalamic edema and microhemorrhage, which can be mistaken for other pathologies such as infection and malignancy. Vascular findings are best seen on contrast CT or MR, with absence of filling of the involved internal cerebral vein. Often times, involvement of the other deep venous structures, such as the vein of Galen, thalamostriate vein, and straight sinus may be seen. We will also review the common presenting symptoms, choice of imaging modality, and approach to treatment once UICVT has been diagnosed. With timely administration of anticoagulation, prognosis appears to be good. We will also address the speculation that curiously, most of these cases appear to be left-sided (as both of our cases also were).

Conclusions
Unilateral internal cerebral vein thrombosis is a potentially fatal disorder in which prompt diagnosis should be made. Although rare, it is important for the radiologist to make an accurate diagnosis. Given the appearance of unilateral edema, it can often be mistaken for tumor or infection. Strong clinical suspicion is needed so that prompt treatment with anticoagulation can be delivered.
Purpose
1) Review chronic subdural hemorrhage (cSDH) pathophysiology and epidemiology
2) Discuss current treatment options for chronic subdural hemorrhage
3) Discuss role of transcatheter embolization of the middle meningeal artery in cases of cSDH
4) Discuss future studies for role of neurointerventional radiology in cSDH

Chronic subdural hemorrhage (cSDH) is a challenging pathology due to high recurrence rates of 2-37%. Embolization of the middle meningeal artery (MMA) has emerged as a minimally invasive intervention utilized as an adjunct or alternative to surgical approaches in the setting of cSDH. This exhibit reviews the angiographic evaluation and transarterial embolization of the middle meningeal artery in patients suffering from cSDH refractory to conservative treatment with medical therapy. As there is limited research on non-surgical treatment of cSDH and limited knowledge regarding indications and approach to treatment in the neurointerventional radiology literature, we present this exhibit with an aim to educate the NIR community on this subject.

Materials and Methods
N/A

Results
Our exhibit includes imaging that demonstrates: 1) Chronic subdural hemorrhage staging using CT and MRI, 2) arterial anatomy to be aware of during embolization, and 3) post-embolization angiography and clinical follow up. Imaging modalities include CT, MRI, arterial angiography, and digital subtraction angiography. We present example images showing angiographic images of the right middle meningeal artery pre and post-embolization and a right-sided chronic subdural hematoma, which resolved after embolization of the right middle meningeal artery. We will discuss the pathogenesis of chronic subdural hematomas, including their potential evolution from CSF density collections such as hygromas or evolution to a chronic state from an acute hemorrhage, and factors that prevent their resolution. We will also discuss current surgical and non-surgical treatment options. We will also discuss imaging and clinical features such as enhancing membranes that could suggest a higher success rate from embolization.

Conclusions
MMA embolization may present a less invasive alternative to surgery for cSDH, which often recur after surgical management. With an aging population and increasing use of systemic anticoagulation amongst the general US population, cSDH incidence may increase in the next decade. Embolization may offer a less-invasive option for treatment which appears promising in the few studies performed to date.
Figure 1: a) Axial CT image showing bilateral subdural fluid collections. The right collection underwent embolization using PVA particles. b) 3 week followup CT showing resolution of the right collection. The untreated left collection increased in density, possibly related to contrast enhancement or hemorrhage. c-d) Angiographic images showing the right middle meningeal artery before and after PVA embolization. (Filename: TCT_2314_csdh.jpg)
Transcranial Doppler, It's More Than Just the Numbers

D Krause¹, B Graner², M Veronesi²

¹Indiana University, Indianapolis, IN, ²Indiana University School of Medicine, Indianapolis, IN

Purpose
Transcranial doppler is an important imaging modality within the neuroradiologists' repertoire that is often overlooked during the radiology training period. Additionally, study interpretation can be elementary at times, simply classifying intracranial peak systolic and mean flow velocities into categories that match the extent or lack of vasospasm. The purpose of this project is to introduce transcranial doppler as a dynamic and non-invasive study essential to the management of critically ill patients. At the completion of the module, the learner will better understand the fundamentals of transcranial Doppler, including waveform analysis and its clinical applications. Interactive case examples will highlight the need for active rather than passive interpretation by the experienced neuroradiologist.

Materials and Methods
This PowerPoint based didactic will include informative, data driven, and interactive slides. Background review will include the history of transcranial doppler, basic physics of vasospasm physiology, imaging technique, natural course of untreated vasospasm and alternative methods of vasospasm identification. The treatments for vasospasm will also be detailed, as they directly affect blood flow. The waveform analysis section will focus on vasospasm secondary to subarachnoid hemorrhage, since it is the most common indication for transcranial doppler evaluation. Analysis is predominantly driven by numeric data. The absolute values of peak systolic and mean flow velocity form the pillars of transcranial doppler interpretation. The ratio of intracranial to extracranial arterial blood flow can also indicate vasospasm, and help determine the relevance of changes in intracranial blood flow over time. Waveform morphology provides a much less objective measure of vasospasm and can allude to additional intracranial and extracranial pathology. Interactive cases will cover the basics of transcranial doppler interpretation and further emphasize the importance waveform morphology.

Results
With the PowerPoint based didactic, residents developed an understanding of the history of transcranial doppler, basic physics of vasospasm physiology, imaging technique, natural course of untreated vasospasm and alternative methods of vasospasm identification which facilitated interpretation of transcranial doppler studies.

Conclusions
Residents can develop a working knowledge of transcranial doppler with a PowerPoint based didactic.

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True Fetal Posterior Cerebral Artery: Rare Variant Mimics AVM on MRI

E Perez¹, P Meyers²

¹Columbia, New York City, NY, ²Columbia University, Scarsdale, NY

Purpose
Educational Objectives: ● True fetal PCAs are extremely rare anatomic variants. ● The true fetal PCA variant is believed to be the result of a persistent anastomotic channel from the ICA-AChA and hypoplasia of the segment of the PCoA-PCA just proximal to the persistent anastamosis. ● True fetal PCA variant supply posterior cerebral structures and should not be embolized when confirmed angiographically. ● There is a reported increased risk of aneurysm with a true fetal PCA. Should a procedure be necessary, a thorough understanding of the angiographic findings and caution of vessel injury is necessary for management. Summary of the planned Presentation: HPI: A 28 year old woman with no significant past medical history developed a transient headache and underwent cerebral imaging using MRI with MRA. Unusual flow-voids adjacent to medial right temporal lobe structures raised concerns about a vascular malformation. Therefore, the patient was referred for diagnostic cerebral angiography to further elucidate the finding. On examination the patient was normotensive with stable vital signs. Her neurologic exam was normal. Imaging Findings Figure 1: Brain MRI, axial T1 with contrast and axial SWI sequences, showing a tangle of vessels with associated SWI artifact. Video 1: A right internal carotid arteriography in the lateral projection showing two dorsal branch vessels continuous with duplications of the right PCA. One branch arising at the expected location of the right AchA consistent with the rare variant pattern of a "true" fetal right PCA. Video 2: Arteriography of the left vertebral arteriography demonstrating a hypoplastic origin of a duplicated right PCA. Figure 2: Static imaging of the diagnostic angiogram highlighting the true fetal PCA anatomy: a PCOM, and tortuous hyperplastic AChA which extends posteriorly to the temporoparietoccipital lobes. Figure 3: Illustrative representation of the "true fetal PCA" anatomy.

Materials and Methods
N/A

Results
N/A

Conclusions
● The true fetal PCA variant is believed to be the result of a persistent anastomotic channel from the ICA-AChA and hypoplasia of the
segment of the PCoA-PCA just proximal to the persistent anastomosis, and is an extremely rare finding. True fetal PCA variant supplies posterior cerebral structures and should not be embolized when confirmed angiographically. Should a procedure be necessary, a thorough understanding of the angiographic findings and caution of vessel injury is necessary for management.

Figure 1

Figure 2

Figure 3

(Ulnshort-TE 4D MR Angiography in cerebrovascular diseases)


Juntendo University, Tokyo, Japan

ASNR20 Virtual Proceedings Page 238
Purpose
We present the clinical usefulness and limitation of a non-contrast enhanced ultrashort-echo time (UTE) 4D MR angiography which has 8 to 12 phases (time points) with a duration of 200 ms between time points.

Materials and Methods
The newly developed UTE-4D MRA using arterial spin labeling (ASL) technique might be used to decrease the susceptibility artifacts and visualizes the dynamic vascular flow. In our institution, we evaluated over 300 patients with cerebral aneurysms with/without coil/stent or dissection, carotid stenosis and occlusion with/without stents, moyamoya diseases, cerebral arteriovenous malformations (AVMs), dural arteriovenous (AV) fistula, etc. using UTE-4D MRA.

Results
UTE-4D MRA using ASL technique reduced metallic artifacts (such as coiling with a stent for aneurysms), dephasing artifacts of a very high flow portion (such as stenosis), and susceptibility artifacts on the petrous carotid artery from the sphenoid sinus. Thrombus within the vessels was subtracted out, thus no possible confusion as vascular flow. The UTE-4D MRA was useful in recently developed neurointerventional devices, including metals with susceptibility artifacts (flow diverter stent, carotid stents, etc.). It could visualize flow within the large aneurysms treated with coil and stent, which was difficult to observe not only in TOF-MRA but also on catheter angiography. In dural AV fistulas and AVMs cases, UTE-4D MRA showed not only feeders and early venous filling but also relatively late cortical venal reflux. Pitfalls and limitations of the UTE-4D MRA were that the slightly lower spatial resolution of UTE-4D MRA compared with TOF-MRA, and no significant acceleration (overestimation) of stenosis/occlusion on UTE-4D MRA. Overestimation of the stenosis/occlusion on TOF-MRA might sometimes help to detect the lesion.

Conclusions
Non-contrast enhanced UTE-4D MRA is a useful tool for the evaluation of cerebrovascular diseases, especially in the evaluation of the patients with neuro-interventional metallic implants.

Figure 1. The four picked-up phases out of 12 phases of UTE-4D MRA in a patient with AVM. 1-mm isotropic 3D data with 12 phases were obtained in about 12 min. Using UTE-4D MRA, not only the feeders and nidus but also the drainers were well visualized.

(Filename: TCT_1713_Figure1ASNR.jpg)
Understanding Causes of Neuropathy in Pediatric Population

J Jun1, Y Li2, J Mathieu3, K Soderlund4, C Glastonbury5
1UCSF, San Francisco, CA, 2UCSF, Corte Madera, CA, 3UCSF, San Francisco, CA, 4UCSF Medical Center, Mill Valley, CA, 5University of California San Francisco, San Francisco, CA

Purpose
Describe and discuss radiologic features pediatric cranial neuropathy.

Materials and Methods
This educational exhibit will briefly discuss the nuclei and courses of the cranial nerves. Then we will highlight different etiologies of cranial neuropathies in pediatric population. These causes will be divided into broad categories including neoplastic, infectious/inflammatory/metabolic, and congenital, developmental/anatomic.

Results
Cranial nerve neuropathies have been studied extensively in adults. When isolated cranial nerve neuropathies are present in adult population, an extensive scrutiny of the nerve in its entire course is crucial to exclude perineural spread of tumor. Cranial nerve neuropathies are less common in children and have different causes. In children, posterior fossa tumors such as DIPG, medulloblastoma, ependymoma, and astrocytoma are responsible for lower cranial nerve symptoms. For infectious/inflammatory causes Miller Fisher syndrome can cause ophthalmoplegia. Additionally, viral infection and its sequela such as ADEM can result in cranial nerve neuropathy. For congenital causes, they may be related with syndromes such as septo-optic dysplasia, CHARGE or osseous abnormalities including osteopetrosis, congenitally narrowed hypoglossal canal, or congenital laryngeal palsy. We will discuss various etiologies that are more common in children to help delineate to localize the causes of cranial neuropathies in children.

Conclusions
Imaging is important in assessing cranial nerve neuropathy as it provides more comprehensive assessment. As there are numerous etiologies for cranial nerve neuropathies and it is important for radiologists to have a better understanding of more common pediatric causes of these abnormalities so we can help and aid proper, timely patient management.

Understanding the Role of Diffusion Tensor Imaging in Spinal Cord Injury - a Big Data Problem

J Gajera1, I Raza2, J Seah2, C Li2, J Tee2, M Law3
1Alfred Health, Melbourne, CA, 2Alfred Health, Melbourne, VIC, 3Alfred Health, Melbourne, VIC

Purpose
Non-invasive imaging biomarkers that may be employed as surrogates for spinal cord injuries are essential to guide the development of protocols for interventional trials. While conventional MRI techniques provide macrostructural information, they are non-specific and cannot reveal underlying microstructural changes that might indicate neurodegeneration and compensatory processes. DTI is an advanced MRI technique that characterizes tissue microstructure by measuring the water diffusion profile of the tissue. Spinal cord DTI metrics have been shown to correlate with neurological outcomes after tSCI and DCM, however, its use is still limited to research settings. Neuroradiologists' understanding of the science behind DTI in SCI is essential for informing standardised research to hasten the clinical adoption of this translational MRI technique.

Materials and Methods
A search within EMBASE, MEDLINE, Web of Science and PubMed databases was conducted for articles relating to the use of DTI in SCI. The citations of relevant articles were also searched for additional articles.

Results
The longitudinal organization of cellular and subcellular physical barriers causes water molecules to diffuse in a direction predominantly parallel, as opposed to perpendicular, to axonal fibres in normal white matter (WM) tissue. The anisotropic diffusion of water in the WM can be characterized by a diffusion tensor, a 3-dimensional object. The most common DTI metrics include axial diffusivity; radial diffusivity; mean diffusivity and fractional anisotropy (FA). Changes in these metrics at the trauma site as well as remote to the injury site reflect changes in microstructure integrity. Several DTI metrics, most notably FA, have demonstrated correlation with clinical outcome after SCI. Upon reviewing the literature, acquisition techniques varied widely across studies, rendering direct comparison of metrics invalid. Challenges to acquiring uniform data include magnetic field inhomogeneity and physiologic motion, resulting in artifact and distortion. Automated segmentation has improved feasibility of extracting DTI metrics. Quantitative metrics, heterogeneous data and confounding clinical factors make this a big data problem.

Conclusions
DTI as a biomarker for diagnosis and prognostication of DCM and tSCI is an emerging area. Advances in data acquisition and reaching consensus on a standardized research protocol are needed to improve the utility of DTI metrics in this population.
Unilateral or Bilateral T1-Weighted Hyperintense Basal Ganglia Signal Abnormality - An Interactive Educational Exhibit Illustrating a Series of Conditions.

S Ge¹, P Goh¹
¹National University Hospital, Singapore

Purpose
The main purpose of this educational exhibit is to familiarise the reader with a series of conditions that can present as unilateral or bilateral T1-weighted hyperintense signal change within the basal ganglia, with discussion of the pathophysiology, MRI physics and clinical background.

Materials and Methods
A series of cases will be presented in a quiz format. The cases will be shown side by side, allowing the user to appreciate their similarity. After selecting a case, the user will be given a multi-choice question to attempt. A brief clinical background, other sequences, comparison studies or other modalities may be uncovered by the user before attempting an answer. After attempting, the answer and a discussion of the case will be shown.

Results
T1-weighted hyperintensity within the basal ganglia may be attributed to a few entities, including calcium, protein, paramagnetic minerals, methemoglobin and neoplasm. Pathologies involving the basal ganglia are often systemic in nature, hence they are usually bilateral and symmetrical. Unilateral or asymmetrical T1-weighted hyperintense lesions may often be confusing to reader, although it can be narrowed down to a smaller range of conditions including calcification, subacute haemorrhage, neoplasm and non-ketotic hyperglycemic hemichorea. We hereby show a series of common and uncommon cases that present as unilateral or T1-weighted hyperintense signal change in the basal ganglia. These can be similar in appearance on imaging and interpretation can be challenging without a good understanding of the underlying pathophysiology, MRI physics and clinical picture.

Conclusions
Combining interactivity, review of literature and a series of cases, we aim to help users tackle the diagnostic challenge of unilateral or bilateral T1-weighted hyperintense signal change in the basal ganglia in their future reading.

Unusual Appearances of Perivascular Space Dilation

A Kadribegic¹, M Kulzer², J Chen³, M Goldberg¹, A Sohn¹, W Chang⁴, M Spearman¹, C Wanamaker¹, C Li¹
¹Allegheny Health Network, Pittsburgh, PA, ²Allegheny Health Network, PITTSBURGH, PA, ³San Diego Veterans Administration Health System, San Diego, CA, ⁴AHN, Pittsburgh, PA

Purpose
Perivascular spaces (PVSs), a.k.a. Virchow-Robin spaces, are congenital interstitial fluid collections surrounding vessels penetrating
the brain parenchyma [1]. These spaces can become dilated, and, when present in atypical locations, have associated mass effect, cluster together, or demonstrate other signal abnormalities, can mimic other pathologic processes including white matter disease, chronic lacunar infarcts, infection, and cystic neoplasms. In this presentation, we provide examples of unusual patterns of PVS dilation to familiarize radiologists with the varied appearances of this phenomenon.

Materials and Methods
We will present the current anatomic and physiologic understanding of PVSs, including their role in the glymphatic system [2]. We will demonstrate the imaging features of typical PVSs on CT and MRI and compare them to examples of atypical patterns of PVS dilation that mimic other disease processes. We will review the organization of PVSs in the brain that can help radiologists better recognize these patterns even in less common, and sometimes bizarre, appearances.

Results
PVS dilation most commonly occurs along the lenticulostriate arteries at the anterior perforated substance, perforating medullary arteries in the cerebral white matter, and collicular and accessory collicular artery penetrating branches at the pontomesencephalic junction of the midbrain [3]. Dilation of these spaces typically results in discrete ovoid, teardrop-shaped, or tubular lesions with CT attenuation and MR signal characteristics identical to CSF. The internal traversing vessel can occasionally be delineated if imaging parameters are optimal, essentially establishing the diagnosis. Unusual patterns of PVS dilation include involvement of PVSs elsewhere in the brain, large size with associated mass effect, clustering, surrounding gliosis, and rarely, hemorrhage and proteinaceous contents.

Conclusions
Dilation of PVSs can have a wide range of appearances. Upon completion of this educational exhibit, the neuroradiologist will be better able to distinguish dilated PVSs from other pathologic processes, leading to improved diagnostic accuracy, better therapeutic decision-making, and reduced inappropriate and unnecessary follow-up testing.
Figure: (A) Typical appearance of a dilated perivascular space along the right lateral lenticulostriate arteries with signal intensity identical to CSF and containing a traversing vessel (arrow). (B) Extensive unilateral cerebral perivascular space dilation without mass effect. (C) “Tumefactive” perivascular spaces centered on the right corpus callosum and cingulate gyrus associated with mild mass effect. (D) “Tumefactive” perivascular spaces centered on the right deep grey nuclei, associated with peripheral hemosiderin from prior hemorrhage (arrows). Several demonstrate decreased T2 intensity relative to CSF, with diffusion restriction (not shown), suggestive of proteinaceous contents (asterisks).

(Filename: TCT_2524_Picture3.jpg)
Unusual Cerebral Infarct Patterns Every Radiologist Should Know

S Wu¹, M Cox¹, S Nabavizadeh¹
¹Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose
Cerebral infarction is a leading cause of morbidity and mortality worldwide. Establishing accurate and timely diagnoses in patients with acute brain infarcts is crucial to patient care and ultimately patient prognosis. Therefore, it is vital for radiologists to be able to recognize more uncommon patterns of cerebral infarctions. The purpose of this interactive educational exhibit is to present unusual cases of brain infarcts associated with infarcts of the anterior cerebral circulation, posterior cerebral circulation, and brainstem stroke syndromes.

Materials and Methods
Multiple cases of unusual brain infarcts will be presented with descriptions of pertinent vascular anatomy, angiographic correlations, and a review of relevant literature. The imaging features and pathognomonic clinical symptoms of these infarction patterns will be discussed.

Results
Over ten cases will be included in this exhibit. These cases fall into the following major categories: 1) Infarctions in the anterior cerebral circulation, including infarctions in the anterior choroidal artery, recurrent artery of Heubner, pericallosal artery, azygos anterior cerebral artery, and lenticulostriate artery territories. 2) Infarctions in the posterior cerebral circulation, including infarctions in the artery of Percheron (Figure 1A and 1B, with a filling defect in the proximal left P1 segment), lateral posterior choroidal, choroid plexus (Figure 1C and 1D, with additional acute infarcts in the body and splenium of the right corpus callosum), and fetal posterior communicating artery territories. 3) Brainstem stroke syndromes, including the facial colliculus syndrome, internuclear ophthalmoplegia secondary to medial longitudinal fasciculus infarct, and the lateral medullary syndrome.

Conclusions
Unusual brain infarct patterns can be challenging for both radiologists and clinicians. Familiarity with vascular anatomy, anatomic variants, patterns of uncommon infarctions, and clinical symptoms of brainstem stroke syndromes is critical for appropriate patient care.
Up in a puff of smoke: role of imaging in the diagnosis, treatment planning and post-operative evaluation of Moyamoya disease

a griffin¹, M Malinzak¹
¹Duke University Medical Center, Durham, NC

Purpose
Moyamoya disease is an arteriopathy of the distal internal carotid arteries and proximal Circle of Willis resulting in progressive vascular stenosis and occlusion. Diagnostic criteria are based on imaging findings which may include evaluation with CT angiography (CTA), MR angiography (MRA), or conventional catheter digital subtraction angiography (DSA). The purpose of this educational exhibit is to review the clinical and diagnostic features of Moyamoya disease.

Materials and Methods
Through illustrative cases, we will review imaging strategies for diagnosis and treatment planning of Moyamoya disease. In addition, we will describe surgical management options and the expected post-surgical imaging findings as well as potential early and delayed post-operative complications.

Results
A noncontrast head CT is typically performed to evaluate an acute presentation of Moyamoya disease. Noncontrast CT findings that can suggest underlying Moyamoya include hypodense areas of ischemia and infarction involving cortical and deep watershed zones as well as hemorrhage. CTA is superior to MRA for showing vasculopathy but diagnosis ultimately requires catheter angiogram. DSA will show associated aneurysms or AVMs as well as provide dynamic information such as collateralization and vessels available for bypass. Treatment is typically direct surgical bypass in adults and indirect bypass in children. Immediate post-operative complications include stroke and hemorrhage from cerebral hyperperfusion syndrome. Delayed post-operative findings may include graft stenosis or occlusion, which can result in ischemia and stroke.

Conclusions
Moyamoya disease is a progressive arteriopathy that often results in cerebral ischemia or hemorrhage. CT and MRI are good screening tests but catheter angiography is almost always required for definitive diagnosis and treatment planning. Surgical treatment options include direct and indirect bypass. Radiologists must be familiar with the post-treatment imaging findings and potential complications.
Purpose
Measurement of response assessment in solid tumors relies on several different methods such as one dimensional measurements (RECIST), two dimensional measurements (RANO), and volumetric measurements. Prior research suggested that one and two dimensional measurements correlate to volumetric measurements, but recent literature in pediatric brain tumors suggests that there is an added value to volumetric measurements. The major drawback in clinical implementation of volumetric measurement of pediatric brain tumors is the time it takes to segment the tumor and lack of widespread availability of 3D measurement tools among different PACS systems. We aim to review the 3D measurement tools available to radiologists and describe different presentation modules that can be applied to clinical reports.

Materials and Methods
Volumetric measurement tools that include Phillips IntelliSpace Tumor Tracking Module, Visage 3D segmentation, Horos, and 3D Slicer segmentation modules will be reviewed and step by step description of applying these tools for segmentation of tumors will be described. The time for segmentation by radiologists at different levels of training will be presented for each of the methods. Format for inclusion of measurements into the radiology report will be described.

Results
Volumetric measurement of tumors is a time intensive process, although incorporation of 3D measurement tools into PACS systems has decreased the time it takes for segmentation. Semi-automatic processes such as Phillips IntelliSpace TTM and 3D Slicer allow rapid segmentation of 3D volumes that can be done in real time during image interpretation. We will present step by step tutorials for implementing these methods into clinical practice. We will present multiple cases of 3D segmentation of pilocytic astrocytomas via these methods. We will also demonstrate the method for measurement of %cystic and %solid component on these tumors that are predominantly heterogeneous in their composition. We will also present multiple examples of longitudinal measurement of tumors after treatment with volumetric measurements demonstrating different outcomes as compared to RECIST or RANO criteria.

Conclusions
The availability of intuitive, quick and reliable volumetric assessments can lead to qualitatively better therapeutic outcomes. We will present a case based review of features important in measurement of pediatric brain tumors and step by step tutorial of 3D segmentation on different platforms and applications to clinical practice.

Utilization of a very novel MRI technique FGATIR (Fast gray matter acquisition T1 inversion recovery) sequence in localizing mammillothalamic tract and its application in treatment of movement disorder

R Patel1, S Khanpara1, O Arevalo1, L Ocasio1, P Rabiei1, A Kamali1
1The University of Texas Health Science Center, McGovern Medical School, Houston, TX
Deep brain stimulation is approved for treatment of number of movement disorders such as Parkinson's disease, essential tremor, dystonia and Huntington's disease. Various targets have been identified over the years following intense research in this area. The anterior nucleus of thalamus (ANT) and the mammillothalamic tract (MTT) have been rigorously studied as target for treatment of movement disorders. In this series, we propose to use a newly developed MRI sequence to identify the mammillothalamic tract for pre-surgical localization and stimulation in patients with movement disorder.

Purpose

Deep brain stimulation is approved for treatment of number of movement disorders such as Parkinson's disease, essential tremor, dystonia and Huntington's disease. Various targets have been identified over the years following intense research in this area. The anterior nucleus of thalamus (ANT) and the mammillothalamic tract (MTT) have been rigorously studied as target for treatment of movement disorders. In this series, we propose to use a newly developed MRI sequence to identify the mammillothalamic tract for pre-surgical localization and stimulation in patients with movement disorder.

Materials and Methods

We proposed a fast gray matter acquisition T1 inversion recovery sequence (FGATIR) for localization of the MMT. We performed this sequence in five patients presenting to our hospital with refractory movement disorder. All of the scans were acquired in Philips Ingenia (3T) magnet. The following parameters were used: TR = 6300 msec, TE = 2.8 msec, slice thickness = 1 mm, flip angle = 8 degree, matrix size = 512 x 512 using standard 32 channel head coil. This sequence performed as a part of the pre-operative imaging was then coregistered with the surgical navigation software for stereotactic guidance. Using the FGATIR dataset, the MMT was identified in three planes. Bilateral tracts were then stimulated using transventricular or lateral transcortical approach.

Results

The identification of the ANT and the MMT was optimal in all patients. The DBS leads were accurately placed targeting bilateral MMT without any complication. All five patients were asked to return after 2 weeks of the DBS stimulator placement for parameter optimization. The optimization of the parameters was performed on a patient to patient basis. All patients achieved significant control of the movement disorder.

Conclusions

Preoperative localization of the mammillothalamic tract can be accurately performed using this novel imaging technique (FGATIR). Deep brain stimulation of the MMT is an effective method for control of refractory movement disorder.

Venous Mapping of Vascular Malformations using Cranial 4D Flow MRI

G Roberts1, M Loecher2, L Rivera-Rivera1, P Turski3, K Johnson4, O Wieben3, L Eisenmenger5
1University of Wisconsin - Madison, Madison, WI, 2Stanford University, Stanford, CA, 3University of Wisconsin, Madison, WI, 4University of Wisconsin - Madison, Madison, WI, 5University of Wisconsin - Madison, Middleton, WI

Purpose

The management of intracranial vascular lesions such as arteriovenous malformations (AVMs), vein of Galen malformations (VGMs), and dural arteriovenous fistulas (DAVFs) can be complex with significant morbidity and mortality. Endovascular intervention via a venous approach, or trans-venous embolization (TVE), is a common method to treat VGMs and DAVFs. TVE for AVM treatment is now also gaining interest [1]; however, accurate characterization of venous drainage is essential to this treatment approach which can be limited on digital subtraction angiography due to mixing of non-opacified blood. We present a novel approach to perform comprehensive venous mapping of flow patterns through retrospective 'virtual injection' applied to high resolution 4D Flow MRI.

Materials and Methods

4D flow data was acquired on clinical 3T scanners with a radially-undersampled PCVIPR [2] acquisition with whole brain coverage: 6min scan, VENC=80cm/s, 0.7mm isotropic resolution. The 4D flow data were used to (1) generate high resolution angiograms, (2) select seeding locations to initiate 'virtual injections' which were (3) calculated from the acquired velocity vector field, and (4)
visualized as streamlines. Processing included stochastic noise corrections, displacement corrections [3], and fluid constraints to track arterial and venous blood flow in areas of interest [4]. For comparisons, pseudo-continuous ASL (PCASL) scans were also acquired.

Results

The new approach was in good qualitative agreement with PCASL with added advantages of (1) retrospective choice of 'injection site' and enabling (2) venous capture, and (3) anterograde and retrograde blood flow evaluation. For example, a portion of a shunt or nidus that is drained by each vein can be visualized, which may prove essential in the appropriate selection of embolization candidates and pre-procedure planning. Fig 1 shows a case with streamline generation seeds placed distal to the AVM nidus. Retrograde tracking shows the portion of the nidus supplied by each vein.

Conclusions

Probabilistic streamlines from corrected 4D flow MR data allow for complex arterial and venous mapping in vascular malformations without being affected by mixing of non-opacified blood. This approach provides valuable new insights into pre-procedural planning with guidance for selective embolization. Future studies are needed to assess the impact on improved pre-procedure planning and patient outcomes.

2258

Vessels on Fire: A Review of Atypical or Uncommon Causes of CNS Vasculopathy and Vasculitis

J Junn1, K SODERLUND2, Y LI3, C Glastonbury4
1UCSF, San Francisco, CA, 2UCSF MEDICAL CENTER, MILL VALLEY, CA, 3UCSF, Corte Madera, CA, 4University of California San Francisco, San Francisco, CA

Purpose

To educate radiologists on often overlooked or atypical etiologies of CNS vasculopathy and vasculitis.

Materials and Methods

We will first describe the difference between the terms vasculopathy and vasculitis. We will briefly discuss MRI vessel wall imaging technique to assess vascular inflammation. Subsequently, we will show cases from our institution highlighting various patterns of CNS vasculopathy and vasculitis to include infarcts, patterns of vasculopathy-related intracranial hemorrhages, and associated symptoms such as hearing or vision loss. We will then discuss different yet important etiologies of vasculopathy and vasculitis which radiologists should have in their armamentarium to assist patient management, as many of these findings have different clinical management and outcomes The goal of this exhibit is to provide radiologists with the necessary tools to recognize vasculopathy and vasculitis, narrow the differential to the characteristic etiologies, and make relevant recommendations to the referring clinician.

Results

The terms vasculopathy and vasculitis are often used incorrectly by clinicians and radiologists. Vasculopathy refers to any pathologic condition affecting blood vessels including atherosclerosis, metabolic conditions, and cerebral autoregulatory disease. Vasculitis, on the other hand, implies a condition when there is inflammation involving the vessel wall. Both cerebral vasculopathies and vasculitis
present clinicians and radiologists with a formidable diagnostic challenge. Understanding the distinction between vasculitis and vasculopathy is critical for radiologists in order to provide a focused differential diagnosis and help guide patient management. In this exhibit, we will discuss various atypical etiologies of CNS vasculitis and vasculopathy. We will highlight overlooked etiologies of both non-inflammatory vasculopathy, such as CNS vascular lymphoma and inflammatory vasculitis including Susac syndrome, Behcet's disease, and amyloid beta-related angiitis. We will also present cases of pediatric vasculopathies: sickle cell disease, ACTA2 gene-related vasculopathy, and focal cerebral arteriopathy. This educational exhibit will also distinguish the differences between RCVS and PACNS. We will conclude with cases of radiation-induced, infectious, and drug-related vasculopathy.

Conclusions
Understanding the difference between vasculitis and vasculopathy is important for radiologists to provide helpful differentials to help guide patient management.

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Virtual Reality and 3D Modeling of Patient Specific Temporal Bone Anatomy and Pathology

c Sturge1, A Eastaway1, R Wiggins2, T Hutchins3, Y Anzai4, E Quigley5
1University of Utah, Salt Lake City, UT, 2University of Utah, Salt Lake City, UT, 3University of Utah, Neuroradiology, Salt Lake City, UT, 4University of Utah School of Medicine, Salt Lake City, UT, 5University of Utah, Salt Lake City, UT

Purpose
For trainees and radiologists alike, visualizing temporal bone anatomy and pathology can be challenging. We propose that our previously developed methodology for creating virtual reality three-dimensional model can create a tangible and interactive way to learn and correlate cross-sectional imaging of complex anatomic structures.

Materials and Methods
Using commercially available 3D segmentation software (Materialise Mimics and 3matics, Michigan, USA), real-world and patient-specific data of representative anatomy and pathology is segmented and turned into 3-D objects. These virtual models are digitally cleaned of extraneous noise and optimized. Subsequently, models are imported into virtual reality (Oculus Rift, HTC Vive Pro, and Google Cardboard). This virtual database is hosted upon a web-based browser creating enduring and interactive models that are readily accessible—and easily printed into tangible objects—for trainee and point-of-care education.

Results
Virtual reality modeling of temporal bone anatomy and pathology provides a novel way for trainees, residents, and consultants to virtually and tangibly grasp and manipulate the complex 3D anatomy of middle and inner ear. Being able to compare a virtual model to patient-specific imaging reinforces the complex anatomic relationships needed for accurate understanding and reporting of cross-sectional temporal bone examinations.

Conclusions
Creation of a virtual database of temporal bone anatomy and pathology categories facilitates education and accelerates trainee identification of normal and abnormal structures. Ongoing research with resident and student trainees can be performed to evaluate the impact of virtual reality simulators for radiology education.

(Filename: TCT_2227_T-Bone.jpg)
What do we know about Structural Brain differences in adolescents born extremely preterm who develop ADHD?

B Setty, W Chavez, R McNaughton, A Mian, O SAKAI, J Frazier, R Joseph, D Kennedy, K Kuban, M O'Shea

Boston University Medical Center, Boston, MA, Boston Medical Center, Boston, MA, Boston University, Boston, MA, BOSTON UNIVERSITY SCHOOL OF MEDICINE, BOSTON, MA, University of Massachusetts Medical School, Worcester, MA, Boston University School of Medicine, Boston, MA, University of North Carolina Health Care, Chapel Hill, NC

Purpose
Educational objective: Elucidate structural brain differences between ADHD and non-ADHD subsets of Extremely Low Gestational Age born adolescents. Purpose A number of previous studies have highlighted structural brain differences in the brain in preterm born children, including the ADHD subset. In our study, we evaluate structural brain differences in adolescents with and without ADHD (around 15 years of age), who were born preterm at < 28 weeks of gestation. These patients were enrolled as a part of a multicenter, observational study of the risk of structural and functional neurological disorders in extremely low gestational age newborns (ELGAN).

Materials and Methods
We will discuss the structural differences in the intracranial (ICM) volumes, brain volumes, white (WM) and gray matter (GM) volumes, CSF volumes, and connectomes (CTM) by volumetric analysis. Multispectral quantitative MRI and dual-clustering segmentation algorithms, coded in Python 3.5 using the Canopy integrated development environment, were implemented to strip the skull and isolate white matter, gray matter, and CSF voxels. These algorithms were conducted between ADHD and non-ADHD subsets in 15-year-old adolescents. We will also analyze the DTI data between these two subsets to identify differences in FA values and organizational changes in the white matter tracts.

Results
Our preliminary findings demonstrate differences between ICM, Brain, WM, and GM, CTM volumes between ADHD vs. non-ADHD ELGAN subjects.

Conclusions
This is one of the first studies to our knowledge elucidating the structural and DTI differences between adolescents with and without ADHD, born as extremely low gestational age newborns.

What is DAT? Imaging of the Dopamine Transporter; Indications, Interpretation and Cases

A Haughey, S Liddy, R Killeen

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Purpose
In this presentation, we discuss dopamine transporter (DAT) imaging of the brain, with I-123 ioflupane (DaTSCAN). We illustrate the uses and benefits of DaTSCAN imaging in clinical practice, using cases from our institution.

Materials and Methods
In this presentation we detail the scientific basis for utilising the radiopharmaceutical I-123 Ioflupane (DaTSCAN), in functional brain imaging. We review the practical applications of DaTSCAN imaging. We outline the qualitative and semi-quantitative approach to DaTSCAN imaging analysis. Finally, we present a number of cases from our institution where DaTSCAN imaging is used in combination with cross sectional imaging +/- PET CT for diagnosis of neurodegenerative processes.

Results
DaTSCAN is a cocaine analogue used for imaging the dopamine transporter (DaT), a sodium chloride-dependent transmembrane protein on the presynaptic nigrostriatal cell surface. Postmortem studies have shown marked reduction in the cocaine-binding dopamine receptors in patients with idiopathic Parkinson's disease. We review the practical applications of DaTSCAN imaging and its use in investigating patients for idiopathic Parkinsonism (IPD) and in differentiating IPD from essential tremor and IPD-like processes including multiple systems atrophy and supranuclear palsy (also known as Parkinson's plus syndromes). There are both qualitative and semi-quantitative approaches to DaTSCAN imaging analysis and we illustrate the various patterns of possible uptake. We review the imaging findings of a multitude of neurodegenerative disorders including findings on DaTSCAN imaging, computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography CT, using cases from our institution. We include Parkinson's disease (PD), Alzheimer's disease (AD), multiple system atrophy (MSA), progressive supranuclear palsy (PSP), corticobasilar degeneration (CBD), Lewy Body Dementia (LBD).

Conclusions
Imaging with DaTSCAN is an effective study that can confirm whether there is dopaminergic neurodegeneration present in patients presenting with Parkinsonian symptoms. We present a multitude of cases where imaging with DaTSCAN, in combination with CT, MRI or PET CT enables diagnosis of the underlying disorder.

2668

What We Should not Forget about Down's Syndrome

D Fragoso1, D Nunes2, A Martins Maia Junior3, L LESSA4, C da Silva5, C Leite6
1Santa Casa de São Paulo, São Paulo, SP, 2Laboratorio Fleury, Sao Paulo, Sao Paulo, 3Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, São Paulo, 4HCFMUSP - BRAZIL, SAO PAULO, Brazil, 5HCFMUSP - BRAZIL, São Paulo, São Paulo, 6Fleury, São Paulo, São Paulo

Purpose
Review and systematize the distinctive characteristics and abnormalities of the central nervous system present in Down's syndrome (DS).

Materials and Methods
We conducted a review in the literature with the following search terms: Down's syndrome; Dementia. The work was organized in a brief introduction, which includes the clinical challenges at presentation. Then, we have focussed on the discussion of both structural and functionally neuroimaging features of this common syndrome. All examples of each situation were cases of our institution.

Results
Down's syndrome s the most common genetic cause of learning difficulties, and individuals with this condition represent the largest group of people with dementia under the age of 50 years. Despite the large number of published papers concerning DS, there is scarce literature focusing specifically on this issue. Genetic drivers result in a high frequency of Alzheimer's pathology in DS, evident from neuroimaging, biomarker, and neuropathological findings. However, cognitive assessment is challenging, and diagnostic methods have not been fully validated for use in these patients; hence, early diagnosis remains difficult. Besides the overall reduced total brain volume, evidence also suggests that DS patients experience premature brain aging, with accelerated volume loss. The most striking parallels between Alzheimer's disease (AD) and AD in DS are common neuropathologies, including the characteristic accumulation of amyloid-β. As a consequence of these similar clinical and structural changes, DS patients with dementia have MRI findings that are comparable to AD patients, which includes diffuse cortical atrophy mainly in the parietal lobes, usually symmetric with an anterior-to-posterior grading and also broadening of the marginal branch of cingulate sulcus, central, post-central, intraparietal, and parieto-occipital sulci; the entorhinal cortex, the amygdala, and the hippocampus are usually also involved.

Conclusions
The incidence of age-related cognitive decline and dementia is greater in patients with DS compared to the general population and also develop sooner in life. For DS individuals older than 40 years, dementia occurs in a similar pattern to AD. Therefore, brain MRI might assist in the early diagnosis of dementia.
What's the Story Morning Glory? A Review of Morning Glory Disc Anomaly and Associated Findings

J Marshall1, J Hallstrom1, J Ormsby1, G Lorenzo1, M Mabray1
1University of New Mexico, Albuquerque, NM

Purpose
To familiarize the participant with morning glory disc anomaly, the imaging appearance, and associated imaging findings to look for.

Materials and Methods
We will review morning glory disc anomaly including how the diagnosis is made, fundoscopic findings, imaging appearance, and associated malformations. We will take a case based approach, reviewing images from clinical cases and will incorporate a short quiz at the end of the exhibit.

Results
Morning glory disc anomaly is a congenital malformation with specific findings on fundoscopic exam where there is a funnel-shaped excavation into the optic disc/optic nerve with surrounding abnormal pigmentation, a central glial tuft, and abnormal peripherally emanating vessels. The fundoscopic appearance is similar to the morning glory flower, thus the name. MRI findings include defect with excavation into the optic nerve head with slight elevation of the adjacent retina and associated abnormal signal and enhancement at the defect/optic nerve. This can be associated with vascular abnormalities including absence or hypoplasia of intracranial arteries and in some cases progressive moya-moya vasculopathy. Other associated abnormalities include midline facial and cranial malformations including cephaloceles, and ocular abnormalities such as persistent hyperplastic primary vitreous, congenital cataract, nanophthalmos, detachment, atrophy of the nerve and chiasm, and some reports of optic nerve glioma. There is some suggestion that it may be found within PHACE syndrome however is less commonly familial or syndrome related than coloboma.

Conclusions
Morning glory disc anomaly is congenital malformation centered at the optic disc/nerve with a specific appearance on fundoscopic exam and corresponding imaging findings. Neuroradiologists and trainees should be familiar with this entity and associated malformations to look for on MRI/MRA.
WHO Glioma Classification Update and Genomics: What Radiologists Need to Know

J Bai\(^1\), J Varghese\(^2\), R Jain\(^3\)
\(^1\)New York University Langone Health, New York, NY, \(^2\)NYU Langone Health, New York, NY, \(^3\)NYU School of Medicine, New York, NY

Purpose
The purpose of the educational exhibit is to review the WHO CNS tumor classification updates primarily pertaining to adult gliomas, to provide an overview of the important genomic markers, and to provide an up-to-date review of imaging features pertaining to various genomic subgroups of adult gliomas.

Materials and Methods
We will review the important genetic mutations incorporated as part of new WHO classification of Glioma and the concept of layered diagnosis. We will provide an up-to-date published literature review on adult glioma genomics and radio-genomics. We will also illustrate clinical cases in our practice as well as from the Cancer Genome Atlas (TCGA)/The Cancer Imaging Archive (TCIA), to explain how genomic markers correlate with structural and advanced imaging features.

Results
Driven by recent advances in understanding the genetic makeup of gliomas and a paradigm shift in the classification and management of CNS tumors, the WHO introduced an update to the CNS tumor classification system in 2016 and modified glioma classification by incorporating molecular markers which correlate better with tumor behavior and biology as well patient prognosis than the previous purely histology-based classification system. Important molecular markers, such as IDH mutation, 1p19q, and MGMT promoter methylation status, have important implications on diagnosis, prognosis, and management of patients with adult gliomas. There are some well-established structural and advanced imaging features which predict the status of molecular markers. We will discuss specific imaging features which predict a specific molecular sub-group. We will also discuss future directions including the role of deep learning tools in glioma and radio-genomics.

Conclusions
Better understanding of molecular markers of gliomas has resulted in a paradigm shift in diagnosis, classification as well as management of these patients with more emphasis on genetic mutations. This also has led to a challenge for the radiologists to learn and use new terminology in brain tumor imaging in order to have better coordination with neuropathology and neuro-oncology world. However, it provides an opportunity for radiologists to have better correlation of imaging phenotype with genotype and hence, led to advancement of the field of radiogenomics. In this educational exhibit, we will review the important genetic mutations incorporated as part of the new WHO glioma classification update and their clinical relevance to imaging.
Electronic Posters (ePosters)

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4D flow MRI Characterization of High-Risk Dural Arteriovenous Fistula Features

L Eisenmenger1, G Roberts2, M Loecher3, L Rivera-Rivera2, P Turski4, K Johnson5, O Wieben2
1University of Wisconsin - Madison, Middleton, WI, 2University of Wisconsin - Madison, Madison, WI, 3Stanford University, Stanford, CA, 4University of Wisconsin, Madison, WI, 5University of Madison-Wisconsin, Madison, WI

Purpose
Dural arteriovenous fistulas (DAVFs) are direct connections between the branches of dural arteries to dural veins or venous sinuses. Digital subtraction angiography (DSA) remains the gold standard for diagnosing these fistulas; however, innovative magnetic resonance imaging (MRI) techniques such as 4D flow MRI offer new insights into the hemodynamics of DAVFs including intravascular flow velocities, pulsatility, pressures, and the presence of retrograde flow. In particular, mixing of non-opacified blood in complex vascular lesions can limit evaluation of high-risk flow features on DSA in comparison to 4D flow MRI. The purpose of this excerpt is to present a DAVF case in which DSA failed to detect retrograde venous flow whereas 4D flow MRI venous mapping with ‘virtual bolus’ [1] identified this high-risk feature.

Materials and Methods
54-year-old female presented to the University of Wisconsin – Madison after incidental discovery of a left transverse sinus DAVF. The patient did report asymmetric left greater than right subjective pulsatile tinnitus. She denied any headache, dizziness, or visual symptoms with a negative physical exam. DSA was performed and resulted in an initial DAVF grade of Cognard type 1. On follow-up MRI, 4D flow was obtained.

Results
4D flow MRI pressure maps (image 1) demonstrate a left transverse sinus DAVF with left ascending pharyngeal, left posterior branch of the middle meningeal, and left occipital feeding arteries. Pressure maps demonstrated increased intravascular pressure within the left transverse sinus. Image 2 demonstrates antegrade blood flow through the contralateral right transverse sinus throughout the cardiac cycle with image 3 demonstrating retrograde blood flow through the ipsilateral left transverse sinus. While DSA did not detect any of the left transverse sinus flow refluxing into the right transverse sinus, 4D flow MRI was able to identify this by quantifying venous flow and using probabilistic streamlines (image 4-5), upgrading the lesion to a Cognard type 2a fistula compared to the initial grade of Cognard type 1.

Conclusions
4D flow MRI offers valuable hemodynamic information that can further characterize vascular lesions in comparison to conventional imaging. Unlike DSA, 4D flow MRI is not as affected by mixing of non-opacified blood, thereby providing improved characterization of the venous vasculature and complex vascular lesions. Larger studies are needed to evaluate the impact of 4D flow MRI on vascular malformation management and patient outcomes.
A pictorial review of parotid pleomorphic carcinosarcoma radiological findings with clinico-pathologic correlation

A Nada¹, C Leiva Salinas²
¹University of Missouri, Columbia, MO, ²University of Missouri, Los Angeles, CA

Purpose
Parotid carcinosarcoma is an extremely rare mixed malignant tumor in the head and neck region. Carcinosarcomas have an aggressive characteristic with distant metastasis, commonly to lungs. These tumors are regarded as high grade tumors. We present a case of parotid pleomorphic carcinosarcoma with review of its characteristic imaging features and correlate these findings with the cytologic and histologic findings including immunohistochemical results.

Materials and Methods
51-year-old male with a history of retinoblastoma during childhood required bilateral eye enucleation followed by external beam radiation treatment. In February 2018, the patient developed left parotid mass.

Results
The patient underwent contrast-enhanced CT study which showed left parotid heterogeneously enhancing mass. The mass extends through the stylo-mandibular tunnel, displaces the left parapharyngeal space medially and compresses the left internal jugular vein. Enhanced MRI study was ordered and revealed the large left parotid heterogeneously enhancing mass, infiltrating the left masticator space muscles without mandibular invasion. The mass has been thought to be metastatic deposit, therefore PET/CT was ordered to evaluate for other distant metastatic lesions. PET/CT showed avid FDG activity within the mass and multiple ipsilateral cervical lymphadenopathy. This mass was resected and pathologically proven as carcinosarcoma of the parotid gland.

Conclusions
Carcinosarcoma is a rare malignant 'mixed' tumor in the head and neck region. It is defined as a biphasic tumor containing both malignant epithelial and mesenchymal elements. These types of tumors have an aggressive characteristics and are often regarded as a high-grade tumor with distant metastasis occurring in 54% of patients. They commonly metastasize to the lung. Carcinosarcoma is known to have arisen from a pleomorphic adenoma, which is the most common neoplasm of major salivary glands though in some cases, this type of tumor appears to have originated de novo. Some authors believe that pleomorphic adenomas and carcinosarcomas share a common stem cell, possibly a myoepithelial cell. Malignant transformation of pleomorphic adenoma occurs in around 5–25% of untreated patients and this encompasses three entities -carcinoma ex pleomorphic adenoma, carcinosarcoma and metastasizing pleomorphic adenoma. The latter two are exceedingly rare.
A Rare Case of Pediatric Head and Neck Giant Cell Fibroblastoma

A Wong1, M Bobinski1, O Raslan1, N Pham1, J Chang1, R Assadsangabi1, V Ivanovic1, A Ozturk1
1UC Davis Medical Center, Sacramento, CA

Purpose
We present imaging findings of a rare presentation of pediatric giant cell fibroblastoma (GSF) in the head and neck.

Materials and Methods
A four-year-old male with no past medical history initially presented to the emergency department with a chief complaint of progressively worsening throat swelling and difficulty swallowing for two weeks. Clinical physical exams demonstrated a palpable right neck mass with leftward uvular deviation and right peritonsillar mass obstructing half the oropharynx. Transoral biopsy with debulking was performed, but given subsequent progressive oropharyngeal airway obstruction, he was urgently taken for gross total resection. At two-month follow-up, the patient was clinically well and attending preschool. Initial Computed Tomography (CT) of neck with contrast on the day of presentation demonstrated a large, heterogeneous, well-circumscribed mass in the right parapharyngeal space containing macroscopic fat with significant mass effect on the airway. Subsequent Magnetic Resonance Imaging (MRI) demonstrated homogenous enhancement of internal solid non-fat containing components. Radiographic differential diagnoses included soft tissue sarcoma, teratoma, or hamartoma. The pathologic diagnosis resulted as GSF.

Results
Figure 1A: Axial CT image of neck with contrast shows a large well circumscribed macroscopically fat containing mass centered in the right parapharyngeal space (arrows) with significant mass effect on the airway. Figure 1B and 1C: Coronal T1-weighted (1B) and post-contrast fat saturated coronal T1-weighted (1C) images demonstrate areas of enhancement of solid internal non-fat containing (star) components of the mass (arrows). Figure 1D: Macroscopic specimen after gross total resection.

Conclusions
GSF is a rare intermediate grade pediatric soft tissue tumor with high incidence of local recurrence. Epidemiologically, these tumors tend to occur in males in the first decade of life. Though most literature case reports show GSFs occurring in the superficial soft tissues of the back and thighs, it may present in unusual sites as in our case. No pathognomonic or even characteristic radiographic features have been described, but a common feature seems to include well-circumscribed margins, with internal heterogeneity, enhancement, and variable macroscopic fat content. GSF radiographically shares many features with soft tissue sarcomas such as liposarcoma. Accurate histopathologic diagnosis is key given disparate management between these two diagnoses.
A Rare Case of Primary Intramedullary Spinal Cord Germ Cell Tumor (Germinoma)

A Aein\textsuperscript{1}, S Khanpara\textsuperscript{1}, B Chen\textsuperscript{1}, M Bhattacharjee\textsuperscript{2}, J Cochran\textsuperscript{3}, R Riascos\textsuperscript{1}

\textsuperscript{1}Department of Diagnostic and Interventional Imaging, McGovern Medical School, UTHealth, Houston, TX, \textsuperscript{2}Department of Pathology and Laboratory Medicine, McGovern Medical School, UTHealth, Houston, TX, \textsuperscript{3}Vivian L. Smith Department of Neurosurgery, McGovern Medical School, UTHealth, Houston, TX
Purpose
To present a rare case of primary intramedullary spinal cord germ cell tumor (germinoma) attached to the filum terminale in a young non-Asian patient.

Materials and Methods
A 27-year-old male presented with chronic low back pain radiating down to the hips and both legs with progressive bilateral lower extremities weakness and tingling sensation. The patient further developed a loss of bowel and bladder functions.

Results
The conus medullaris at the T12 to L2 levels contains a well-defined, homogenously enhancing intramedullary mass, measuring 2 cm x 1.9 cm x 6.5 cm (AP x Transverse x Craniocaudal). This mass is isointense on T1-weighted images and hyperintense on T2-weighted images. The CSF space is effaced at the level of mass. The histopathologic examination was consistent with germinoma. The tumor showed a high proliferation index (Ki-67 > 90%).

Conclusions
About 90% of the intramedullary spinal cord tumors are glial tumors such as ependymomas and astrocytomas. The remaining 10% are hemangioblastoma and metastasis tumors. Spinal germinoma is more likely to be a disseminated involvement of intracranial germinoma (1-3% of all intracranial tumors). The primary spinal germinoma is rare and best described in young Japanese adults. Germinomas show excellent sensitivity to chemotherapy and radiation. To the best of our knowledge, the occurrence of primary spinal cord germinoma is extremely rare, especially among the non-Asian population and only a few cases have been described in the literature, this justifies the value of describing the imaging characteristics. Primary germinoma may be considered in certain clinical presentations of intramedullary spinal mass differential diagnosis.

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A Rare Pediatric Case of Neuroangiostrongyliasis

P Rabiei\textsuperscript{1}, S Khanpara\textsuperscript{1}, M Bhattacharjee\textsuperscript{1}, E Supsupin\textsuperscript{1}, R Patel\textsuperscript{1}, C Sitton\textsuperscript{1}

\textsuperscript{1}The University of Texas Health Science Center at Houston, Houston, TX

Purpose
Angiostrongylus is the cause of a rare parasitic CNS infection that predominantly occurs in Southeast Asia and the Pacific Islands (1,2). Occasional serious and fatal complications of this disease warrant prompt diagnosis and follow-up (3,4).

Materials and Methods
A 15-year-old male with a history of epilepsy, developmental delay, and Pediatric Autoimmune Neuropsychiatric Disorder Associated with Streptococcal Infections (PANDAS) under treatment with monthly infusions of intravenous immunoglobulin (IVIG) presented with 1-week of severe headaches, neck pain, lower extremity numbness, and intermittent fevers up to 102F. The patient did not have vision loss or motor deficit on physical exam. A complete blood count showed mild eosinophilia. First brain MRI findings were concerning for meningitis and increased intracranial pressure. High CSF opening pressure on lumbar puncture and further CSF analysis were suggestive of aseptic and eosinophilic meningitis. A comprehensive infectious workup was unremarkable. Subsequent brain MRI findings were concerning for meningitis and increased intracranial pressure. High CSF opening pressure on lumbar puncture and further CSF analysis were suggestive of aseptic and eosinophilic meningitis. A comprehensive infectious workup was unremarkable. Subsequent brain MRI revealed multiple hemorrhagic and enhancing parenchymal lesions. A brain biopsy was pursued to yield a diagnosis and was consistent with parasitic infection reported as Angiostrongylus Cantonensis by Real-Time PCR in a CSF sample.

Results
Initial brain MRI only showed subtle abnormal leptomeningeal enhancement and flattening of the posterior globes, but subsequent
imaging revealed multiple hemorrhagic and enhancing lesions in the right inferior frontal and left parietal lobes as well as the left aspect of the medulla with associated perilesional edema (Figure 1). Scattered areas of subarachnoid hemorrhage were also noted. Entire spine MRI demonstrated scattered leptomeningeal and patchy intramedullary enhancement with diffuse thickening of the cauda equina nerve roots and cord edema (images not shown here). It is worth noting that during this investigation, MRA/MRV and PET-CT scan were performed which failed to show any evidence suggestive of vasculitis or hypermetabolic malignancy.

Conclusions
Angiostrongylus Cantononis can be introduced to the human body by ingestion of infected aquatic gastropods and usually lead to classical eosinophilic meningitis (2,5). Although most of the imaging findings remain non-specific (1), we suggest a radiologic diagnosis of CNS strongylus infection should be strongly suspected in the setting of atypical infection and supporting evidence such as peripheral and CSF eosinophilia, recent travel to endemic regions, or suspected dietary history.
Figure 1. T2W (a), FLAIR (b), and post-contrast (c,d) brain MR axial images showing posterior globe flattening (black arrowheads), perilesional edema (black arrow) and enhancing parenchymal lesions (white arrows).
Acute Rhinosinusitis Complicated by Cavernous Sinus Thrombophlebitis and Internal Carotid Artery Pseudoaneurysm

J. Lee¹, E. Lin¹, J. Comunale¹
¹Weill Cornell Department of Radiology, New York, NY

Purpose
We report a case of acute rhinosinusitis complicated by cavernous sinus thrombophlebitis (CST) and internal carotid artery (ICA) pseudoaneurysm.

Materials and Methods
Our patient was a healthy 81 year old Korean woman with no significant past medical history who presented with headache, encephalopathy, and left cranial nerve VI palsy for the past several days. MR orbits and contrast enhanced CT sinus showed diffuse mucosal disease and opacification of the paranasal sinuses, as well as soft tissue infiltration of the left retroantral fat, (Fig. 1) which raised the possibility of acute invasive rhinosinusitis. The patient was also found to have left CST (Fig. 2,3). However, blood cultures and nasal biopsy were negative. Despite treatment with broad spectrum antibiotics and systemic antifungal treatment, the patient continued to clinically decline. Three days later, a CT angiogram showed that the patient developed a new 1.5 cm pseudoaneurysm arising from the left posterior ICA (Fig. 4) secondary to CST. Patient underwent coil embolization of the pseudoaneurysm and continued broad spectrum medical treatment, but unfortunately passed away within several days of admission.

Results
Fig 1. Paranasal sinus disease with soft tissue infiltration of the retroantral fat. Fig 2. Coronal T2 image of the cavernous sinuses show expansion of the left cavernous sinus, which contains heterogeneous T2 signal. Fig 3. Contrast enhanced CT of the sinus shows diffuse paranasal mucosal disease and opacification of the paranasal sinuses. Right cavernous sinus enhances normally the the left cavernous sinus lacks enhancement. Fig 4. CTA of the head shows the patient rapidly developed a new broad based protrusion off the posterior wall of the left cavernous ICA with arterial contrast enhancement, as opposed to the normal venous enhancement in the right cavernous sinus. *DSA and additional CTA images are available, if accepted, to better show the 1.5 cm pseudoaneurysm in entirety*

Conclusions
It remains unclear whether our patient had acute bacterial or acute invasive fungal sinusitis; however, CST and ICA pseudoaneurysms are complications that can be seen with both infections. CST is more frequently seen with bacterial infections, with S. Aureus as the most common pathogen, but fungi may be occasionally be identified and are usually present in immunocompromised patients. Prompt diagnosis and treatment of intracranial complications remain important as mortality rates of CST remain 20-30% with antibiotic therapy.
Acute Thrombosis of a Large Developmental Venous Anomaly with Secondary Venous Infarction and Petechial Hemorrhage in a Young Patient

r sharma¹, V Spektor¹
¹Columbia University Irving Medical Center, New York Presbyterian Hospital, New York, NY

Purpose
To outline a case of acute thrombosis of a large frontal developmental venous anomaly in a young patient and elucidate pertinent radiologic findings.

Materials and Methods
A 17-year-old female with obesity was transferred from OSH after being found unresponsive and seizing in the shower. Workup revealed acute thrombosis of a large right frontal developmental venous anomaly with associated venous infarction, edema, and petechial hemorrhage. The patient was admitted to PICU and received systemic anticoagulation with heparin and neuromonitoring. The patient was hemiplegic on the left with left vocal cord paralysis. Follow-up imaging 1 week later showed partial recanalization of the DVA. The patient continued to improve and was discharged to outpatient rehabilitation with plans for outpatient angiography.

Results
Noncontrast CT scan from CTA/CTV showed a tubular hyperdensity in the right frontal lobe with surrounding white matter hypoaeduation. Additional scattered hyperdense foci were seen in the right frontal lobe. MR imaging revealed a large right frontal DVA with extensive filling defect. Diffusion and susceptibility images demonstrated surrounding gyriform restricted diffusion and edema with areas of petechial hemorrhage in the right frontal lobe.

Conclusions
This case highlights a rare presentation of acute thrombosis of a large right frontal DVA with associated venous infarction and petechial hemorrhage. The patient was begun on systemic anticoagulation with Heparin. The patient's left hemiplegia and vocal cord paralysis improved while on this therapy and she was discharged to outpatient rehabilitation. Developmental venous anomalies are the most common intracranial vascular lesions and represent variation in transmedullary veins draining white and gray matter. A network of thin-walled, dilated transmedullary veins often drain into a large "collector" vein lacking a normal smooth muscle layer and elastic lamina which ultimately drain into deep or cortical superficial veins. Acutely thrombosed DVA with resulting venous ischemia is a rare complication which can carry severe morbidity and is frequently lethal. Venous ischemia has high propensity to hemorrhage and therefore anticoagulation therapy has been controversial in the past. Current literature supports using anticoagulation as an immediate therapy despite high risk of hemorrhage. Further studies are needed to elucidate the efficacy and safety of systemic anticoagulation even in the setting of secondary hemorrhage and/or venous infarct.
Age-related assessment of the arterial inflow and venous outflow using 4D flow MRI

R Abdalla¹, M Aristova², M Hurley³, S Ansari⁴, S Schnell², A Shaibani³
¹Northwestern University, Chicago, IL, ²Northwestern University - Feinberg School of medicine, Chicago, IL, ³Northwestern University Feinberg School of Medicine, Chicago, IL, ⁴NORTHWESTERN UNIVERSITY FEINBERG SCHOOL OF MEDICINE, CHICAGO, IL, ⁵Northwestern University Feinberg School of Medicine, Chicago, IL

Purpose
Cerebral circulation is highly regulated to maintain satisfactory brain perfusion as governed by the Monro-Kellie doctrine. Abnormalities in the cerebral venous system have been implicated in multiple neurological conditions including multiple sclerosis, leukoaraiosis, and idiopathic intracranial hypertension. We aim to quantitatively study the relationship between total cerebral blood flow (TCBF) and cerebral venous outflow (CVO) in the cerebral circulation in adults and pediatrics and highlight the discrepancies in cerebral venous drainage.
Materials and Methods
An IRB approved study of 31 healthy volunteers (24 adults and 7 children), who underwent 4D flow MR imaging and 2D CINE PC-MRI was conducted. 3D volumetric ECG-gated PC-MRI data with 3-directional velocity encoding (4D flow MRI) was acquired. 2D CINE PC MRI was acquired at both transverse sinuses. 4D flow MRI data was processed using in-house software tools in Matlab. We calculated the cumulative TCBF in ml/sec as the sum of inflow in the bilateral ICAs and basilar artery. The CVO was calculated as the sum of the flow in the bilateral transverse sinuses. The ratio of CVO to TCBF was calculated.

Results
There was a significant correlation between TCBF and CVO (r = 0.81 and P< 0.001). The TCBF (20.21 +/- 4.58 ml/s versus 11.78 +/- 2.03 ml/s; P<0.001) and CVO (12.80 +/- 3.82 ml/s versus 9.03 +/-2.31 ml/s; P = 0.010) were significantly higher in children compared to adult volunteers. TCBF (rho = -0.81, P < 0.001) and l CVO (rho = -0.44, P = 0.012) correlated negatively with age in the combined adult and pediatric cohort. The CVO/TCBF ratio was significantly lower in children versus adult volunteers (0.63 +/- 0.01 versus 0.76 +/- 0.02, P = 0.009). In adults, the correlation of TCBF with age remains strong (rho = -0.69, t-stat = -4.5, P = 0.00018). However, CVO (rho = -0.29, t-stat = -1.42, P = 0.171) and CVO/TCBF ratio (r = 0.16, P = 0.446) were not significantly associated with age in the adult cohort.

Conclusions
Both TCBF and CVO decrease with age, however unlike TCBF, there is no correlation between age and decreased CVO in adults, suggesting earlier maturation of the venous system, which could explain the early presentation in diseases with underlying venous pathology. The ratio of CVO through the transverse sinuses to AI through the ICAs and basilar, suggest an important role for emissary and extracranial veins in cerebral venous drainage.

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An Extremely Rare Case of Infantile Filum Terminale Capillary Hemangioma

M Mitsunaga¹, O Raslan¹, A Ozturk¹, J Chang¹, R Assadsangabi¹, V Ivanovic¹, M Bobinski¹, N Pham¹
¹University of California Davis, Sacramento, CA

Purpose
To present an exceedingly uncommon case of pathologically-proven capillary hemangioma of the filum terminale in an infant.

Materials and Methods
A six-month-old term male presented with a cutaneous sacral hemangioma which prompted further investigation with a MRI of the lumbar spine. The study revealed a mixed intensity, homogenously enhancing mass dorsal to the filum, a low-lying conus, and thickened filum terminale, concerning for a tethered spinal cord. There was no filar lipoma. He underwent L4 laminectomy, resection of the filum terminale mass, and untethering of the spinal cord. Pathology showed "dilated capillaries with heterotrophic endothelial cells, on a background of dense connective tissues," consistent with capillary hemangioma. The patient recovered uneventfully following surgery and was meeting all of his milestones on follow-up clinical visits.

Results
MRI lumbar spine with contrast shows a low-lying conus at L3 level. Dorsal to the filum terminale at the L4 level is an 11 x 6 mm heterogenous T1 and T2 intensity multilobulated mass with prominent serpentine flow voids and homogenous enhancement.

Conclusions
Although soft tissue hemangiomas are common pediatric tumors in the cutaneous and subcutaneous locations, they are extraordinarily rare in the neuroaxis in pediatric patients, with few case reports. Capillary hemangiomas have been reported in adults, presenting as intradural, extramedullary masses in the thoracic spine. MR characteristics include serpentine feeding vessels appearing as T2 flow voids, heterogeneous T1 and T2 signal intensity and homogenous, avid enhancement. Statistically, the most common tumor of the conus/filum is the myxopapillary ependymoma in the adult patient. Other differentials for pediatric patients include vascular tumors such as paraganglioma and hemangioblastoma. Complete surgical resection is typically the treatment.
Analysis of serial Magnetic resonance imaging in 3 patients with Diffuse leptomeningeal glioneuronal tumor (DLGNT): How imaging helps understand the nature of a rare pediatric neoplasm!

P Watal1, S Sato2, L Hayes3, T Chandra3

1Nemours Childrens Healthcare System, Orlando, FL, 2University of Iowa Hospitals and Clinics, Iowa City, IA, 3Nemours Children’s Healthcare System, Orlando, FL

Purpose
To understand the behavior of this rare pediatric neoplasm (DLGNT) using imaging at multiple time points.

Materials and Methods
Retrospective search of the electronic database from 2 academic pediatric medical centers for past 10 years yielded 3 patients which
matched our search criteria. The search is limited by the recent introduction of this entity and therefore any similar entity prior to 2016 may not be detected by this search. Only pediatric patients (less than 21 years) with histological diagnosis of DLGNT including immunohistochemistry for BRAF gene status were included. This is important in view of evidence of two distinct molecular subtypes of DLGNT. The inclusion criteria included presence of at least 1 dedicated preoperative/prebiopsy imaging study of the affected area (brain or spine or both) and at least 2 adequate follow up studies of the craniospinal axis (follow up imaging spread over a minimum of 12 months). No therapy inclusion or exclusion criteria were used.

Results
Patient 1 and 3 showed similar immunohistochemistry with presence of BRAF-KIAA fusion gene. The overall longitudinal imaging of these patients had important similarities, even in the presence of obvious individual differences. Patient 1 presented with an intramedullary spinal cord mass in thoracolumbar region associated with syrinx and presence of extensive spinal leptomeningeal disease. No brain involvement was seen in patient 1 at any time point. The overall extent of leptomeningeal disease or tumor did not show significant interval change (in absence of chemotherapy) over the follow up. Patient 3 had extensive leptomeningeal disease at presentation with NO parenchymal lesion (unlike patient 1) at any time point over 2 years of follow up. Patient showed grossly stable leptomeningeal tumor extent over 2 years of follow up (including one year while on therapy). Unlike above patients, Patient 2 showed negative immunohistochemistry for BRAF gene mutation. Patient 2 had focal abnormalities in bilateral optic nerves associated with papilledema at presentation, with NO intraaxial focal masses or leptomeningeal nodules (unlike patient 1, 3) with leptomeningeal disease progression in the early follow up period and development of parenchymal CNS lesions later on.

Conclusions
1. DLGNT molecular subtypes based on BRAF status may have distinct imaging phenotypes. 2. Extent of leptomeningeal disease on imaging may not directly correlate with tumor aggressiveness during the early phase of the disease.

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Angiographic Results of Clipped or Coiled Intracranial Aneurysms: Systematic Review and Inter-/Intra-Rater Agreement Study

A Benomar1, B Farzin1, D Volders2, R Fahed3, T Darsaut4, J Raymond1
1Centre Hospitalier de l'Université de Montréal (CHUM), Montreal, QC, 2Queen Elizabeth II Health Sciences Centre, Halifax, NS, 3Rothschild Foundation, Paris, France, 4Walter C. Mackenzie Health Sciences Centre, University of Alberta Hospital, Edmonton, AB
Purpose
Randomized clinical trials comparing surgical clipping to endovascular coiling of intracranial aneurysms often measure angiographic results. A standardized, reliable method to report angiographic results applicable to both coiling and clipping is needed. Our aim was to systematically review methods of classifying aneurysm remnants and their reports of reliability, and to propose and assess the inter-/intra-rater reliability of a new angiographic classification of clipped or coiled aneurysms.

Materials and Methods
We conducted two separate systematic reviews of post-clipping and post-coiling classifications of intracranial aneurysms and their reported reliability, on July 2017 and June 2019 respectively. Post-clipping (n=30) and post-coiling (n=30) angiographic results of 59 patients were independently evaluated by 19 raters of various backgrounds and experiences, using a new 3-grade scale. Raters were then asked how they would manage the patient (delayed follow-up; close follow-up; immediate endovascular treatment of the residual; or immediate surgical treatment). Inter- and intra-rater agreements were analyzed with generalized κ statistics. Strength of relationship between the raters' choice of grade of residual and chosen management was assessed using Cramer's V test.

Results
65 different grading scales (37 for clipping, for 29 coiling) were found in the literature. Reported agreements varied from 0.12 to 1.00 and 0.17 to 0.90 for post coiling and post clipping respectively, with significant heterogeneity in terms of number of patients and raters. Inter-rater agreement using the new 3-grade scale was moderate (κ=0.588 ; 95% confidence interval [CI], 0.510 – 0.666), but became substantial (κ=0.742 ; 95% CI, 0.629 – 0.829) and almost perfect for the core lab subgroup (κ=0.830 ; 95% CI, 0.706 – 0.929) after dichotomization of the scale (grade 1/2 vs. 3). Senior raters (κ=0.586 ; 95% CI, 0.497 – 0.674) did not perform better than juniors (κ=0.584 ; 95% CI, 0.496 – 0.672). Intra-rater agreement ranged from moderate (κ=0.594 ; 95% CI, 0.417 – 0.771) to almost perfect (κ=0.897 ; 95% CI, 0.796 – 0.999). A strong positive relationship was found between the choice of grade and the clinical management of aneurysmal remnants (mean Cramer's V= 0.803 ± 0.122 ; p <0.001 for all raters).

Conclusions
Various classifications for clipping and coiling exist. The proposed grading scale can be used for current and future trials comparing angiographic results following clipping or coiling of intracranial aneurysms.

Applications of Diffusion-Weighted Imaging in the Etiological Diagnosis of Infectious Central Nervous System Diseases

F Reis¹, K Schumacher¹, M Raeder¹, V Jarry¹
¹UNICAMP, Campinas, São Paulo, Brazil

Purpose
Infectious diseases of central neural system (CNS) are important causes of morbimortality in the developing countries. These conditions often manifest as cystic lesions that the basics Magnetic Resonance (MR) sequences does not allows to radiologists make the differential diagnosis. This study aim establishes if ADC values of the capsule and core lesion enable differentiation by imaging between fungi, bacterial, parasitosis or even mycobacterial diseases.

Materials and Methods
We retrospectively analyzed the images of MR (3T) performed between the years 2016 and 2018 of 39 cases of central nervous system involvement, who had a diagnosis confirmed by laboratory criteria or by anathomopathological examination, by progressive multifocal leukoencephalopathy (3), septic emboli (3), neurotuberculosis (7), abscess (4), neurocryptococcosis (5), neurotoxoplasmosis (6), neurocysticercosis (7) and lymphoma (4) of the Clinical Hospital of the University of Campinas (Unicamp). The apparent diffusion coefficient (ADC) of the center of the lesions were measured in order to establish a relationship between the values obtained and the etiology of the pathologies. We performed a 2-tailed Student independent t test and ANOVA one way by using the SPSS version 25.0 (SPSS, Chicago, Ill). We computed P values for mean signal intensities from the center of the lesion and the wall to look for any significant differences. A P value of less than .05 was regarded as statistically significant.

Results
The analysis of the ADC value measured at the center of the lesions showed a statistically significant difference (P < 0.05) between the etiological groups of septic embolism and neurotoxoplasmosis, neurocysticercosis and abscess, neurocysticercosis and neurotoxoplasmosis, as well as neurocryptococcosis and abscess. When the etiological agents were grouped in the classifications of viral diseases (LEMP), bacterial (septic emboli, neurotuberculosis and cerebral abscess), fungal (neurocryptococcosis), parasitic (neurotoxoplasmosis and neurocysticercosis) and neoplastic (lymphoma), it was observed a difference (p < 0.05) between bacterial and fungal diseases.

Conclusions
The study of the absolute value of the ADC map measured inside the lesions proved to be effective in differentiating the etiological agent between septic embolism and neurotoxoplasmosis, neurocysticercosis and abscess, neurocysticercosis and neurotoxoplasmosis, and finally neurocryptococcosis and abscess.
Appropriateness Criteria to assess Overuse of MRI in Inpatient vs Outpatient Setting

R Rehmani1
1St Barnabas Health System, Affiliate of Albert Einstein College of Medicine, NEW YORK, NY

Purpose
Rising healthcare costs may in part be attributed to overuse of services like MRI (magnetic resonance imaging) during hospital admissions. Judicious and appropriate use of inpatient MRI services may affect duration of hospital stay and overall healthcare-related costs.

Materials and Methods
We retrospectively reviewed MRI performed over the past 1 year at our institution. ACR appropriateness criteria was used in making a decision about appropriateness of the exam based on the clinical scenario for each case. A nine-point scoring system is used with the American College of Radiology appropriateness criteria. Scores of 1–3 indicate low yield (red) or inappropriate MRI; scores of 4–6 (yellow), marginal yield or uncertain use; and scores of 7–9 (green) indicates appropriate indication for MRI. These patients were also identified by their location whether inpatient, emergency department or outpatient. Hence the criteria we used were twofold; first - whether MRI is the correct test of choice, and second, if it is appropriate to do it in hospital vs outpatient. The margins are blurred for the second issue and clinical judgment is utilized based on the acuity and urgency of clinical situation.

Results
26 procedures out of a total of 107 inpatient procedures, or 24.3% MRI exams could have potentially been performed as outpatient studies. Utilizing ACR appropriateness criteria, the exams were inappropriate approximately 10% of the time. The average facility reimbursement for an outpatient MRI study in 2017 was $1,456.76. Using this amount for the January 2018 studies would yield a total of $37,875.76 of potential gain in facility revenue if these patients identified above had the MRI procedures performed as outpatients.

Conclusions
Overuse of medical procedures like MRI is a growing problem and escalates the overall healthcare cost. Hospital costs are categorized by DRG or diagnostic related grouping which allows fixed pay based on the diagnosis rather than the actual total amount the hospital spends during the patient’s hospital stay. Since 2017 Centers for Medicare and Medicaid Services (CMS) now further requires use of a Clinical Decision Support System (CDS) to justify appropriate use of MRI, CT and Nuclear Medicine inclusive of PET scans. It is important that physicians make the correct choice of the imaging test to be done and also choose the correct setting (inpatient vs outpatient) to keep costs under control and utilize these resources for those who really need it.
Are RVU’s the Best Measure of Clinical Interpretation Work in Neuroradiology?

J Varghese1, G Fatterpekar2, T Shepherd3
1NYU Langone Health, New York, NY, 2NYU School of Medicine, New York, NY, 3NYU Langone Health, New York City, NY

Purpose
Radiology practices often use the professional component RVU to assess clinical productivity. RVU’s however may not reflect the true work associated with interpreting imaging studies. Alternatively, we characterized image number, report word counts and interpretation times associated with common neuroradiology studies. This study also characterized variance across attendings and assessed the impact of trainees for these alternative measures of clinical interpretation work.

Materials and Methods
Data were collected from 5 imaging studies for 5 attendings in academic neuroradiology over 3 months by querying Powerscribe (Nuance; Burlington, MA). Data included study type, image number, dictated word count, trainee participation (i.e. study was drafted by trainee: 36% of studies) and "Interpretation time" (the time between the attending opening and signing the report). The image number, dictated word count and interpretation time were correlated to RVU. These parameters also were compared between imaging studies, attending and trainee participation.

Results
The mean study images, report dictated word count and attending interpretation time (with or without trainee participation) differed for 5 common neuroradiology studies (P<0.05; see Table). There were good correlations between RVU and the number of images (R2 = 0.794), report word count (R2 = 0.825) and attending interpretation time (R2 = 0.881). Despite such strong correlations, the time required to generate 1 RVU ("Efficiency") varied ~60% between studies (7.8 vs 12.5 min). Brain tumor perfusion MRI is a specific contrast MRI protocol with the same RVU, yet 64% more images, 68% more dictated words and 62% longer interpretation times. We observed large variances between individual radiologists (e.g. interpretation time differed by 24 min between the slowest and fasting readers of brain tumor perfusion MRI). Trainee participation reduced CTA interpretation time for all 5 attendings (mean 52.7% reduction). Otherwise, trainee participation did not affect dictated word count or attending interpretation time.

Conclusions
These data support widespread concerns that RVU is a limited measure of work, particularly for individual radiologists. Contrast MRI head is the best "choice" for most readers with incentive to maximize RVU production (Table: 1 RVU per 7.8 min). We suggest individual groups should consider alternative measures of interpretation work – it may be fairer or less prone to surrogation if based on mean interpretation time for local protocols.

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Artery of Davidoff and Schechter- A Rare yet Crucial Sighting

N SEDORA-ROMAN1, M Cox2, H Nasser3, P Ramchand2, P Rodriguez2, O Choudhri2, D Kung2, B Pukenas2, R Hurst2
1HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA, 2Hospital of the University of Pennsylvania, Philadelphia, PA, 3University of Pennsylvania Health System, Philadelphia, PA, 4University of Texas Heath San Antonio, San Antonio, TX

Purpose
The artery of Davidoff and Schechter (DAS) is the only meningeal branch of the posterior cerebral artery (PCA), supplying the medial tentorial margin and posterior portions of the falx. Given its small size, it is rarely identified on angiographic studies, unless enlarged in pathologies such as dural arteriovenous fistulas (DAVFs) or vascularized masses. First described by Wollschlaeger and Wollschlaeger in 1965, to date few reports have described its significance. The objective of this study is to report our experience with the artery of DAS in DAVFs and to emphasize the importance of recognizing this artery during angiographic examination of vascular tentorial and posterior fossa lesions.

Materials and Methods
We report the identification of the artery of DAS in 6 patients ranging between the ages of 52 and 74. All patients had enlarged arteries of DAS secondary to posterior fossa or tentorial DAVFs. The artery was found arising from the right PCA in 3 of our 6 cases; bilateral arteries of DAS were identified in one patient. Clinical presentation included pulsatile tinnitus, hearing loss, worst headache of life, lethargy and altered mental status. One patient had an incidentally identified DAVF diagnosed during a stroke workup. The majority of patients were treated with Onyx embolization with successful microcatheter selection; one patient required both Onyx embolization and surgical clipping while a second was treated exclusively with surgery.

Results
Figure 1. 74-year-old female with history of pulsatile tinnitus and hearing loss. Cerebral arteriogram demonstrates a DAVF in the posterior fossa prior to embolization. An enlarged artery of DAS arising from the left PCA is seen in the early arterial phase (red arrow in A). Early venous drainage is noted (white arrow in B). Complete obliteration of the DAVF is demonstrated by post Onyx embolization control injections through the right vertebral artery (C and D).

Conclusions
To our knowledge, this report demonstrates the largest compilation of angiographic studies demonstrating the artery of DAS in
patients with DAVFs. Our cases validate the importance of prompt identification of the artery of DAS for the diagnosis as well as endovascular treatment of vascular malformations and neoplasms in the posterior fossa and tentorial region. Knowledge of this angiographic anatomy is fundamental for neurointerventionalists and neuroradiologists alike - especially given repercussions of embolization while selecting meningeal feeders from an eloquent PCA.

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Assessment of Giant Cerebral Aneurysms: Which Imaging Modality Works Best?

X Wang¹, J Benson², A McKinney¹
¹University of Minnesota, Minneapolis, MN, ²Mayo Clinic, Rochester, MN

Purpose
Scant research has compared imaging modalities to evaluate giant cerebral aneurysms (GCAs, defined as greater than 25 mm in maximal dimension). This study retrospectively evaluated computer tomographic angiography (CTA), 3D time-of-flight (TOF) MRA, contrast enhanced MRA (CEMRA), and digital subtraction angiography (DSA) in characterizing GCAs.

Materials and Methods
A retrospective review was completed of patients with 1) a known intracranial giant aneurysm, and 2) at least two imaging modalities of either: CTA, 3D TOFMRA, CEMRA, or DSA. The visibility of overall aneurysmal margins and luminal patency versus
intraluminal thrombus was assessed using a semi-quantitative scoring system, with measured sizes of the overall aneurysm and patent lumen compared between imaging modalities using paired t-tests.

**Results**

This study included 21 patients with 12 males and 9 females. Each patient had 1 giant intracranial aneurysm, most commonly within the cavernous ICA (7/21, 33.3%), MCA (6/21, 28.6%), basilar artery (3/21, 14.3%), and anterior communicating artery (ACA) (2/21, 10%). Aneurysm size ranged from 26-58 mm (mean 31.3 ± 12.2). Notably, 18/21 (85.7%) had intraluminal thrombus. No significant difference was found between the measured overall aneurysmal sizes of any two modalities (p = 0.72-0.83) regarding comparisons of CTA, 3D TOF MRA, and CEMRA with each other. However, there were significant differences in the aneurysmal patency visibility grade between CTA (mean score 3.6 ±0.5) versus TOF MRA (score 1.8 ±0.6, p = 0.001), and CTA versus CEMRA (score 2.0 ±0.8, p = 0.02). Moreover, the patent luminal size measured on CTA was significantly larger than DSA (p = 0.05).

**Conclusions**

CTA, 3D TOF MRA, and CEMRA are equivalent in the delineation of overall size of GCAs. However, 3D TOF MRA and CEMRA seem to be inferior to CTA in demonstrating luminal size/patency, likely because of the signal loss resulting from the presence of intraluminal thrombus and flow turbulence. Moreover, CTA is superior to DSA in determining patent lumen in GCAs, probably due to CTA's multi-pass phenomenon related luminal enhancement while DSA are generally filling via the first pass of enhancement or soon thereafter. In addition, CTA may also better demonstrate the other characteristics of the GCAs when compared to DSA, such as the intraluminal thrombus, adjacent anatomical structures and calcified rings.
Association between Intracranial Vertebrobasilar Atherosclerotic Calcification and Luminal Stenosis

U ERDENEBOULD, S Hiremath, M Willie, M Kontolemos, N Zakhari
THE OTTAWA HOSPITAL, OTTAWA, ON, The Ottawa Hospital, Ottawa, Ontario

Purpose
Almost one-quarter of the acute stroke is in the posterior circulation. However, the relationship between luminal stenosis and calcium burden in the intracranial vertebrobasilar system is still unclear and understudied. It is a common practice of neuroradiologists who identify varying degrees of intracranial vertebral and basilar artery calcifications on non-contrast computed tomography (NCCT). We evaluated the significance of the intracranial vertebrobasilar artery calcifications to predict the level of the luminal narrowing on the computed tomography angiography (CTA).

Materials and Methods
We conducted a retrospective review of consecutive patients who had both NCCT and CTA examinations as part of a diagnostic evaluation for ischemic stroke from January 01, 2015 to December 31, 2015. The calcifications were quantified using an automatic program of Agatston Janowitz 130 (AJ-130) Calcium Score on NCCT. The degree of stenosis of intracranial vertebrobasilar arteries was measured by using the warfarin-aspirin symptomatic intracranial disease method (WASID) on CTA. Two neuroradiologists subjectively assessed the pattern of calcification using Modified Woodcock Visual Score (MWVS) and the degree of stenosis. We evaluated correlation coefficients between the degree of luminal narrowing and calcium burden quantitative measures as well as between the subjective assessment of stenosis and calcification pattern. We also measured the interrater agreement.

Results
78 patients were included with a total of 234 posterior circulation arteries assessed. Atherosclerotic calcification was detected in 120 arteries (51.3%) on NCCT. Of these, 91 (38.8%) arteries had measurable (nonzero) stenosis on CTA. We found strong positive correlation between MWVS and WASID (r=0.72, p=0.001). Positive correlation between Volume of the Calcification and WASID (r=0.62, p=0.001), and AJ-130 Calcium Score and WASID (r=0.59, p=0.001). The correlation between the subjective assessment of calcification and stenosis was 0.52 (reader one) and 0.53 (reader two). The interrater agreement was substantial for identifying calcification on NCCT and moderate for visual assessment of stenosis on CTA (k=0.70 and 0.59 respectively).

Conclusions
There is a positive correlation between atherosclerotic calcium burden and luminal narrowing in the intracranial vertebrobasilar arteries. This may suggest that measurable atherosclerotic calcified plaques on NCCT can predict the degree of luminal narrowing in the intracranial vertebrobasilar arteries.

Association of Local Anesthesia Versus Conscious Sedation on the Functional Outcome of Acute Ischemic Stroke Patients Undergoing Embolectomy

J Marion, S Seyedsaadat, J Pasternak, A Rabinstein, W Brinjikji, D Kallmes
Mayo Clinic, Rochester, MN, Westchester Medical Center, Valhalla, NY

Purpose
Compare the functional outcome of acute ischemic stroke (AIS) patients undergoing embolectomy with either local anesthesia or conscious sedation. Secondarily, the aim is to identify differences in hemodynamic parameters and complication rates between groups.

Materials and Methods
A single institution, retrospective review was performed of all patients with AIS who underwent embolectomy between January 2014 and July 2018 (n=185). Patients who received general anesthesia (n=27) were excluded from analysis. 111 of 158 (70.3%) patients were included in the local anesthesia (LA) group, and 47 (29.7%) were included in the conscious sedation (CS) group. The median age was 71 years (IQR 59.79). 78 (49.4%) were male. The median NIH stroke scale score was 17.5 (IQR 11-21). Hemodynamic and medication administration data were collected from the anesthesia record. Follow up data including complication and functional outcome were collected from the medical record. Good functional outcome was defined as mRS <2 three months after embolectomy. A multivariate analysis was performed to estimate the association of anesthesia type on 90-day mRS score adjusted for other variables.

Results
Both groups demonstrated a similar rate of 3 month mRS score <2 (LA: 35% versus CS: 41%, OR 0.8 95% CI 0.4-1.6, P = 0.5). Younger patients were more likely to receive conscious sedation than local anesthesia (median age in years (IQR): LA: 72 (62-80) vs CS: 63 (49-75), p = 0.01). Patients in the CS group were more likely to receive intravenous thrombolytic prior to embolectomy (LA: 47 (42.3%) vs CS: 29 (61.7%), p = 0.025). The rate of successful recanalization was higher in the CS group compared to the LA group (93.6% vs. 81.1%, OR= 3.3; 95% CI= 0.9-11.6; P = 0.04). The rate of complications including vascular dissection (P = 0.8), vascular perforation (P = 0.9), and intracranial hemorrhage (P = 0.3) were similar between groups. Hemodynamic parameters were similar between groups.
Conclusions
The functional outcome of patients undergoing embolectomy for AIS is similar for patients receiving local anesthesia as it is for patients receiving conscious sedation. This similarity may be beneficial to a future study comparing general anesthesia to LA and CS during embolectomy. The use of LA or CS does not significantly impact patient hemodynamic status.

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Association of White Matter Integrity and Age on Cognitive Performance in U-2 Pilots

P Sherman1, B Cerqueira2, J Sladky3
1Wilford Hall ASC/USAF School of Aerospace Medicine, JBSA - Lackland, TX, 2KBR, JBSA Lackland, TX, 359MDW/Brooke Army Medical Center, JBSA Lackland, TX

Purpose
To assess whether fractional anisotropy (FA) values within white matter tracts or age had a significant factor in U-2 pilot neurocognitive performance.

Materials and Methods
MRI and neurocognitive data were obtained from 103 U-2 pilots prior to implementation of the cabin altitude restriction effort (CARE). The CARE program modified the cabin altitude during flight operations above 21,000 m from approximately 9,000 m (28,000-30,000 ft) to approximately 4,500 m (15,000 ft). FA values within multiple white matter tracts were acquired from diffusion tensor imaging (n=103). Neurocognitive data was attained through MicroCog evaluation (n=101). A generalized linear model was utilized to investigate independent effects of FA value and age on MicroCog metrics.

Results
Higher FA values of the corpus callosum body, internal capsule, corona radiata, external capsule, and fronto-occipital tracts were independently associated with higher MicroCog Spatial Processing scores when controlling for age. Fronto-occipital tract FA values were significantly negatively associated with reaction time. Age was positively associated with reaction time across all tracts.

Conclusions
In our U2 pilot group both age and FA values independently influence certain microcognitive metrics with positive correlation to spatial processing when controlling for age in numerous tracts. Increasing age correlates with improved reaction time independent of FA values for all tracts. This study provides further insight that numerous white matter tracts are important in visual spatial integrity enhancing the concept that cortical function is emblematic of a diffuse network between brain regions rather than a discrete anatomical site.

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Automated Cerebrospinal Fluid (CSF) Volume Measurement by Deep-Learning Based Segmentation of the Ventricular System on Brain Magnetic Resonance Imaging

B Yousefi1, A Vossough2
1University of Pennsylvania, Philadelphia, PA, 2University of Pennsylvania - CHOP, Philadelphia, PA

Purpose
Accurate assessment of acute and chronic hydrocephalus and ventricular size is important in management and treatment planning. In this study, we propose a deep learning-driven measurement for ventricular cerebrospinal fluid (CSF) volume applying automatic segmentation performed using a UNet architecture, a fully convolutional neural network.

Materials and Methods
The cancer genome atlas (TCGA-GBM) dataset, publicly available from the National Cancer Institute's Cancer Imaging Archive (TCIA) was analyzed, randomly selected 84 patients (age range: 60 [18,84], male/female: 53/31, event: death [71], White/African American/Asian/unknown: 75/4/5/1). A trained imaging expert manually segmented the ventricles in 3D using the ITKsnap semi-automated toolkit (version 3.6.0). These segmentations were used as a gold standard (ground truth) to benchmark the system's performance. A total of 3741 images with the size of 256x256x1 extracted as input of the system and segmented to train U-Net. The model complied with Adam optimizer and a binary based cross entropy loss function with calculation of how often the predictions matched the labels (ground truth) for accuracy.

Results
The proposed algorithms were tested on 100 T1 MRI imaging series and 1,966,321 trainable parameters were trained while they were modified for this application. Out of 3741 images, 2741 images were used for model training (63.5% of overall data). The model trained by 100 epochs and batches of 16 randomly shuffled during training process. The results obtained from the brain MRI exams indicated that this method can perform an automated segment the ventricles with 90% accuracy (intersection of union). The results of segmentation indicated no difference between male and female patients.

Conclusions
Brain ventricle segmentation from MRI datasets can be automated using a deep learning approach. The proposed method performs
very well in terms of segmentation accuracy, robustness, and computational time. The high correlation between the automatic and manual references indicates the accuracy and potential clinical applicability of the proposed framework for automatic evaluation of the ventricular system.

Figure. (a) presents the segmentation of the ventricle with ITKSnap (3.6.0). (b) shows 3D presentation of the brain and ventricle. (c) Workflow. The structure of U-Net used for segmenting ventricle is shown in the image. 100 T1 MRI imaging series used to train 1,966,321 trainable parameters while they were modified for this application (receiving an input image by 256*256*1 dimension).

Beyond MRI: Differentiating Perineural Tumor Spread from Radiation Neuritis in the Setting of Metastatic Prostate Cancer with Prostate-Specific Radiotracers.

K Dahlstrom¹, L Shah¹, T Hutchins¹, M PECKHAM¹

¹University of Utah Health Care, Neuroradiology, Salt Lake City, UT

Purpose
To demonstrate how inconclusive MRI findings in the setting of suspected extra-prostatic recurrence can be easily delineated with prostate specific radiotracers.

Materials and Methods
61-year-old male with metastatic prostate adenocarcinoma post radical prostatectomy and chemoradiation presented with chronic perineal, rectal and pelvic pain. Multiple ganglion impar blocks were performed with limited relief. Post prostatectomy PSA was 0.01 ng/mL which rose to 0.9 ng/mL three years after surgery.
Results
MRI of the lumbosacral plexus performed 17 months after prostatectomy demonstrated nodular thickening, T2 hyperintensity and enhancement of the bilateral S3 and S4 nerve roots. Most recent follow-up MRI demonstrated similar findings involving the bilateral S2 and S3 nerve roots, most pronounced involving the left S2 nerve (blue arrow, Figure 1 A-C). Fluciclovine-PET/CT performed in 2017 demonstrated uptake of radiopharmaceutical extending along the left S3 and S4 nerves, with follow up study demonstrating increased activity along the bilateral S2 and S3 nerves (Figure 1D). Radiologists favored nerve changes to represent radiation neuritis over perineural tumor spread on multiple MRI reports, before and after Fluciclovine-PET/CT.

Conclusions
Fluciclovine is a synthetic amino acid which is preferentially taken up by prostate cancer cells via specialized amino acid transporters, and has from 97-100% specificity for extra-prostatic cancer recurrence. Though highly specific, this relatively new technique is not familiar to many practicing radiologists who may rely on MRI for diagnosis. There is considerable overlap of MRI features between perineural tumor spread and radiation-induced plexopathy, both demonstrating nerve enlargement, T2 hyperintensity and enhancement. In this particular case, had the utility of Fluciclovine PET been known by interpreting radiologists, perineural tumor involvement would have been the clear diagnosis. Prostate cancer-specific Fluciclovine-PET provides valuable insight into disease recurrence when anatomic imaging is nonspecific. Radiologists should be aware of this recently developed technique for confounding MR findings in the setting of suspected extra-prostatic prostate recurrence.
Brain MR imaging in Epstein Barr virus meningoencephalitis in children

S Vyas1, R Suthar1, A Kumar1
1Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh

Purpose
Epstein Barr virus (EBV) meningoencephalitis can have variable and non-specific brain MR imaging finding in children. Our study aimed to describe spectrum of different brain MRI findings in patients with EBV meningoencephalitis.

Materials and Methods
Forty-five pediatric patients who presented with variable neurological symptoms and found to have EBV meningoencephalitis
[positive EBV deoxyribonucleic acid (DNA) in cerebrospinal fluid]; and also had undergone brain MRI were included in this study. Retrospective evaluation of the clinical and radiological database was done.

Results
Fever was presenting feature in all the cases. Signs of meningitis and raised ICP were seen in 24(53.3%) cases, encephalopathy in 15(33.3%) cases and seizures were present in 33(73.3%) cases. A normal MRI scan was observed in 16(35.5%) cases. The cortical/subcortical pattern was diagnosed in 9(20%) cases, white matter involvement in 7(15.5%), Basal ganglia in 5(11.1%), thalamic involvement in 4(8.8%) cases, brain stem involvement in 2(6.2%) cases, substantia nigra involvement in 2(4.4%) cases and cerebellar involvement in 2(4.4%) cases. Diffusion restriction was present in 11(24.4%) cases and susceptibility changes in 7(15.5%) cases. Meningeal enhancement was present in 10(22.2%) cases. In addition, brain abscess and subdural effusion/empyema was present in 1(2.2%) case each.

Conclusions
Pediatric EBV meningoencephalitis has varied clinico-radiological spectrum. Common MRI imaging findings includes cortical-subcortical involvement, white matter changes, basal ganglia and thalami involvement.

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Brain MRI Imaging Spectrum of Japanese Encephalitis in Children

R Srinivas1, S VYAS1, R Suthar1
1Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh

Purpose
Japanese Encephalitis is one of the leading causes of encephalitis in endemic areas with high morbidity and mortality. The imaging patterns in adults have been described by various authors but the imaging manifestation in the children has not been addressed to the best of our knowledge.

Materials and Methods
This is a retrospective study carried out on patients with acute meningoencephalitis who had positive serology for Japanese Encephalitis.
Encephalitis and whose imaging studies were done in our institute. The cases were done in 1.5T and 3T MRI systems, and were evaluated under the following protocol: T2 weighted axial, fluid-attenuated inversion recovery pulse image (FLAIR), T1 weighted 3D magnetization prepared – Rapid Gradient echo (MPRAGE), axial Diffusion-weighted imaging (DWI) with ADC (Apparent diffusion coefficient), axial GRE/SWI and post contrast 3D-MPRAGE.

Results
12 cases of acute meningoencephalitis were included. The imaging spectrum in pediatric patients were wide and variable. The predominant finding was that of bilateral, symmetrical, altered signal intensity involving the thalamus (n=11), substantia nigra (n=9) and basal ganglia (n=6). Most of the cases also showed diffusion restriction (n=9), but only one patient showed hemorrhage in SWI images. There was variable involvement of the brainstem, cortical grey matter and white matter. There was incidental findings of neurocysticercosis (n=5) in these cases.

Conclusions
Brain MRI imaging spectrum of Japanese Encephalitis in children were same as reported in the literature for the adults. MRI brain plays a pivotal role in differentiating it from other acute meningoencephalitis.

Can Radiologists Reliably Use SWI as a Biomarker of Prior Aneurysmal Subarachnoid Haemorrhage?
E Hughes
Leeds Teaching Hospitals, Leeds, West Yorkshire

Purpose
Evaluate whether susceptibility weighted imaging (SWI) can be used as an accurate biomarker of prior cerebral aneurysmal subarachnoid haemorrhage (SAH).

Materials and Methods
A retrospective search of a tertiary neuroscience centre radiology information system (01/01/2018-31/12/2018) identified 70 patients that had a cerebral aneurysm + cranial CT + SWI, giving 140 sets of images. 40 patients had CT evidence of acute SAH at ictus as stipulated in the radiology report and confirmed by a neuroradiologist. Two additional neuroradiologists blinded to the clinical information evaluated independently, the 140 anonymized CT and SWI by stating the presence/absence of haemorrhage. When haemorrhage was present the neuroradiologists specified the distribution of blood and applied Fisher grading. This was repeated after a washout period (≥ 2-weeks) to permit intra and interobserver correlation.

Results
Medium time between CT and SWI = 911 days, (range 1-5239). Neuroradiologists showed excellent interobserver concordance in the detection of haemorrhage using CT (Cohens Kappa (κ) 0.9, specificity (spe) 0.96, sensitivity (sen) 0.96). Conversely, there was poor interobserver concordance in the detection of haemorrhage on SWI (κ=0.32, spe=0.75, sen=0.77), which resulted in variation amongst Fisher grades. Intraobserver concordance was excellent for both observers (CT κ=1 for both; SWI: κ=0.95 Observer 1; κ=0.86 Observer 2). False positive rates for the detection of blood on SWI: observer 1, 77%; observer 2, 57%. False negative rates: observer 1, 2.5%; observer 2, 17.5%.

Conclusions
Variability exists between radiologists when assessing for prior SAH on SWI. The high false positive rate may be partially explained by a reported greater sensitivity of SWI over CT, but prospective trials should be considered to further elucidate the true utility of SWI as a biomarker of SAH including its temporality.

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Cerebrospinal Fluid Flow Alterations in Craniocervical Syndrome: A Phase-Contrast MRI Study
N Kulkarni1, B Damadian1, D Chu1, M Gianni1, L Minkoff1, R Wolf1, R Damadian1
FONAR Corporation, Melville, NY

Purpose
Patients with craniocervical trauma (whiplash or mild traumatic brain injury) and craniocervical instability due to other reasons (ex: Ehlers Danlos Syndrome, EDS) often complain of a characteristic headache that originates in the occipital region (1,2). These patients also present with a constellation of other neurologic symptoms including tinnitus, visual disturbances, gait difficulty, and syncopal episodes. This group of non-focal neurologic symptoms has been described as the craniocervical syndrome (CCS), but the physiologic basis is not fully understood (3). It has been reported that alterations in CSF flow are associated with occipital headache in patients with Chiari I malformation regardless of the degree of tonsillar ectopia, suggesting that decreased CSF flow may be responsible for the symptoms (4). Due to the similar symptoms in Chiari and CCS, we hypothesize that the etiology of CCS is related to CSF dynamics. This retrospective study aims to identify the relationship between chronic occipital headache and CSF flow in patients with suspected CCS.

Materials and Methods
16 patients (6 male, mean age =48.4) with the primary complaint of occipital headache were chosen from the adult patient population referred to our MRI center for clinically suspected CCS. 11 patients had prior head/neck trauma, 2 patients had EDS, and 3 patients had no discernible history of trauma or connective tissue disorder. Patients with any major neurological disorder or spinal surgery were excluded. 18 asymptomatic volunteers (8 male, mean age= 48.4) were used as controls. All subjects underwent MRI in a sitting position on a 0.6T positional MRI. A phase encoded sequence was applied with peripheral gating to image and quantify CSF flow. CSF flow data was obtained at the mid-C2 level. Unpaired t-test was used to compare the CSF parameters between the two groups. One of two radiologists reviewed each brain MRI to assess the position of the cerebellar tonsils.

Results
A significant decrease in CSF stroke volume per cardiac cycle (p=0.029) and total systolic CSF flow (p=0.044) was seen in CCS patients (Fig. 1). No CCS patients exhibited cerebellar tonsillar ectopia (CTE) >5mm: 5 patients had CTE 1-4mm, and 11 patients had no CTE.

Conclusions
Our results suggest that occipital headache is related to decreased CSF flow even in the absence of Chiari I malformation and that alterations in CSF dynamics may be responsible for CCS. Further study is warranted into the effect of head and neck trauma on CSF hydrodynamics.
Figure 1. Total systolic flow and CSF stroke volume are decreased in patients with occipital headache and suspected craniocervical syndrome compared to asymptomatic controls.
Challenges to Utility of Abbreviated MRI Brain Protocol Designed for Acute Stroke

M BHALLA¹, S Quinet¹
¹Medical College of Wisconsin, Milwaukee, WI

Purpose
Imaging plays a critical role in acute stroke management. While predictive values of MRI are far more superior to CT, one of the main limiting factors for MR is scanning time. At our institute, typical time for performing a routine brain MRI is 13:08 minutes. An abbreviated protocol for suspected stroke patients that excludes acquisition of Sagittal T1 and axial T2 sequences shortens the scan time by 5:05 minutes. The abbreviated protocol was labeled as "ED Brain protocol" and available as an option in protocol selection. Purpose of this study was to assess the application of this protocol, and challenges associated with its utilization. Besides saving door-to-diagnosis time (one of the metrics in reimbursement model) and scanner operating time, the protocol promotes optimized utilization of health care resources.

Materials and Methods
A prospective study for duration of 1 year was performed, wherein protocol users in Radiology were encouraged to use "ED Brain" protocol. A baseline data about number of stroke studies performed using the routine as well as abbreviated protocol was obtained. The target for percentage of stroke studies performed using abbreviated protocol was 45% at the end of 1 year. It was estimated that with the given work load, 94 hours of scanner time could be saved annually. Protocol users were electronically communicated about the availability and potential of this new protocol at our institute. A 3 month interim assessment was performed, following which the protocol information was reinforced to the users by periodic reminders. The utilization of protocol and the annual MRI scanner time saved was assessed at 1 year. A survey was sent to all faculties involved in reading MRI ED brain protocoled studies to gain feedback about their experience with the protocol, and to assess the response from clinical colleagues.

Results
At baseline only 25% acute stroke MRI studies were performed using abbreviated protocol, which increased to 45% at end of 1 year, thereby achieving the set target. Annual MRI scanner operating time saved was 98 hours. 1-2 patient recalls in a year was reported by 20% faculty and one ordering physician for obtaining additional sequences. Periodic reminders to protocol users impacted use of new protocol.

Conclusions
Reinforcing reminders to protocol users in a busy work environment can impact protocol utilization in the department. Optimized utilization of imaging resources fastens a critical diagnostic step in stroke management without impacting diagnostic ability.

Chimeric Antigen Receptor (CAR) T-cell Therapy Neurotoxicity in Patients with DLBCL and ALL: Imaging Findings and Correlation with Clinical Severity

W Kleich¹, M Robinson¹, S Ali¹
¹University of Chicago, Chicago, IL

Purpose
CAR-T cell therapy is a novel form of immunotherapy approved for patients with relapsed or refractory diffuse large B-cell lymphoma (DLBCL) and B-cell acute lymphoblastic leukemia (ALL). Initial clinical trials have demonstrated promising results in refractory disease but have been tempered by high rates of neurotoxicity. The pathophysiology is poorly understood, with recent studies suggesting a role of endothelial activation and increased blood brain barrier permeability. Few case reports are available on the neuroimaging manifestations, and we sought to evaluate the neuroradiological findings of neurotoxicity after CAR-T cell therapy in a retrospective study.

Materials and Methods
Retrospective chart review was performed of patients from a single academic center who underwent CAR-T cell therapy for DLBCL and developed neurotoxicity according to standard CARTOX criteria. All brain CT and MR studies performed in these patients immediately pre- and post- CAR-T cell therapy were independently reviewed by two radiologists. A second cohort of patients with ALL receiving formulations of CAR-T therapy currently undergoing clinical trial were preliminarily examined.

Results
A total of 47 adult patients with DLBCL were evaluated. 34 (72%) patients had available baseline pre-therapy CT or MR imaging, all of which were normal or demonstrated no acute finding. 36 (77%) patients had documented neurotoxicity. 30 (64%) patients received post-therapy neuroimaging (28 with CT, 18 with MR) due to neurotoxicity. Positive post-therapy imaging findings were seen in 3 (6%) patients with DLBCL including punctate acute left cerebellar infarct (n=1), acute subdural hematoma (n=1), and punctate foci of T2 hyperintensity which were reversible between available pre-/post-therapy MR exams (n=1). A total of 11 patients with ALL were evaluated. Positive post-therapy imaging findings were seen in 5 (45%) patients including central variant posterior reversible
encephalopathy syndrome, intracranial hemorrhage, and cerebral edema. Clinical severity of neurotoxicity did not correlate with presence of positive imaging findings in both cohorts.

Conclusions
MRI findings of CAR-T related neurotoxicity are varied and may relate to blood brain barrier dysfunction. Clinical severity of neurotoxicity did not correlate with incidence of positive imaging findings in this small cohort. Future studies should continue to investigate neurotoxicity neuroimaging with MRI, which may help facilitate early recognition and treatment.

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Circumferential segmental vessel wall enhancement on vessel wall MRI in patients without vasculopathy: Normal or abnormal?

D Gaddam¹, G Crews¹, T Chryssikos¹, R Morales², J Zhuo¹, R Almardawi¹, D Gandhi¹, P Raghavan¹
¹University of Maryland Medical Center, Baltimore, MD. ²N/A, Clarksville, MD, ³University of Maryland School of Medicine, Baltimore, MD

Purpose
High resolution intracranial vessel wall MRI has recently gained traction in characterizing atherosclerosis, vasculitides, and inflammatory changes in the aneurysm wall. However, the occurrence of uniform circumferential segmental arterial vessel wall enhancement (CSWE) in patients without these diagnoses has not previously been studied. The aims of this study are as follows: 1) To evaluate the occurrence of CSWE in the major intracranial arteries in patients without the aforementioned diagnoses and 2) to determine the association between CSWE and risk factors for cerebrovascular atherosclerotic disease.

Materials and Methods
Retrospective analysis of vessel wall MRI to evaluate for CSWE in 26 patients without vasculitides, symptomatic atherosclerosis or aneurysmal SAH. CSWE was rated as present or absent in 5 arterial segments in both the anterior and posterior circulation by two observers. Prevalence of CSWE in each segment and its association with demographic data and cerebrovascular atherosclerotic risk factors including hypertension, hyperlipidemia, diabetes mellitus and smoking were assessed.
Results
Occurrence of CSWE 1. CSWE was seen in 42% of the posterior circulation segments versus 19% of the anterior circulation segments. 2. Highest occurrence of CSWE were the V4 vertebral and basilar arteries, 30.8% and 15.4%, respectively. CSWE Association with Atherosclerotic Risk Factors 1. CSWE in the posterior circulation posterior circulation demonstrated a statistically significant association with hyperlipidemia (p-value 0.011). 2. Anterior circulation CSWE showed a statistically significant association with diabetes mellitus, hypertension, and hyperlipidemia (p-values 0.0007, 0.007 and 0.011, respectively) .

Conclusions
We describe the occurrence of CSWE in intracranial arteries in a cohort of patients without a diagnosis of vasculopathy. Highest incidence of CSWE was noted in the proximal segments of the intracranial vessels, particularly in the vertebral and basilar arteries. Although the distribution of CSWE mirrors that of vasa vasora described in the pathology literature, its presence may also be an early sign of atherosclerosis. CSWE, in the absence of supporting clinical evidence, must not be mistaken for vasculitis.

\[\textit{VW-MRI of CSWE versus vasculitis and atherosclerotic plaque}\]

Axial post-contrast (A) VW-MRI images demonstrates CSWE (arrowhead) in the V4 segment of the left vertebral artery. Oblique reformatted post-contrast (B) images better demonstrate CSWE (arrowheads).

Axial 3D VW-MRI post-contrast images (C) in a different patient demonstrates eccentric vessel wall enhancement (straight arrow) in the basilar artery consistent with atherosclerotic plaque. Oblique reformatted post-contrast (D) images in a different patient demonstrates findings of asymmetric short segment vessel wall enhancement (curved arrow) in the V4 segment of the left vertebral artery in a patient with vasculitis.
Clinical Application of 3D HR MR VWI (3-Dimensional High Resolution Magnetic Resonance Vessel Wall Imaging) for the Evaluation of the Whole Intracranial Large Artery in Patients with Angio-negative, Diffuse SAH (subarachnoid hemorrhage)

Suh1, I Ryoo1, H Jung1, W Yoon2
1Guro Hospital, Korea University Medicine, seoul, Seoul, 2Guro Hospital, Korea University Medicine, seoul,

Purpose
SAH, mainly due to ruptured saccular aneurysm, is a serious devastating disease. Among them, about 15% case shows no definite structural pathology in routine radiologic study including conventional angiograms. The standard practice for this angio-negative, diffuse SAH is a 1 – 2 weeks follow-up cerebral angiograms. Among them, 10% of cases shows recurrent hemorrhage and 20% reveals poor clinical outcome. Thus, we need the additional early diagnostic imaging tool. 3D HR VWI has been applied as an innovative and promising imaging technique for evaluation of intracranial arteriopathy such as atherosclerotic disease, moyamoya disease, and cerebral aneurysm etc. The purpose of this study is to evaluate the feasibility of 3D HR VWI for the clinical application and the detectable structural causes in patients with angio-negative, diffuse SAH.

Materials and Methods
We has collected the imaging data from our HR VWI study for intracranial aneurysms, about 500 study from 2013 July to 2019 September. Among them, 25 cases were conducted in patients with acute diffuse SAH. 5 cases were a ruptured saccular aneurysmal SAH. We evaluated the imaging findings and clinical management in 20 patients with angio-negative, non-perimesencephalic, diffuse SAH. The imaging protocol of HR MR VWI for cerebral aneurysms is as followed: 1) 3T scanner (Skyra, Prisma: Siemens, Erlangen, Germany); 2) T2 WI, pre and post gadolinium enhanced T1 WI sagittal images by isotropic 3D SPACE sequences with blood suppression for whole intracranial large artery; 3) multi planar reconstruction for coronal or axial acquisition; 4) advanced imaging technique since 2017 such as DANCE for flow suppression and CAIPRINA for rapid acquisition.

Results
We could not evaluate imaging findings in one case (1/20, 5%) due to motion artifact. 16 cases (16/20, 80%) showed the structural causes for angio-negative, diffuse SAH in 3D HR VWI: 9 cases, arterial dissection; 4 cases, blood blister like aneurysm; 2 cases, ruptured growing perforator aneurysms; 1 case, ruptured fusiform aneurysm. 3 cases showed no causative pathology. We managed 9 cases (9/16, 56%) by endovascular approach at early period according to HR VWI findings and clinical situation and obtained good clinical results.

Conclusions
3D HR VWI for intracranial large artery was feasible, additional useful adjunctive imaging tool for the evaluation and management of the angio-negative, diffuse SAH patients.

Clinical Experience of a 1-minute Full Brain MRI Using Multicontrast EPI sequence with Different Scan Environment: Can It Replace the Clinical Routine Protocol?

H Baek1, K Ryu1, S Skare2, T Sprenger3, M Hwang4
1GNU Changwon Hospital, Changwon, Republic of Korea, 2Karolinska University Hospital, Stockholm, Sweden, 3GE Healthcare Europe, Stockholm, Sweden, 4GE Healthcare Korea, Seoul, Republic of Korea

Purpose
The long scan time of MRI is a major drawback limiting its clinical use in neuroimaging; therefore, we aimed to investigate the clinical feasibility of a 1-minute full brain MRI using the newly-developed, fast, multicontrast echo-planar imaging (EPI) sequence (EPIMix) at a different site and using a different MR scanner than the ones previously reported.

Materials and Methods
We retrospectively reviewed the records of patients who underwent EPIMix including T1-weighted fluid-attenuated inversion recovery (T1-FLAIR), T2-FLAIR, T2-weighted image (T2WI), diffusion-weighted image (DWI), and T2*WI sequences between January and May 2019. We compared the images with those obtained with the routine brain MRI protocol, and two independent neuroradiologists assessed the image quality of each sequence. We used paired t-tests to compare the readers' ratings of the two different MRI protocols.

Results
Although the overall image quality of all sequences derived from EPIMix, except for DWI, was significantly lower than those of routine MRI, the EPIMix sequences showed at least sufficient image quality, with > 2 points on the average assessment rating. Among the five EPIMix sequences, T2WI had the lowest mean score for the overall image quality assessment. In contrast, the overall quality of EPIMix DWI was comparable to that of routine MR DWI (mean ± SD, 3.88 ± 0.36 vs. 3.87 ± 0.34; P = 0.564). On EPIMix T1-FLAIR, delineation of gray matter–white matter was comparable to that on routine T1-FLAIR (mean ± SD, 3.99 ± 0.06 vs. 4.00 ±
0.00; P = 0.317). In terms of artifacts, there were less motion artifacts in the EPIMix protocol than in the routine protocol. However, EPIMix T1-FLAIR, T2WI, T2-FLAIR, and T2*WI showed significant susceptibility artifacts compared to the corresponding fast spin echo-based sequences of routine MRI.

Conclusions

EPIMix showed sufficient image quality with fewer motion artifacts and a shorter scan time; however, it was limited by inferior image quality and frequent susceptibility artifacts compared to routine brain MRI. Therefore, EPIMix cannot completely replace the routine MRI protocol at present; however, it may be a feasible option in specific clinical situations such as screening, time-critical diseases, or for use with patients prone to motion.

Clinical Profile, Imaging and Prognosis of CNS Mold Infections - A single Institutional Experience

L Sebastian1, P Balasundaram2, M GUPTA3, A Garg4
1All India Institute of Medical Sciences, NEW DELHI, Delhi, 2MGM Healthcare, Thanjavur, Tamil Nadu, 3ALL INDIA INSTITUTE OF MEDICAL SCIENCES, new delhi, delhi, 4AIIMS New Delhi, New Delhi, Delhi

Purpose

To analyse the imaging patterns of CNS mold infections and correlate them with clinical profile and outcome.

Materials and Methods

Patients with clinically or pathologically proven mold infection of central nervous system with adequate imaging, presented to our department during January 2012 to December 2017, as identified from our Picture archiving and communication system (PACS) were included in this retrospective study. Patient records were reviewed for epidemiological variables, clinical history, imaging findings, management, treatment outcome and response and the imaging were reviewed independently by two neuroradiologists.

Results

Of the 49 patients included in our study (mean age = 35.1 years (15 to 65 years), median age =32 years 32 & M:F=32:17), 41 (83.7%) were immunocompetent. Acute, acute on chronic and chronic presentation was seen in 17,12 and 20 patients respectively. Of them 28 patients had primary paranasal sinus involvement, 2 isolated orbital involvement, 4 primary dural based disease without involvement of PNS or orbits and the remaining 15 patients had only parenchymal involvement. PNS involvement was mostly unilateral. Dural involvement was mostly seen in cavernous sinus region or adjacent to paranasal sinuses as T2 hypointense thickening or mass like lesions with homogeneous enhancement. In the intraparenchymal group 15 patients had isolated parenchymal lesions while rest had contiguous sinus or orbital disease. The lesions varied from what we describe as 'dirty' T2WI appearance, punctate lesions, small (<1 cm) and large (>1 cm) solid nodules and ring enhancing lesions including abscesses showing an evolution pattern in the order described in some of the patients. Fourteen patients showed imaging evidence of meningitis while 21 developed infarcts. Incidence of various types of mold infections in our cohort and their relation with infarcts and mortality is given in Table1. Survival analysis showed a median survival period of 1.5 years from the onset of symptoms and 1.3 years from the time of first presentation to us. Rapid fall in the survival probability (less than 60%) is seen in the initial 120 days from the presentation, which is followed by a
plateau. Mean survival of patients with and without infarcts were 204 and 754 days respectively which was statistically significant (p=0.0005) by analysis of survival curves.

Conclusions
Most of our patients were immunocompetent. Distinct imaging patterns of mold infections were observed on MRI. Presence of infarcts heralded poor outcome.

Table 1: Types of Mold Infections and their Imaging Pattern and Prognosis

<table>
<thead>
<tr>
<th>Type</th>
<th>Total patients</th>
<th>Infarct</th>
<th>% of infarct</th>
<th>p value</th>
<th>Death</th>
<th>% of death</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspergillus</td>
<td>42</td>
<td>16</td>
<td>38.1%</td>
<td></td>
<td>15</td>
<td>35.7%</td>
<td></td>
</tr>
<tr>
<td>Primary P</td>
<td>11</td>
<td>0</td>
<td>0%</td>
<td>0.008</td>
<td>2</td>
<td>18.2%</td>
<td>0.297</td>
</tr>
<tr>
<td>PNS/orbit/dural</td>
<td>31</td>
<td>16</td>
<td>51.6%</td>
<td></td>
<td>13</td>
<td>41.9%</td>
<td></td>
</tr>
<tr>
<td>Mucor</td>
<td>4</td>
<td>4</td>
<td>100%</td>
<td></td>
<td>2</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Primary P</td>
<td>1</td>
<td>1</td>
<td>100%</td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>PNS</td>
<td>3</td>
<td>3</td>
<td>100%</td>
<td></td>
<td>2</td>
<td>66.7%</td>
<td></td>
</tr>
<tr>
<td>Dematiaceous fungi</td>
<td>3</td>
<td>1</td>
<td>33.3%</td>
<td></td>
<td>2</td>
<td>66.7%</td>
<td></td>
</tr>
<tr>
<td>Primary P</td>
<td>3</td>
<td>1</td>
<td>33.3%</td>
<td></td>
<td>2</td>
<td>66.7%</td>
<td></td>
</tr>
<tr>
<td>Grand Total</td>
<td>49</td>
<td>21</td>
<td>42.9%</td>
<td></td>
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<td>38.8%</td>
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<td>Primary P</td>
<td>15</td>
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<td>0.014</td>
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<tr>
<td>PNS/orbit/dural</td>
<td>34</td>
<td>19</td>
<td>55.9%</td>
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1140

Combination of MRI and Clinical Features Predicts Vertebral Osteomyelitis and Discitis

S KIHIRA, C Koo, T Leong, B Rigney, A Aggarwal, A DOSHI

1Icahn School of Medicine at Mount Sinai, New York, NY

Purpose
Pathology results for suspected infectious osteomyelitis on MRI are negative in up to 60-70% of cases (1). We aim to develop an imaging and clinical based model to predict vertebral discitis/osteomyelitis.

Materials and Methods
This was a retrospective single center IRB approved study. A total of 225 patients with radiologically suspected discitis/osteomyelitis underwent image-guided core needle biopsies at one institution from August of 2012 to May of 2019. Demographic data, vital status, laboratory values, culture results, antibiotic exposure, and radiological features were collected. Pathology results were obtained to determine final diagnosis of discitis/osteomyelitis. Two independent observers provided MR-based scoring for suspicion of osteomyelitis, presence of paraspinal enhancement/collection, and presence of epidural enhancement/collection. Cohen's kappa analysis was used to assess for inter-observer agreement. ROC analysis was performed to determine optimal combination of laboratory and radiological features to predict histopathologically positive discitis/osteomyelitis.

Results
Our patient cohort consisted of a total of 72 patients, of which 33.3% (24/72) of patients had histopathologically proven discitis. The mean ± standard deviation of age (years) was 63 ± 16 with M/F of 41/31. Inter-observer agreement for suspicion of osteomyelitis, presence of paraspinal enhancement/collection, and epidural enhancement/collection was fair to moderate with kappa of 0.54, 0.49, and
Logistic regression revealed a combination of temperature, ESR, and CRP to predict discitis/osteomyelitis with an AUC of 0.74. With the addition of radiological features, specifically presence of epidural enhancement/collection, the AUCs for prediction model increased to 0.87 and 0.80 for readers 1 and 2, respectively.

Conclusions
Our findings demonstrate that discitis/osteomyelitis can be predicted through a combination of MRI and clinical features with good predictability of AUC 0.80-0.87 despite fair inter-observer agreement.

**Predictive Performances of MRI and Clinical Features for Vertebral Discitis/Osteomyelitis**

![Graph showing predictive performances of MRI and clinical features for vertebral discitis/osteomyelitis](TCT_1140_Discitis_ASNR.jpg)

Comparison of infarct core volume measurements in ischemic cerebral stroke using standard and Bayesian CT perfusion algorithms

F Meijer¹, T Gosseling¹, T Landman¹, M Prokop¹, E Smit¹
¹Radboudumc, Nijmegen, GLD

(Filename: TCT_1140_Discitis_ASNR.jpg)
Purpose
Multiple brain CT perfusion algorithms are commercially available for infarct core volume measurements in acute ischemic stroke, which is of clinical relevance for patient selection to mechanical thrombectomy in the extended time window (6-24 hours). However, it is unclear which CT perfusion algorithm is most accurate in predicting the final infarct core volume. The aim of this study was to compare a standard CT perfusion technique (singular value decomposition, SVD) to a new Bayesian based CT perfusion technique for predicting the final infarct core volume in acute ischemic stroke.

Materials and Methods
In a prospective study, patients scanned with whole-brain CT perfusion for the clinical suspicion of acute ischemic stroke (up to 24 hours after onset) underwent brain MRI-DWI at follow up (up to day 4). Infarct core volumes on CT perfusion were measured on a single workstation (Vitrea, Vital Images) using the SVD and Bayesian based algorithms and were compared with final infarct core volumes on MRI-DWI. Correlation coefficients were calculated for both algorithms. The mean volumes were compared between the two algorithms. Also, the SVD+ and Bayesian perfusion maps were visually assessed for the presence of a perfusion deficit and were compared to the presence of an infarct core on MRI-DWI.

Results
Visual assessment of CTP maps resulted in a specificity of 93% and a positive predictive value of 100% at a sensitivity of 59% for the detection of an infarct on MRI-DWI. This was equal for both perfusion algorithms. The infarct core volume measurements on CTP had a low correlation to the final infarct core volumes on MRI-DWI, with coefficients below 0.4 for both algorithms. The correlation was not improved by changing the thresholds defining infarct core and penumbra. A subanalysis for treatment effects and recanalization also did not affect correlation.

Conclusions
Visual evaluation of CTP has a high positive predictive value but a modest sensitivity for detection of infarct cores in acute cerebral stroke. With the tested algorithms, automatic infarct volume measurements show a low correlation with final infarct core volumes. Therefore, automatic CT perfusion volume measurements should interpreted with caution when used for patient selection to intra-arterial thrombectomy in the extended time window.
to the spine. We present a case of SNUC with multifocal extra/epidural metastases resulting in cord compression as well as invasion of the adjacent spine at the level of largest extradural metastatic deposit.

Materials and Methods
A 66-year-old male initially presented with first reported seizure history and Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) studies (not shown) revealed infiltrative expansile right sinonasal mass with extensive local invasion with pathological diagnosis of SNUC. After 2 years of uneventful clinical course following chemotherapy and radiotherapy, he presented with significant clinical deterioration and suspected cord compression/cauda equina symptoms. Subsequent MRI of total spine demonstrated multiple extradural masses throughout thoracic and lumbar spine with spinal cord compression, extension into paraspinal tissues and bone invasion at the level of largest metastatic disease. The patient underwent laminectomy for resection of the largest extradural tumor at thoracic spine with posterior spinal fusion. The patient was symptomatic on most recent follow-up visit with last PET/CT demonstrated disease progression.

Results
Figure 1A, 1B, and 1C: Sagittal T2 weighted(1A), sagittal (1B) and axial post-contrast T1-weighted (1C) images demonstrate a large enhancing epidural mass along left dorsolateral aspect thoracic spinal canal (arrows) causing cord compression with extension into ipsilateral neural foramen (star) and extraforaminal component invading paraspinal soft tissues (arrowheads). Adjacent vertebra body involvement also noted (double arrows). Fig1D. Sagittal post-contrast T1 weighted images of lumbar spine show additional epidural enhancing nodules at lower thoracic, lumbar spine, and masses around nerve roots in the caudal thecal sac (arrows).

Conclusions
SNUC is a rare and locally aggressive neoplasm commonly invading skull base and intracranial structures. It can show rare distant metastases including cervical lymph nodes, lung, bone, and liver. However, metastasis to extradural spine is extremely uncommon with a few case reports in the current literature. Peri-dural metastasis and resulting symptoms should be included in the differential diagnosis and assessment of patients with SNUC.
**Correlation Between Susceptibility-Weighted Imaging and Vascular Biomarkers at Pathology in Diffuse Gliomas**

A Hilario Barrio¹, E Salvador², P Martin Medina², I Koren³, T Cejalvo¹, P Sanchez-Gomez³, A Perez-Nuñez¹, A Hernandez-Lain¹, J Sepulveda¹, a Lagares¹, A Ramos⁴  
¹Hospital 12 de octubre, MADRID, SPAIN, ²Hospital 12 de Octubre, Madrid, Madrid, SPAIN, ³Hospital 12 de octubre, Madrid, SPAIN, ⁴Hospital 12 de Octubre, Madrid, Madrid, Spain

**Purpose**  
Susceptibility weighted imaging (SWI) provides vascular information and plays an important role in the preoperative diagnosis of diffuse gliomas. Glioblastomas IDH wild-type are the most common and aggressive forms of primary brain tumors. Forty to fifty percent of glioblastomas IDH wild-type show amplification of EGFR (commonly EGFRvIII deleted isoform), which has been related with the angiogenic capacity of gliomas. Our objective was to correlate number and patterns of intratumoral susceptibility signal intensity (ITSS) with EGFR mutation and vasculature features at histopathology.

**Materials and Methods**  
We have performed a retrospective analysis of 33 glioblastomas (WHO 2016 classification). SWI was performed in addition to conventional sequences and perfusion imaging. ITSS was classified on the basis of morphology (dots, linear structures or mixed, chunk) and grade (number of ITSS, percentage of ITSS relative to volume of enhancing tumor). An RNAseq panel has been used to detect the main genomic alterations. Vasculature features were analyzed by immunohistochemistry measuring the expression of CD34 (endothelial cells), CD248 (pericytes) and CD45 (immune cells) in paraffin sections.

**Results**  
We analyzed 29 IDH wild-type and 4 IDH-mutant glioblastomas. At SWI glioblastomas were different (p<0.01) depending on the IDH mutation. In the group of IDH wild-type glioblastomas, 20 had EGFR mutation and 9 were classified as non-mutant EGFR tumors. Glioblastomas IDH wild-type with EGFR mutation showed a higher proportion of dilated vessels and a lower microhemorrhage/enhancing tumor ratio. Glioblastomas IDH and EGFR wild-type showed hemorrhages > 1cm (chunk) at SWI and broken vessels with high vascular proliferation at histology.

**Conclusions**  
IDH and EGFR mutations correlate in a group of glioblastomas with histological and SWI differences.

**Correlations Between Sleep Quality and Connectivity in Subjects Practicing Guided Meditation**

J Smith¹, J Allen², C Haack², K Wehrmeyer², J Mascaro²  
¹Emory University, Atlanta, GA, ²Emory University, Atlanta, GA

**Purpose**  
To examine the impact of mindfulness meditation on functional connectivity and self-reported sleep disturbance.

**Materials and Methods**  
22 subjects were randomly assigned to a mindfulness meditation program using the 10% Happier application and were asked to practice app-guided meditation for approximately 12 minutes/day for 8 weeks (n=12), or to a control group without meditation (n=10). Baseline and post-program evaluations of subjects' sleep quality, depth, and restoration were obtained via the PROMIS Sleep Disturbance Instrument. Post-program resting state functional MRI (rsMRI) data were acquired on a 3T Siemens Prisma FIT (8-minute multiband acquisition with 2 sec TR, 2.97×2.97×2.00 mm voxels, 70° FA, ETL=37). Preprocessing, seed-to-voxel connectivity, and ROI-to-ROI connectome analyses were performed in the CONN Toolbox. rsMRI preprocessing consisted of slice timing, field-map, and motion correction, EPI/T1/MNI coregistration and normalization, smoothing at 8mm FWHM, and denoising using the CompCor method. Practitioners' actual practice times as logged on the mindfulness application were used as a covariate during data analysis. ROIs consisted of 1-mm MNI-space functionally- and anatomically-defined atlas regions included in the CONN Toolbox.

**Results**  
Greater PROMIS scores across all subjects at the post-completion time point were strongly correlated with decreased connectivity between the left hemisphere angular gyrus and the lateral parietal [t(20) = -4.43, p(FDR) = 0.021] regions of the default-mode network (DMN); between left amygdala and right-hemisphere frontopolar [t(20) = -4.73, p(FDR) = 0.013] and right-hemisphere posterior middle temporal gyrus [t(20) = -4.64, p(FDR) = 0.013]; between the brainstem and the left frontopolar region [t(20) = -4.37, p(FDR) = 0.048]; and between left temporo-occipital inferior temporal gyrus and the left posterior aspect of the superior temporal gyrus [t(20) = -4.87, p(FDR) = 0.015] (Figure 1).

**Conclusions**  
These findings are consistent with previous research indicating that mindfulness-based interventions are effective in reducing sleep disturbance and for altering neurobiology related to the default mode in sleep disturbed adults. These data also suggest that improvements in sleep are associated with connectivity changes between the default mode network and regions important for emotion, attention, and social cognition.
Cranial Intraosseous Arterio-venous Fistula

W Chen¹, L Wang², C Lin³, Y Tsuei³
¹Taichung Veterans General Hospital, Taichung, Taiwan, ²Tunghai University, Taichung, Taiwan, ROC, ³Taichung Veterans General Hospital, Taichung, Taiwan, ROC

Purpose
Intraosseous arterio-venous fistula (AVF) is a rare type of cranial AVF with fistula location situated in skull bone. We retrospectively analyzed imaging findings of cranial intraosseous AVF, and evaluated the treatment methods and result.

Materials and Methods
We reported eight patients with cranial intraosseous AVF received treatment at our institute over the past four years. In all of these patients, we retrospectively reviewed the medical records and images. We sought to find the intraosseous fistula location and evaluate feeding arteries and drainage veins in all patients from conventional DSA, source images of CT angiography (CTA), MR angiography (MRA) and 3D rotational angiography. Patients were treated by endovascular embolization or Gamma knife radiosurgery. Follow-up MRA 6-8 months after treatment were available in 7 patients.

Results
Eight patients were enrolled into the study, including 5 males and 3 females, with a mean age of 61 years old. Intraosseous AVFs were located at the jugular tubercle of occipital bone adjacent to the hypoglossal canal in 4, the calvarial bone in 1, and the sphenoid bone in 3 cases. Conventional DSA showed high flow vascular lesions with multiple feeding arteries and early drainage veins confirming cranial AVF in all of these patients. The corresponding fistula location showed a dilated venous pouch manifesting as an osteolytic lesion on source images of CTA, or as an intraosseous high signal intensity on source images of MRA, or a strongly opacified intraosseous lesion in source images of 3D rotational angiography. One patient was treated with transvenous endovascular coil embolization by catheterizing the dilated venous pouch. Three patients were treated with transarterial embolization by catheterizing the feeding arteries and filling the venous pouch with Onyx. Immediately complete obliteration of the fistula was achieved in all these 4 patients. Three patients received Gamma knife radiosurgery by targeting the intraosseous venous pouch. All of the treated patients...
gained complete obliteration of fistula without complication after 6-8 months followed by MRA. One patient refused treatment and lost follow up.

Conclusions
Evaluating the angioarchitecture using conventional DSA, source images of CTA, MRA and 3D rotational angiography helps to determine intraosseous AVF. Intraosseous AVF could be completely cured with endovascular embolization and Gamma knife radiosurgery if the intraosseous venous pouch can be clearly revealed and targeted.

1104

Cranio cervical CT angiography at 80 kVp combined with iterative reconstruction algorithm and low-dose contrast medium: a feasibility study

P. LAI

DEPARTMENT OF RADIOLOGY, KAOSHIUNG VETERANS GENERAL HOSPITAL, KAOSHIUNG, Taiwan

Purpose
To assess the image quality of 80-kVp craniocervical CT angiography (CCCTA) protocol combined with adaptive statistical iterative reconstruction-V (ASIR-V) and low-dose contrast medium (CM).

Materials and Methods
A total of 119 patients were randomly divided into three groups. For group A, 120-kVp protocol was followed with 60 ml CM and filtered back projection; for group B, 80-kVp protocol with 60 ml CM and ASIR-V; and for group C, 80-kVp protocol with 45 ml CM and ASIR-V. Both subjective and objective image quality and radiation doses were evaluated.

Results
Arterial attenuation, signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) of the head, neck, and shoulder regions were significantly higher in groups B and C compared with group A. Group C yielded significantly better subjective image quality than that observed in groups A and B (both p < 0.05). As compared with group A, effective radiation dose and the iodine load of group C were reduced by 51.4% and 25%, respectively.

Conclusions
The CCCTA protocol with 80 kVp, 50% ASIR-V, and 45 ml of CM injected at 3 ml/s significantly reduced the radiation dose, iodine load, and iodine delivery rate while providing better subjective and objective image quality, including higher arterial enhancement and a higher SNR and CNR compared with the 120-kVp protocol.

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CT-Guided Cervical Spinal Puncture for Nusinersen Injections in Patients with Spinal Muscular Atrophy: Easier than a Lumbar Puncture?

T. Everett, D. Sorte, M. Mabray, J. Ormsby

University of New Mexico, Albuquerque, NM

Purpose
To propose that CT-guided C1-C2 puncture may be a more ideal method for administration of nusinersen in patients with spinal muscular atrophy (SMA) whose lumbar anatomy makes lumbar puncture for intrathecal medication administration difficult.

Materials and Methods
The patient is a 22-year-old female with SMA type 2 diagnosed at 9 months of age. The patient experienced sequelae of associated weakness including dysphagia and respiratory insufficiency requiring permanent ventilator and G-tube dependence. She also experienced recurrent UTIs and occasional urinary incontinence. Furthermore, she underwent posterior spine fusion from T2 through the pelvis for neuromuscular scoliosis. Recently the patient and her neurologist decided to pursue nusinersen injections through radiology. A CT-guided lumbar puncture was attempted for initial nusinersen administration; however, given the patient's anatomy and orthopedic hardware, there was no technically feasible approach within this region. The decision was then made to attempt a cervical puncture for nusinersen administration which has resulted in four successful CT-guided C1-C2 punctures for initial dosing followed by maintenance dosing at subsequent four month intervals. The patient and her mother have endorsed improved speech and head control after initiation of nusinersen injections. Improved urinary continence was also reported. Lastly, they both perceived an apparent arrest in muscle strength decline following initiation of injections.

Results
On CT-guided lumbar puncture imaging, there is sciotic orthopedic hardware throughout restricting access. Additionally, the lungs, kidneys, and other abdominal soft tissues restrict access for transfuraminal approach. A CTA neck shows amendable access without any variant vertebral artery or posterior inferior cerebellar artery anatomy. Finally CT-guided C1-C2 puncture imaging shows clear access within the dorsal canal and needle being safely placed in the thecal sac for administration of nusinersen.

Conclusions
CT-guided C1-C2 puncture should be considered for administering intrathecal medications in patients with SMA who may have
anatomy, post-surgical and/or degenerative, that makes lumbar puncture technically challenging. Minimal preprocedural imaging is necessary prior to a cervical puncture and the procedure is generally well tolerated by patients. Indeed, increased provider awareness of this approach as well as improved proceduralist skills could confer benefits to patients requiring this type of care.

CTA Quantification of Intracranial and Extracranial Vascular Narrowing in Patients with Ischemic Stroke Fails to Show Differences Between Patients with Drug Use and Patients Without Drug Use.

E Bonfante-Mejía¹, S Calle², A Jagolino³, C Sitton⁴, X Zhang¹, A Syed Muhammad¹, R Riascos⁵
¹Univ. Of Texas Health Science Center, Houston, TX, ²The University of Texas MD Anderson Cancer Center, Houston, TX, ³UTHSC HOUSTON, HOUSTON, TX, ⁴UTHSC Houston / UT Health, Houston, TX, TX, ⁵Univ. Of Texas - Houston, Houston, TX

Purpose
It has been reported that illicit drug use and abuse increases the risk for stroke, both hemorrhagic and ischemic. Marijuana is the most commonly used illicit drug in the United States. Studies have shown that marijuana can affect cerebral auto regulation and vascular tone, leading to reversible vasoconstriction syndrome. Cocaine use can lead to intracranial hemorrhage and can induce vasoconstriction, vasculitis, vasospasm, or directly affect hemostasis. CTA of the head and neck is routinely used in the care of stroke patients, not only to search for potentially treatable large vessel occlusion, but also to determine the etiology of the stroke. We hypothesized that CTA can show vascular changes in the intracranial and extracranial circulation that may help elucidate the role of marijuana and cocaine in stroke.

Materials and Methods
We conducted an IRB approved retrospective review of patients who were admitted for stroke from 2005 to 2015 who had either a positive urine toxicology screen and/or reported drug use (marijuana and/or cocaine) in their medical histories. A control group of patients without drug use was matched for the following stroke risk factors: [1] age difference is at most 5 years, [2] type II diabetes, [3] hypertension, [4] elevated cholesterol, and [5] smoking status. Two neuroradiologists blindly interpreted the CTA of the both groups using a previously validated scale which provides an individual and cumulative quantification of the narrowing with or without calcification of the intracranial and extra cranial carotid and vertebrobasilar systems.

Results
The case group consisted of 87 patients with a median age of 54 (range 19-72) and the control group of 87 patients with a median age of 56 (range 24-73). The incidence of stroke risk factors was the same for both groups: DM 20.7%, Elevated cholesterol 26.4%, Hypertension 78.2% and Smoking history 54%. Our analysis did not find statistically significant differences in the extent of vascular narrowing in the intracranial or extracranial vessels in the patients with drug use as compared to the patients without it, when matched for other risk factors for stroke.

Conclusions
CTA failed to identify quantifiable differences in the extent of vascular narrowing with or without atherosclerosis in the intracranial or extracranial vessels in patients with stroke and drug use compared to stroke patients without drug use when matched for multiple risk factors for stroke and vasculopathy.
Cysticercal Meningitis: A Rare Manifestation of Neurocysticercosis

J Ma¹, J Handwerker¹, E Welford¹, A Cowell¹
¹UC San Diego Health System, San Diego, CA

Purpose
To present the imaging findings and the clinical features of a case of cysticercal meningitis.

Materials and Methods
A previously healthy 47-year-old man presented to an ophthalmology clinic with worsening blurred vision, diplopia, headaches, and fatigue. On examination, he was found to have bilateral papilledema. Following emergent imaging evaluation, CSF sampling revealed an elevated opening pressure, pleocytosis, and CSF cytology showing atypical lymphoid cells and plasmacytoid cells. The hydrocephalus was treated by placement of an external ventricular drain. During the course of an extensive evaluation for infectious, inflammatory, and neoplastic etiologies given the unusual cytology, cysticercal meningitis was suggested by imaging and subsequently confirmed by ELISA antibody testing. The patient was then treated with anti-inflammatory and anti-parasitic agents.

Results
CT of the head demonstrated hydrocephalus with transependymal edema and multiple punctate calcifications suggesting a history of longstanding neurocysticercosis. MRI of the brain demonstrated leptomeningeal enhancement along the brainstem and subtly along the calcifications. The calcifications could also be identified on high-resolution susceptibility weighted-imaging (SWI). High-resolution balanced steady-state gradient echo sequence demonstrated cystic and curvilinear signal abnormalities in the basal cisterns and subtly in the cerebral aqueduct associated with underlying extraparenchymal neurocysticercosis.

Conclusions
Cysticercal meningitis is rare manifestation of neurocysticercosis, caused by an inflammatory response to extraparenchymal disease. It may mimic other infectious, inflammatory or neoplastic disorders. The mainstay of treatment involves anti-inflammatory medication. High-resolution MRI techniques were especially helpful in this case to suggest the underlying etiology.
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Cytotoxicity Mimicked Hypoxic Brain Injury

D Cebrian1, B Chen1, A Kamali1, O Arevalo1, R Riascos1, R Patel1

1The University of Texas Health Science Center at Houston, Houston, TX

Purpose
It is important to recognize the MRI abnormalities caused by the cytotoxic effects of some epilepsy medicines such as Vigabatrin. Vigabatrin is a gamma-aminobutyric acid transaminase inhibitor that is used for treatment of seizures in childhood epilepsy. The imaging findings may be confused with metabolic or hypoxic ischemic brain injuries.

Materials and Methods
A 5-month-old female patient, asymptomatic, with history of tuberous sclerosis, subependymal giant cell astrocytoma and infantile spasms was being treated with Everolimus and vigabatrin. The kid underwent general anesthesia for a routine MRI for epilepsy workup. MRI abnormalities including areas of diffusion restrictions in the thalami and brainstem were observed, raising concern for metabolic or hypoxic ischemic brain injury. A cytotoxic effect of anesthetic medicines was considered. On examination, the patient was arousable, with spontaneous and symmetric movements. Vigabatrin (VGB) was recognized as the cause of the imaging findings. VGB was discontinued and the patient was discharged with levetiracetam for the infantile spasms. The imaging findings were reversed on the follow up MRI scan.

Results
Diffusion restriction was found bilaterally in the thalami and brainstem, raising concern for hypoxic ischemic brain injury.

Conclusions
Imaging abnormalities, in the form of diffusion restriction in the basal ganglia, thalami and brainstem have been seen in around 22%-32% of patients <12 months old taking Vigabatrin (VGB) for seizure. The pathophysiologic mechanism is not completely understood. These abnormalities may present without any symptom, but there is also the risk of VGB toxicity, which presents with hyperkinetic movement disorders such as choreoathetosis, tremor, myoclonus, as well as a life-threatening acute encephalopathy. Therefore, surveillance MRI is encouraged for patients on VGB to prompt early diagnosis and treatment of possible drug-related effects and to avoid dismal outcomes.
Decreased Procedural, Fluoroscopic and Wait Times as a Result of Moving Spine Interventional Pain Procedures from a Hospital Based Interventional Suite to an Outpatient Clinic Setting

G de Gennaro¹, M PECKHAM², L Shah³, Y ANZAI⁴, T Hutchins⁵
¹University of Utah, Salt Lake City, UT, ²UNIVERSITY OF UTAH HEALTH SCIENCE CENTER, SALT LAKE CITY, UT, ³University of Utah Health Care, Salt Lake City, UT, ⁴UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT, ⁵University of Utah, Neuroradiology, salt lake city, UT

Purpose
Spine interventional procedures are commonly performed for the treatment and diagnosis of pain. At our institution, such procedures are performed in both hospital based interventional suites as well as in an outpatient clinic environment. Given the volume of such procedures, approaches to reducing the associated procedural and wait times to increase throughput would be beneficial for patients and providers.
Materials and Methods
To investigate any differences between hospital based and outpatient settings, we reviewed all spine interventional pain procedures performed by the Neuroradiology service over a two year period. We then analyzed the associated procedural times, fluoroscopic times and wait times for each case, as well as any complications. Comparison was then made between the hospital based and outpatient based settings.

Results
Our analysis demonstrated decreased average procedural time (16 minutes vs. 28 minutes), fluoroscopic time (112 seconds vs. 187 seconds) and wait time (18 minutes vs. 31 minutes) in the outpatient setting versus the hospital based setting. In addition, there was no increased rate of complications when performing procedures in an outpatient setting.

Conclusions
Given the findings of decreased procedural, fluoroscopic and wait times without increased rate of complications in the outpatient compared to hospital based setting, consideration should be given to performing spine interventional pain procedures in an outpatient clinic setting when possible.

Delay and Dispersion Corrected Cerebral Blood Flow and Comparison against Pial Collaterals in Acute Ischemia

Y Jeong1, G Christoforidis1, N SAADAT2, S Roth3, T Carroll1
1University of Chicago, Chicago, IL, 2UNIVERSITY OF CHICAGO MEDICAL CENTER, CHICAGO, IL, 3University of Illinois College of Medicine, Chicago, IL

Purpose
The purpose of this work is to show that quantification of cerebral perfusion must account for delay and dispersion effects in the contrast bolus, and in doing so could be used as a quantifiable scoring system of collateralization.

Materials and Methods
In acute ischemic stroke, tissue infarction can be reduced when tissue is adequately perfused by robust collateral arterial blood supply. Dynamic Susceptibility Contrast (DSC) MRI is used to ascertain the volume of tissue at risk of infarction. However, the calculation of cerebral blood flow (CBF) using DSC can be inaccurate due to bolus delay and dispersion. In this study, we compare tissue perfusion against pial collaterals after correcting delay and dispersion effects. The study was approved by the University of Chicago Institutional Animal Care and Use Committee. Six mongrel canines underwent permanent endovascular occlusion of the M1 segment of the middle cerebral artery. Anesthesia was maintained using isoflurane, propofol and rocuronium. Arteriography images were taken 15 minutes after occlusion for scoring of pial collaterals based on a previously established 11-point system. For CBF, MR DSC and T1 Look-Locker EPI scans, based on the Bookend method, were acquired 2 hours post-occlusion. The delayed arrival and dispersion were accounted for by convolving the arterial input function by a dispersion model as a function of delayed arrival time. The tissue contrast curve was then shifted and deconvolved via singular value decomposition to obtain corrected CBF. Cortical ROIs were drawn on the infarct side and the average CBF before and after correction were compared against pial collateral scores by linear regression. The difference in CBF was also compared, as well as the volume of voxels with an increase in CBF.

Results
The correlation increased between CBF and pial collateral score when correction for delay and dispersion effects were applied (Figure 1a). The change in CBF between corrected and non-corrected was also found to correlate with collaterals (Figure 1b). Higher increases were observed at higher pial collateral scores. Similarly, the volume of voxels with increased CBF correlated well with pial collateral scores (Figure 1c).

Conclusions
In this study, we found that correcting for delay and dispersion led to better a correlation between CBF and pial collateral score. The relationship observed between pial collateral score and the change in CBF could allow for an indirect measure of the degree of pial collaterals upon future research.
Purpose
Differentiation between the structures of the oral cavity such as the floor of the mouth and the tongue can be difficult in a conventional cross-sectional study because the spaces between oral cavity structures are collapsed when the mouth is at rest. This distinction is particularly important in patients with oral cavity cancer, as lesions that cross boundaries may be treated differently. The aim of this study is to describe a novel computed tomography (CT) and magnetic resonance imaging (MRI) compatible mouth device that will separate relevant structures and allow for improved evaluation of the oral cavity.

Materials and Methods
This mouth device is composed of a hypoallergenic material that is compatible with CT and MRI. The device expands the gingivo-buccal and gingivo-labial crevices across the mandible and maxilla. A stabilizing flap passes below the tongue to better differentiate the floor of the mouth from the tongue.

Results
This device is MR and CT compatible. The MR and CT characteristics of this device are different from the adjacent oral cavity structures. The mouth device is easy to place and possible to maintain during an imaging study. When utilized, a uniform expansion of the oral vestibule is achieved for better anatomical visualization.
Conclusions
This device provides a uniform and consistent separation between the different parts of the oral cavity during a cross sectional examination, which allows for improved image interpretation.

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Diagnostic challenges in primary sacral tumors and the critical importance of preoperative CT-guided percutaneous needle biopsy

M Safaee¹, C Chin², A MASHHOOD³, L Eisenmenger⁴, N Liang¹, P Weinstein¹
¹University of California, San Francisco, San Francisco, CA, ²N/A, N/A, ³University of California, San Francisco, SAN FRANCISCO, CA, ⁴University of Wisconsin - Madison, Middleton, WI

Purpose
Sacral lesions often present diagnostic challenges given their vague clinical symptoms, complex radiographic features, and diversity of potential pathologies. Although metastases are most common, primary sacral tumors pose unique challenges since the appropriate oncologic treatment strategy varies dramatically based on the tumor pathology. Although advances in MRI have improved our non-invasive diagnostic capabilities, CT-guided percutaneous needle biopsy (PNB) provides a highly accurate diagnosis to guide the most appropriate treatment.

Materials and Methods
Patients with newly diagnosed primary sacral lesions treated over a 12-year period were identified by a review of the medical records. Metastatic lesions were excluded. Preoperative MRI scans were reviewed to generate a comprehensive differential diagnosis. Preoperative CT-guided percutaneous biopsy results were reviewed and compared with both preoperative imaging and gross pathology for patients who underwent surgical intervention.

Results
A total of 40 patients were identified with a mean age of 49 years and 28 females. Among 38 patients who underwent PNB, 31 yielded diagnostic tissue on the first attempt (82%). Five of the remaining 7 obtained diagnostic tissue on the second attempt and two required open biopsy. Among 19 patients whose histologic diagnosis required open surgical resection, there was a 100% correlation between PNB and gross pathologic results.

Conclusions
CT-guided percutaneous biopsy of sacral lesions is a safe and effective strategy for obtaining diagnostic tissue. This is of critical importance given the diverse pathology of primary sacral lesions and the dramatic differences in treatment strategy, as well as the significant morbidity associated with surgery for complex lesions requiring en bloc resection.

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Differentiating malignant from benign salivary gland lesions: A multiparametric non-contrast MRI approach

K Takumi1, H Nagano2, Y Kumagae3, Y Fukukura3, M Nakajo4, T Yoshiura5

1Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Select a State or Province, 2Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Select a State or Province, 3Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Kagoshima, 4Kagoshima University Medical and Dental Hospital, Kagoshima, Select a State or Province, 5Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan

Purpose
To determine whether the evaluation of non-contrast MR imaging such as diffusion-weighted imaging (DWI), arterial spin labeling (ASL) and APT-weighted imaging can help differentiate malignant from benign salivary gland tumors.

Materials and Methods
The study population consisted of 41 patients with 31 benign salivary gland lesions (11 pleomorphic adenomas, 11 Warthin tumors, and 9 other benign lesions) and 10 malignant lesions. All patients were evaluated using DWI (b=0,800 s/mm2), three-dimensional pseudo-continuous ASL and APT weighted imaging on 3T MRI before treatment. The apparent diffusion coefficient (ADC) value, TBF, and APT-related signal intensity (APTSI) within the lesion were compared between the malignant and benign lesions using the Mann-Whitney U test. For each parameter, optimal cutoff values were chosen by using a threshold criterion that was maximizing the Youden index for predicting malignant tumors. The performances of ADC value, TBF, APTSI, and their combination in diagnosing malignant lesions were evaluated. The diagnostic performances were compared by the McNemar test.

Results
APTSI in malignant lesions (2.30 ± 0.84%) was significantly higher than that in benign lesions (1.49 ± 0.83%) (p=0.017). There were no significant differences in ADC value and TBF between benign and malignant lesions (p=0.092, 0.520, respectively). The accuracy for diagnosing malignant lesion of ADC value, TBF and APTSI were 51.2%, 46.3%, and 68.3%, respectively, while the accuracy of their combination was 87.8% which resulted in a significantly increased accuracy compared with each parameter (p=0.001, <0.001, 0.008, respectively).

Conclusions
The combination of ADC value, TBF and APTSI can help differentiate malignant from benign salivary gland lesions.

Figure. Scatterplot of ADC versus TBF versus APT values of salivary gland tumors.

Table. Performances of MR parameters in diagnosing malignant salivary gland tumors

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Threshold Criterion</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>Accuracy (%)</th>
</tr>
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<tbody>
<tr>
<td>ADC (×10−3 mm²/s)</td>
<td>≤1.416</td>
<td>100.0</td>
<td>35.5</td>
<td>33.3</td>
<td>100.0</td>
<td>51.2</td>
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<tr>
<td>TBF (mL/100 g/min)</td>
<td>≤59.86</td>
<td>100.0</td>
<td>29.0</td>
<td>31.3</td>
<td>100.0</td>
<td>46.3</td>
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<tr>
<td>APT (%)</td>
<td>≥1.779</td>
<td>80.0</td>
<td>64.5</td>
<td>42.1</td>
<td>90.9</td>
<td>68.3</td>
</tr>
<tr>
<td>ADC+TBF</td>
<td>100.0</td>
<td>64.5</td>
<td>47.6</td>
<td>100.0</td>
<td>73.2</td>
<td></td>
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<tr>
<td>ADC+APT</td>
<td>80.0</td>
<td>80.6</td>
<td>57.1</td>
<td>92.6</td>
<td>80.5</td>
<td></td>
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<tr>
<td>ADC+TBF+APT</td>
<td>80.0</td>
<td>90.3</td>
<td>72.7</td>
<td>93.3</td>
<td>87.8</td>
<td></td>
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TBF, tumor blood flow; APT, amide proton transfer signal; PPV, positive predictive value; NPV, negative predictive value.
Differentiating Tumefactive Demyelinating Lesions from Lymphoma Using the ADC Values

A Aein1, A Gandhi2, N Doyle3, F Kebbel4, R Riascos5, R Patel1, A Kamali6
1The University of Texas Health Science Center, McGovern Medical School, Houston, TX, 2Rice University, Houston, TX, 3University of Texas Health Science Center Houston, Houston, TX, 4McGovern Medical School, University of Texas Health Sciences Center at Houston, Houston, TX, 5Univ. Of Texas - Houston, Houston, TX, 6UT Health, Houston, TX

Purpose
Unlike lymphoma which almost always demonstrates diffusion restriction, most cases of tumefactive demyelinating lesions (TDL) exhibit increased ADC values within the lesion. However, less than 50% of TDLs may exhibit decreased ADC values and diffusion restriction. TDLs typically respond well to corticosteroid treatment, which is the first line of therapy for acute lesions. Unfortunately, lymphoma also may respond to corticosteroid therapy and this might complicate differentiation from TDL. Given the difference in therapy for lymphoma (chemotherapy) versus TDL (corticosteroid therapy), a non-invasive imaging biomarker would be helpful for differentiation of these two entities from one another. We set out to explore if measuring ADC values would be helpful to differentiate lymphoma from TDL.

Materials and Methods
The subjects included 50 patients with lymphoma and 43 patients with TDL. All pathology proven patients were retrospectively selected from the Memorial Hermann hospital system in 2016-2018. MRI images dated immediately after symptom presentation and before treatment started were selected. Cases of TDL that did not exhibit restricted diffusion on MRI were excluded. Two regions of interest (ROI) were selected, one in the darkest area of diffusion restriction within the lesion and the other in the normal appearing white matter (NAWM) in contralateral cerebral hemisphere. A ratio of the ADC values within the lesion over the NAWM was calculated. This ratio was used to prove the homogeneity of the data acquired from different scanners.

Results
All ADC values are presented in units of \( \times 10^{-6} \text{ mm}^2/\text{s} \). Among the TDL group (n=45), the mean ADC value for the lesion was 480.16 ± 126.58, and the mean ADC value for the normal white matter was 740.0 ± 82.9. Among the lymphoma group (n=30), the mean ADC value for the lesion was 532.78 ± 73.38, and the mean ADC value for normal white matter was 751.0 ± 68.5. No significant difference was seen between the ADC values of the normal white matter in both groups (p<0.05). However, there was a significant difference in ADC values between the lymphoma and TDL groups (p<0.001).

Conclusions
Using ADC values of the lesions may be used as a non-invasive technique to easily differentiate lymphoma from tumefactive demyelinating lesions.
Discordant Cerebellar Width as a Prenatal MRI Indicator of Rhombencephalosynapsis

J Reagan1, M Antonucci2
1Medical University of South Carolina, Charleston, SC, 2MEDICAL UNIVERSITY OF SOUTH CAROLINA, CHARLESTON, SC

Purpose
Rhombencephalosynapsis (RES) is a rare posterior fossa malformation in which the cerebellar hemispheres appear fused, with bilateral continuity of transverse folia, in association with absent or hypoplastic vermis (1,2). Accompanying abnormalities, such as aqueduct stenosis, ventriculomegaly, and callosal dysgenesis, when present, can exacerbate an inherently poor prognosis (3). In addition, the process can occur with genetic disorders such as Gómez-López-Hernández (GLH) syndrome (1). Given the prognostic significance, the need for genetic assessment, and the importance of identifying coexisting anatomical abnormalities, accurate prenatal diagnosis is essential. However, the early gestational age at the time of MRI (and related technical issues limiting optimal visualization of anatomical features) can hinder diagnostic capabilities. The purpose of this presentation is to demonstrate a simplified diagnostic approach in which readily measurable discordant cerebellar growth patterns can suggest the presence of RES.

Materials and Methods
A screening OB ultrasound in a gravid female of advanced maternal age raised concern for cerebellar hypoplasia. At 28-weeks gestation, prenatal MRI revealed abnormal cerebellar width. Postnatal MRI confirmed RES, and genetic assessment ultimately provided a diagnosis of GLH.

Results
Prenatal MRI (Figure A) revealed an isolated biometric abnormality. Specifically, the cerebellar width was below the 10th percentile, while other supra-/infra-tentorial measurements were normal (4). While detailed anatomic assessment of the posterior fossa was limited, this solitary & strikingly disproportionate measurement raised concern for RES. The diagnosis was subsequently confirmed on serial post-natal MR imaging (Figure B – coronal T2 MRI at 15 months).

Conclusions
Transverse cerebellar growth restriction has been previously reported in post-natal MRIs in patients with RES (1). This case demonstrates that a similar, easily quantifiable finding can be made on pre-natal MR imaging, even when more detailed assessment of posterior fossa anatomy is limited. We hypothesize that cerebellar fusion effectively produces an anatomical constraint on cerebellar growth (analogous to calvarial narrowing seen with sagittal synostosis). Discordant cerebellar biometric measurements can represent a prenatal MR finding of RES, suggest the need for additional post-natal imaging and genetic screening.
E DERVISOGLU1, C ALTINTAS TASLICAY2, I CAM1, I ANIK1, Y ANIK1
1KOCaeli University Faculty of Medicine, Kocaeli, Turkey, 2Kocaeli University Faculty of Medicine, Kocaeli, Turkey

Purpose
The aim of this study is to determine and define differential MRI findings of pituitary adenomas and craniopharyngiomas.

Materials and Methods
Retrospective analysis was performed on MR imaging findings of 45 pituitary adenomas and 41 craniopharyngiomas with solid and cystic mixed appearance. MRI findings including shape-ovoid, snowman, lobulation, chiasma compression, cavernous sinus invasion, 3rd ventricle compression, calcification, predominant type—cystic vs solid, contrast enhancement patterns—homogenous, reticular and extension were assessed.

Results
Superiorly lobulated shape, third ventricle compression and reticular enhancement of solid parts were common in craniopharyngiomas while snowman shape, predominantly solid content, homogenous enhancement of solid parts were compatible with adenomas significantly at p <0.05 for all.

Conclusions
Tumor shape and contrast enhancement patterns of solid parts seem discriminative MRI features for pituitary adenoma and craniopharyngiomas.

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Disequilibrium of Trans-nidal Flow is Associated with Hemorrhagic Risk of Cerebral Arteriovenous Malformation

C LIN1, K Chen2, J Hong3, Y Hu4, W Guo5
1Taipei Veterans General Hospital, Taipei, Taiwan, 2National Yang Ming university, Taipei, Taiwan, 3National Yang Ming university, Taipei, Taiwan, 4Taipei Veterans General Hospital, Taipei, Alberta, 5Taipei Veterans General Hospital, Taipei, Taiwan

Purpose
Appropriate patient selection is the key to successful treatment outcome. The annual hemorrhagic risk of cerebral arteriovenous malformation (CAVM) is 2 to 4% but varies according to different risk factors such as location, size, and drainage venous patterns etc. Recent quantitative digital subtraction angiography studies showed stagnant venous flow was associated with hemorrhage in CAVM. The purpose of this pilot study is to explore the feasibility of using MR phase contrast (PC) technique to evaluate the hemorrhagic risks of CAVM.

Materials and Methods
Prospectively, we recruited 26 CAVM without prior treatments for flow analysis in the same 3T MR scanner (DiscoveryTM, GE healthcare, Waukesha, WI). Time of flight MR angiography and MR venography were obtained and sent to reconstruct a 3D surface rendering of the vasculature for determining the perpendicular scan plane to feeders and drainage veins respectively. The velocity encoding was automatically adjusted by noninvasive optimal vessel analysis (NOVA) software (VasSol,Inc, River Forest, IL). All flow measurements were performed using an oblique 2D fast phase contrast sequence with retrospective gating. Volumetric flow rates (mL/min) in feeders and drainage veins were processed on the NOVA workstation. The flow, diameter, and wall shear stress (WSS) of feeders and drainage veins as well as trans-nidal flow ratio, defined as flow of feeders divided by total drainage venous flow, were measured and compared between non-hemorrhagic and hemorrhagic groups by student t-test.

Results
the flow rate of the feeder is significant higher in non-hemorrhagic group (475±198) than that in hemorrhagic group (256±114); the diameter of the feeder is significant larger in non-hemorrhagic group (4.15±0.69) than that in hemorrhagic group (3.59±0.37). The flow rate of the drainage vein is significant higher in non-hemorrhagic group (294±194) than that in hemorrhagic group (109±125); the diameter of the feeder is significant larger in non-hemorrhagic group (6.74±2.26) than that in hemorrhagic group (4.13±1.87). Neither arterial nor venous WSS is associated with hemorrhage in CAVM. The trans-nidal flow ratio was significant higher in hemorrhagic group (3.84±2.73) than in non-hemorrhagic group (2.28±1.55).

Conclusions
Inadequate venous drainage was associated with hemorrhagic risks in CAVM. Quantitative MR PC can serve as a complimentary risk assessment of CAVM in additional to digital subtraction angiography.

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Does Registration Method Influence the Evaluation of Distortion of Parotid Gland Tumors on Fast Spin Echo PROPELLER Diffusion-Weighted Imaging?

C Juan1, Y Liu2, S Lin2, J Lin2, C Chang1, C Liu1
1China Medical University Hsinchu Hospital, Zhubei City, Hsinchu County, Taiwan, 2Feng Chia University, Taichung, Taiwan
Purpose
The aim of this study was to evaluate whether the evaluation of imaging distortion using Dice coefficient influenced by the different imaging registration methods between T2WI and DWI including fast spin echo PROPELLER DWI (FSE-PROP-DWI) and single shot echoplanar DWI (SS-EP-DWI).

Materials and Methods
This study enrolled 30 patients (22 males, 8 females, age: 30 to 91 years, median: 65 years) with parotid gland tumors including 13 patients with pleomorphic adenoma (PMA) and 17 patients with Warthin tumor (WT). All patients received FSE-PROP-DWI and SS-EP-DWI. Imaging registration was performed using DWI as reference image and T2WI the image for registration. ROIs of the cervical cord and the parotid gland tumor were contoured, respectively. The whole image and the spinal cord were selected as the input of the transformation matrix, respectively. A rigid-body transformation matrix was applied (Fig. 1A). Dice coefficient was used to evaluate the imaging distortion. Statistical analysis was performed by using SPSS 12.0 (SPSS, Chicago, III) software. Paired t test was used for comparison based on the central limited theorem. A P value less than 0.05 was considered as statistically significant.

Results
The Dice coefficient for the cervical cord and parotid gland tumor on both FSE-PROP-DWI and SS-EP-DWI using whole image and spinal cord as the input of transformation matrix, respectively, was shown on Fig. 1B. FSE-PROP-DWI showed significantly higher Dice coefficient than SS-EP-DWI for both parotid gland tumor and cervical cord in both registration methods. In addition, there is no difference between using whole image and spinal cord as the input of transformation matrix, except regarding the cervical cord, in which the Dice coefficient using the spinal cord as input was significantly higher than that using the whole image.

Conclusions
FSE-PROP-DWI provides less distorted images than SS-EP-DWI for both parotid gland tumor and cervical cord either using whole image and spinal cord as the input of transformation matrix. There is no difference between using whole image and spinal cord as the input of transformation matrix when the parotid gland tumor is concerned.

Fig. 1. (A) Flow diagram of imaging registration using whole image (middle left) and spinal cord (middle right) as reference and overlapped images of T2WI and DWI (lower).

Fig. 1. (B) Dice coefficient of parotid gland tumors and cervical cord imaging registration using whole image (gray) and spinal cord (white) as reference. Note: *** represents a P value < 0.001.
Does Ruptured Aneurysm Treatment by Clip Versus Coil Affect Vasospasm Incidence and Outcomes?

V Patel\(^1\), V Ding\(^1\), E Sussman\(^1\), D Boothroyd\(^1\), M Wintermark\(^2\), M Marks\(^3\), H Do\(^4\), R Dodd\(^1\), N Telischak\(^5\), G Steinberg\(^1\), S Chang\(^1\), J Heit\(^7\)

\(^1\)Stanford University, Stanford, CA, \(^2\)Stanford, San Carlos, CA, \(^3\)Stanford Univ. Med. Ctr., Stanford, CA, \(^4\)Stanford Univ Medical Center, Stanford, CA, \(^5\)Stanford University School of Medicine, Stanford, CA

Purpose
Cerebral arterial vasospasm and delayed cerebral ischemia (DCI) following aneurysmal subarachnoid hemorrhage (aSAH) results in significant morbidity and mortality. The incidence of vasospasm and clinical outcomes after endovascular coiling versus surgical clipping of the ruptured aneurysm remains uncertain. We hypothesized that aSAH patients treated with coiling would have reduced DCI and more favorable clinical outcomes when compared to clipping.

Materials and Methods
We performed a retrospective cohort study of patients after either coiling or clipping of their ruptured aneurysms who underwent at least one endovascular vasospasm treatment from 2006 to 2016 at our neurovascular referral center. Primary outcome was good clinical outcome at 6-12 months (modified Rankin Scale [mRS] of ≤2). Secondary outcomes were mortality at discharge and at 6 months. Propensity analysis was performed to account for baseline differences between the two groups.

Results
174 patients developed DCI after aSAH and met inclusion criteria. Ruptured aneurysms were coiled in 82 patients (47%) and clipped in 92 patients (53%). Median age was similar between clip (51 years [IQR 45-57]) and coil patients (50 years [IQR 45-58]; p=0.71). Clip patients presented with a more favorable Hunt and Hess score (3 [IQR 2-3] vs 3 [IQR 3-4] in coil patients; p=0.001). There were no other differences between these groups. Vasospasm treatment frequency and modality were similar, though coil patients tended to have less cerebral angioplasty (38% vs 45%), which however was not significant (p=0.33). The frequency of a good outcome was similar between clip (71%) and coil patients (73%; p=0.64). There were no differences in in-hospital mortality (9% clip vs 11% coil; p=0.86) or discharge location (31% clip patients discharged to home vs 25% coil; p=0.42). Propensity analysis adjusting for baseline differences also did not show a significant difference (p>0.999 for both mRS ≤2 and mortality and p=0.78 for discharge location). Adjusted point estimates showed clip patients at lower odds of achieving a good outcome, however this was not significant.

Conclusions
The frequency of good clinical outcomes after aSAH and endovascular vasospasm treatment was similar between patients treated with clipping versus coiling despite a less favorable clinical presentation in coil patients. Additional studies examining these differences are needed to further determine the impact of aneurysm treatment modality on aSAH-induced vasospasm/DCI and clinical outcomes.

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Does the Registration Method Influence ADC Calculation and Diagnosis Performance in Parotid Gland Tumor of Fast Spin Echo PROPELLER Diffusion-Weighted Imaging?

C Juan\(^1\), Y Liu\(^2\), S Lin\(^2\), J Lin\(^2\), C Chang\(^1\), S Chou\(^1\)

\(^1\)China Medical University HsinChu Hospital, Zhubei City, Hsinchu County, \(^2\)Feng Chia University, Taichung, Taiwan

Purpose
The aim of this study was to evaluate whether the calculated ADC and diagnostic performance of parotid gland tumors differ between different imaging registration methods between T2WI and DWI including fast spin echo PROPELLER DWI (FSE-PROP-DWI) and single shot echoplanar DWI (SS-EP-DWI).

Materials and Methods
This study enrolled 30 patients (22 males, 8 females, age: 30 to 91 years, median: 65 years) with parotid gland tumors including 13 patients with pleomorphic adenoma (PMA) and 17 patients with Warthin tumor (WT). All patients received FSE-PROP-DWI and SS-EP-DWI. Imaging registration was performed using T2WI and DWI as reference image, respectively, plus using whole image and spinal cord as the input of the transformation matrix, respectively. A rigid-body transformation matrix was applied. Apparent diffusion coefficient was calculated for the original DWI and the transformed DWIs for all parotid gland tumors. Statistical analysis was performed by using SPSS 12.0 (SPSS, Chicago, III) software. Wilcoxon signed-rank test was used for paired comparison between FSE-PROP-DWI and SS-EP-DWI, while Mann-Whitney U test were used for independent group comparison between PMAs and WTs. Receiver operating characteristics (ROC) curve analysis was used to assess the diagnostic performance of mean ADC, using FSE-PROP-DWI and SS-EP-DWI, respectively, in distinguishing PMAs from WTs. A P value less than 0.05 was considered as statistically significant.

Results
ADC of PMA and WT in both FSE-PROP-DWI and SS-EP-DWI under different registration methods was shown on Fig. 1B. ROC curves and AUC in distinguishing PMA from WT under different registration methods was shown on Fig. 1C. The calculated ADC of parotid gland tumors does not differ between different registration methods. The diagnostic performance, better in SS-EP-DWI than FSE-PROP-DWI, does not alter either.
Conclusions
The choice of registration methods neither alters the calculation of the ADC of parotid gland tumors, nor changes the diagnostic performance of SS-EP-DWI and FSE-PROP-DWI.

Fig. 1. (A) Flow diagram of imaging registration using whole image (left) and spinal cord (right) as reference.

Fig. 1. (B) ADC of parotid gland tumors including PMA and WTs in original and registered DWIs. Note: PMA denotes pleomorphic adenoma, WT denotes Warthin tumor, *** represents a P value < 0.001.

Fig. 1. (C) ROC curves in distinguishing PMA from WT using original and registered DWIs.

Early Experience of Sacroplasty for Insufficiency Fractures using a Lateral Decubitus Position for Needle Placement

D JOHNSON1, S Islam2
1ST GEORGE’S HOSPITAL LONDON UK, THAMES DITTON, UK, 2Imperial College London, London, United Kingdom

Purpose
Sacral insufficiency fractures are an increasingly recognised cause of lumbosacral back pain in the elderly particularly in women prone to osteoporosis. The mainstay of treatment has been analgesia, treatment for osteoporosis and physical therapy. Some patients undergo invasive orthopaedic procedures. An alternative treatment for those that fail conservative management is Sacroplasty. This involves image guided percutaneous injection of polymethylmethacrylate cement into the fracture site in order to locally stabilise fractures with consequent pain relief across presumed previously moving segments. The standard technique requires the patient supine/prone for needle placement. We have recently trialled an approach with the patient in a lateral decubitus position with the needle placed under CT and cement injected under fluoroscopy.

Materials and Methods
6 patients with sacral insufficiency fractures underwent unilateral sacroplasty at a level commensurate with clinical examination. Patients with fracture lines into the neural foramina were excluded. Fracture lines into the sacroiliac joints were included. Patients were positioned in the lateral decubitus position, and the image intensifier angled to view the sacral foramina with the patients hips and pelvis manipulated to obtain the best view of the sacrum. An 11g vertebroplasty needle was then placed into the fracture cleft.
most likely contributing to symptoms using CT guidance. 3-6 ml Polymethylmethacrylate cement was injected under fluoroscopy using a mobile c-arm with intermittent CT check imaging for 15 minutes until the fracture cleft was adequately filled.

Results
5/6 patients achieved pain relief on verbal response on the day of the procedure or by discharge the next day. 1 patient failed to improve. At 1 month 5/6 patients had returned to most baseline activities of daily living when compared to status pre fracture. Post procedural imaging confirmed cement leakage into the soft tissues and sacro iliac joints but there was no leak into the sacral foramina identified. No significant post procedural complications.

Conclusions
Most patients were pleased with the outcome with a "Lazarus" type effect in two patients who handed in their walking sticks before leaving hospital. The lateral decubitus position allows superior visualisation of the sacrum and this may have contributed to the outcomes by increasing operator confidence in avoiding the major complication of leakage of cement into sacral foramina.

Early Fludarabine Leukoencephalopathy Mimicking Acute Infarct

A Vasireddi1, A Weyer2
1University of Pittsburgh Medical Center, Pittsburgh, PA, 2University of Pittsburgh, Pittsburgh, PA

Purpose
Neurotoxicity is an established adverse event associated with fludarabine therapy. Severe leukoencephalopathy occurs in 2.4% of patients receiving fludarabine, and vision loss is a common presenting symptom. On MRI, fludarabine leukoencephalopathy generally demonstrates symmetric diffusion restriction and T2 prolongation in the bilateral periventricular white matter. We present a case of early fludarabine leukoencephalopathy manifest by a single focus of diffusion restriction, mimicking an acute infarct.

Materials and Methods
54-year-old female with metastatic follicular lymphoma complicated by multiple recurrences underwent lymphodepletion with fludarabine/cyclophosphamide 3 weeks prior to receiving CAR T-cell infusion. Patient then presented for marked vision loss and mild
cognitive deficits 6 weeks following chemotherapy. Brain MRI was suspicious for acute infarct. She was treated with high dose steroids for presumed CAR T-cell associated neurotoxicity given proximity in time to the infusion. However, CSF analysis from a lumbar puncture showed no expansion of CAR T-cells in CSF, and the patient experienced worsening vision. She was subsequently diagnosed with fludarabine leukoencephalopathy.

Results
Initial brain MRI demonstrated focal diffusion restriction and T2 prolongation within right occipital periventricular white matter which was attributed to acute ischemia, although the location was noted to be atypical for an acute infarct. 3 subsequent exams performed over the next 2 months demonstrated expansion of diffusion restriction and T2 prolongation into the bilateral occipital periventricular white matter, raising the possibility of toxic/metabolic leukoencephalopathy or PRES. The most recent exam showed further progression of T2 prolongation, symmetrically involving bilateral occipital and parietal white matter and the corpus callosum with resolution of diffusion restriction. Abnormal contrast enhancement was never present.

Conclusions
Focal periventricular diffusion restriction may represent an early manifestation of neurotoxicity in a patient who has received fludarabine.
Early MRI Signs of WNV Meningitis: Findings Associated with Improved Prognosis that the Radiologist Needs to Know

M Lake¹, E Kipervasser¹, J Sasson¹, S Teoh¹
Mount Auburn Hospital, Cambridge, MA

Purpose
To demonstrate early radiologic signs of West Nile Virus (WNV) meningitis, which has affected more than 46,000 people in the US since 2002, through analysis of a serologically-proven case involving leptomeningeal enhancement and cranial neuropathies.

Materials and Methods
A 56-year-old previously healthy woman presented to the emergency department with a 5 day history of fever, progressive myalgias, headache and diplopia. The patient denied paresthesias, focal weakness and skin changes. Physical exam demonstrated a partial left 6th cranial nerve (CN) palsy with preserved facial strength and without meningismus. CBC revealed thrombocytopenia to 64 with normal WBC. Lumbar puncture demonstrated elevated WBC to 118, Protein of 113 and a normal Glucose of 50. CSF and serum testing were both positive for West Nile IgM antibody; all studies for Lyme, Influenza antigen, HSV and VZV were negative. After supportive management, the standard of care, the patient experienced continued fatigue but had resolution of her diplopia with no neurologic sequelae by hospital day 5, at the time of her discharge.

Results
Head CT is normal. MRI of the brain demonstrates subtle leptomeningeal enhancement along the cerebellar folia. There is abnormal enhancement of the cisternal segment of the left 6th CN and asymmetric enhancement of the distal intracanalicular portion of the left 7th CN. There is also increased enhancement of the geniculate ganglion and tympanic segment of the left 7th CN compared to the right.

Conclusions
WNV meningitis is often characterized by a normal brain CT and a spectrum of non-specific MRI findings, commonly including T2/FLAIR hyperintensities in the brain and brainstem. Recognition of leptomeningeal and cranial nerve enhancement, which are early findings associated with an improved prognosis, is critical to a timely diagnosis. The mortality of WNV meningitis in severe cases is between 3 and 15 percent, further emphasizing the importance of the Radiologist's understanding of early MRI manifestations. Cranial nerve enhancement also opens a broad differential diagnosis that includes infection, such as WNV, demyelination, neoplasm, ischemia and entrapment. Synthesis of this imaging finding with the clinical presentation is critical to tailoring a relevant discussion of diagnostic considerations.
Ectopic Cervical Thymoma: a Great Mimic of Thyroid Neoplasm

S Cai, B Branstetter
1University of Pittsburgh, Pittsburgh, PA, 2UPMC, Wexford, PA

Purpose
Thymus develops from the ventral portions of the third and fourth pharyngeal pouches and descends into the anterior mediastinum by the sixth week of gestation. Cervical thymic ectopia results from failure of this migration. Thymic neoplasm arising from an ectopic cervical thymus is exceedingly rare and often misdiagnosed as a thyroid neoplasm given its close proximity to the thyroid gland, often superjacent or embedded within the lower pole of the thyroid gland. Radiographic appearance of an ectopic cervical thymoma will closely resemble that of the more common anterior mediastinal thymoma. Although in contrast to mediastinal thymoma, ectopic cervical thymoma has a female predominance and no convincing association with Myasthenia gravis.

Materials and Methods
A 56 year old man with no significant past medical history presented with a slow-growing left neck mass for the past three years. He denied hoarseness, odynophagia, dysphagia, or constitutional symptoms. Physical examination revealed a non-tender, mobile 5 x 5 cm left neck mass at the level of the thyroid gland. Nasal endoscopy showed normal oropharynx, hypopharynx, and larynx.

Results
CT revealed a lobulated, homogenously hyper-enhancing mass centered just lateral to the left thyroid lobe which extends inferiorly and splays the brachiocephalic trunk and the left common carotid artery. The mass imposed mass effect on the left thyroid lobe and the trachea to a lesser degree without invasion of the intervening tissue planes. A core biopsy showed T-cell lymphocytes mixed with spindle cells forming rosettes, findings suggestive of a thymoma. The patient underwent excision of the mass, and surgical pathology revealed microscopically invasive thymoma.

Conclusions
Although a rare entity, ectopic cervical thymus should be considered in the differential when presented with a cervical mass intimately associated with the thyroid gland. The radiographic appearance is similar to the more common anterior mediastinal thymoma.
Purpose
To evaluate the impact of mindfulness meditation on functional connectivity.

Materials and Methods
22 subjects were randomly assigned to practice meditation for 12 minutes/day for 8 weeks using a mindfulness meditation program (10% Happier application, practitioners group, n=12) or to a control group (n=10). Post-program resting state functional MRI (rsMRI) data were acquired on a 3T Siemens Prisma FIT (8-minute multiband acquisition with 2 sec TR, 2.97x2.97x2.00 mm voxels, 70° FA, ETL=37). Preprocessing, seed-to-voxel connectivity, and ROI-to-ROI connectome analyses were performed using CONN. rsMRI preprocessing consisted of slice timing, field-map, and motion correction, coregistration and normalization, smoothing at 8mm FWHM, and denoising using the CompCor method. Practitioners' actual practice times as logged by the application were used as a variable. ROIs consisted of 1-mm MNI-space functionally- and anatomically-defined atlas regions.

Results
Practitioners exhibited significantly stronger positive correlations between the default-mode network (DMN) and the left frontal eye fields [t(20) = +3.58, p(FDR) = 0.009] (component of dorsal attention network) and inferior frontal [t(20) = +3.43, p(FDR) = 0.036] and posterior superior-temporal [t(20) = +3.66, p(FDR) = 0.026] language areas, but weaker negative correlations between DMN regions and the left [t(20) = -3.88, p(FDR) = 0.003] and right [t(20) = -5.30, p(FDR) < 0.001] anterior insula (components of salience network) and lateral [t(20) = -4.01, p(FDR) = 0.019] and occipital [t(20) = -2.63, p(FDR) = 0.044] visual areas (Figure 1). Correlations between the salience and DMN regions became more negative and correlations between frontoparietal and DMN regions became more positive with increasing practice time. Practitioners also exhibited practice-dependent weaker thalamoamygdala (t = -2.84) and frontoparietal-accumbens connectivity (abs max t = -5.35) and stronger hippocampal-occipital (abs max t = +2.84) and frontoparietal-caudate connectivity (t = +2.72) versus controls.

Conclusions
These findings are consistent with prior research of intra- and inter-network changes in the DMN both during meditation and at rest. In our study, practitioners had less negative correlation between the DMN and the SN, indicating that these networks were more likely to become active together. Our data indicate that app-delivered mindfulness practice is associated with functional connectivity changes in a dose-dependent manner.

![Figure 1. rs-fMRI connectome demonstrating connectivity within the default-mode network (DMN) and between the DMN and other brain regions as correlated with mindfulness meditation practice time as logged by the 10% Happier application. Red color indicates that connectivity increased and blue color indicates that connectivity decreased as a function of increased meditation practice time. All differences shown significant at P < 0.05, FDR-corrected.](TCT_2317_DMN_figure_1.jpg)

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Endovascular Management of a DAVF in a Patient with Loeys-Dietz Syndrome

R Dahl, G Benndorf
Purpose
Loeys-Dietz syndrome (LDS) is an autosomal dominant connective tissue disease caused by mutations in genes encoding transforming growth factor β (TGF-β) receptors (1). Clinical characteristics include skeletal and craniofacial deformities, aortic dissections, diffuse arterial aneurysms, and vascular tortuosities. The association of LDS with intracranial dural arteriovenous fistulas (DAVF) is exceedingly rare (2).

Materials and Methods
A 52-year-old woman with a family history of LDS presented with a pulsatile tinnitus and headache. Digital subtraction angiography (DSA) showed a Borden Type III DAVF involving the left transverse sinus. The patient was referred for endovascular treatment (EVT).

Results
Procedure: The patient underwent staged transarterial embolization (TAE) using liquid embolic agents. Vessel tortuosity of supplying arteries, the distal occipital and middle meningeal arteries, were noted being moderate and allowed straightforward catheter advancement to the fistula site. No particular technical difficulties of catheter or wire navigations were encountered, and no complications due to increased vessel fragility occurred. After one retreatment session the patient developed a small left-sided occipital lobe intracerebral hemorrhage resulting in a transient right-sided homonymous hemianopsia. The patient recovered completely from her clinical symptoms after EVTs. Follow-up DSA showed persistent occlusion of the dural AV shunt but also demonstrated minimal residual pial shunting, inaccessible to EVT, for which the patient underwent surgical removal.

Conclusions
To our knowledge, this is only the second reported case of LDS associated with an intracranial DAVF. More data are required to assure a causal relationship between LDS and DAVFs. In some patients with LDS the degree of tortuosity of craniofacial arteries can be less severe than previously described and within the range of commonly seen vessel morphology in DAVFs. In such milder forms, EVT can be safely, effectively and repeatedly performed using standard techniques.

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Endovascular Treatment of Intracranial Carotid Blowout with PK Papyrus Coronary Covered Stent

T Sivapatham1, S Satti1, A Iaia1, B Albani2
1Christiana Care Health System, Newark, DE, 2N/A, N/A

Purpose
Carotid blowout syndrome (CBS) is a life-threatening complication of head and neck cancer. Surgical ligation is associated with 60% neurologic morbidity and 40% mortality, and endovascular vessel sacrifice with 15-20% risk of ischemic complications. Reconstrucive endovascular treatment with covered stents may reduce the neurologic morbidity associated with carotid occlusion. The most frequently used devices for CBS are PTFE-covered nitinol stent grafts (Gore Viabahn, Bard Fluency). While these devices are amenable to delivery in the extracranial carotid artery, their rigidity may preclude delivery to the more tortuous intracranial segments of the ICA. Treatment of intracranial ICA lesions (CCF, postsurgical iatrogenic injury) with coronary stent grafts has previously been reported (Jostent Graftmaster, which has a double stent sandwich design). The Biotronik PK Papyrus covered stent was recently introduced in the US market for treatment of coronary artery perforations. Its covered single stent design offers greater flexibility and a smaller crossing profile. Here we present the first reported case of endovascular treatment of CBS involving the ICA using the Papyrus covered stent.

Materials and Methods
65 yo man presents with right facial droop, hemoptysis, epistaxis, and otorrhagia. Imaging demonstrated a ruptured petrous RICA pseudoaneurysm (PSA) with active extravasation within a nasopharyngeal (NP) mass. After inability to deliver a Viabahn stent graft, a Papyrus covered stent was deployed. Eptifibatide was given prior to stenting, and dual antiplatelet therapy afterwards. Mild LUE weakness noted post-stenting, but patient otherwise stable.

Results
Head CT: Large right NP soft tissue mass extending cephalad into the skull base, eroding the clivus and bony canal of the petrous ICA. MRI: Confirms skull base invasion and intratumoral hematoma containing a region of contrast extravasation. CTA: Brisk contrast extravasation into the mass from the distal horizontal petrous segment of the ICA (1A). Angiography: Active contrast extravasation from the petrous RICA into a 1.8cm PSA (1B). No residual filling of the PSA (1C) after treatment with a single 4.5mm x 20mm Papyrus covered stent (1D).

Conclusions
Covered stents are a reasonable option for treatment of life-threatening CBS, and can mitigate the significant morbidity associated with vessel sacrifice. This is the first reported case of successful endovascular treatment of CBS of the petrous ICA using the PK Papyrus coronary covered stent.
Enlarged perivascular space in centrum semi-ovale is associated with brain amyloid deposition in cognitively impaired patients

M Park 1
1Gangnam Severance Hospital, SEOUL, Korea, Republic of

Purpose
Enlarged perivascular space in centrum semi-ovale (CSO-ePVS) has been associated with cerebral amyloid angiopathy and Alzheimer's disease. To evaluate the underlying mechanisms of this association, we investigated the relationship between amyloid-β deposition assessed by 18F-Florbetaben PET (FBB-PET) and CSO-ePVS in the patient with cognitive impairment.

Materials and Methods
We retrospectively evaluated patients (Alzheimer's disease = 66, mild cognitive impairment = 78) with brain MRI and FBB-PET imaging. MRI-visible perivascular spaces were rated using a validated 4-point visual rating scale, and then scale more than >3 was considered as the presence of ePVS. Univariable and multivariable regression analyses were performed.

Results
Those with FBB-PET positivity were older, more likely to have the lower cognitive function, deep microbleeds, CSO-ePVS, and carry at least one apolipoprotein E4 allele than those with negativity. In a multivariable analysis adjusted for age, APOE4 status, white matter hyperintensity, CSO-ePVS positivity was independently associated with FBB-PET positivity (odds ratio 2.32, 95% confidence interval (CI) 1.06 – 5.07; p = 0.035).

Conclusions
CSO-ePVS is an independent predictor for identifying FBB-PET scan positivity, in patients with cognitive impairment and the findings provide further evidence that CSO-EPVS are markers of brain amyloid burden that may be useful in diagnosing Alzheimer's disease.
Eosinophilic Granulomatosis with Polyangiitis: Findings on MRI of the Brain

M Rizk¹, A Khan¹
¹Beaumont Health, Royal Oak, MI

Purpose
1. To present a case of Eosinophilic Granulomatosis with Polyangiitis (previously known as Churg Strauss disease) with pachymaningeal involvement. 2. To discuss imaging features of Eosinophilic Granulomatosis with Polyangiitis on brain MRI. 3. To discuss response to treatment and review imaging following treatment.

Materials and Methods
The patient is a 36 year old healthy male who presented to our emergency department with progressive worsening left sided diplopia. Upon physical exam the right pupil was dilated and nonreactive. A CT of the head was obtained which was positive for mucosal
thickening of the paranasal sinuses. MRI was positive for subtle peripheral white matter changes of uncertain significance. The patient was diagnosed with left 6th nerve palsy. The patient returned two months later with hoarseness, dysphagia, and recent visual disturbances. Physical exam findings were positive for right 6th nerve palsy. MRI of the brain was positive for significantly progressed dural thickening and enhancement. Differential at time of imaging included infectious, inflammatory, and paraneoplastic process. A lumbar puncture and CT of the chest abdomen and pelvis were performed both of which were negative. Additional laboratory tests were performed, all of which were negative. A dural biopsy was performed five days after presentation. The biopsy was positive for granulomatous inflammation associated with inflammatory infiltrate and focal vasculitis. Findings are consistent with eosinophilic granulomatosis with polyangiitis. Symptoms improved following treatment with IV steroids. CNS involvement is seen in 8-14% of patients with eosinophilic granulomatosis with polyangiitis. Cerebral infarction is the most common type of CNS involvement. Intracerebral hemorrhage and pachymeningitis are less common(1).

Results
MRI of the brain demonstrates extensive dural thickening along the tentorium and posterior to the clivus with extension of the dural thickening and enhancement in the internal auditory canals. There is also thickening along the dural reflections of the Meckel's cave on the left. There is a more solid-appearing area of enhancement that is also dural based and is located along the inferior right side of the posterior fossa.

Conclusions
Few cases of CNS involvement in Eosinophilic Granulomatosis with Polyangiitis have been reported. Our case demonstrated nonspecific symptoms and MRI findings. The MRI findings were consistent with prior reports. The diagnosis was confirmed with biopsy.

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Episode-Based Cost Measures and Implications for the Neuroradiology Profession

K Wang1, R Lee2, L Golding3, O Schoeck2, J Hirsch4, G Nicola5, M Chen6
1Baylor College of Medicine, Houston, TX, 2Albert Einstein Medical Center, Philadelphia, PA, 3Triad Radiology Associates, Winston-Salem, NC, 4Massachusetts General Hospital, Boston, MA, 5Hackensack Radiology Group, Hackensack, NJ, 6MD Anderson Cancer Center, Houston, TX
Purpose
Under the 2020 Quality Payment Program (QPP) Proposed Rule, the Cost performance category weighting under the Merit-based Incentive Payment System (MIPS) will continue to increase for 2020 (20%). Episode-based cost measure (EBM) is one of three measures in the Cost performance category. Our aim is to inform neuroradiologists of EBMs and their pivotal role in ensuring efficient spending of healthcare resources.

Materials and Methods
The components of Cost performance category (Medicare spending per beneficiary clinician measure, total per capita cost measure, EBMs) and how the category is scored will be reviewed. The primary aim will be to discuss current and newly proposed EBMs, their development process, types of EBMs, how it is attributed and scored, and implications for neuroradiologists.

Results
To empower clinicians with a stronger understanding of healthcare resource spending, the Center for Medicare & Medicaid Services (CMS) contracted with Acumen LLC to develop EBMs that relies on significantly on input from patients, expert stakeholders, and clinicians. EBMs define an episode of care as the cost to Medicare for clinical coherent set of services provided to treat a given medical condition. Such services include diagnostic imaging, and EBMs relevant to neuroradiology include the recently proposed lumbar spine fusion for degenerative disease (procedural EBM) and the existing intracranial hemorrhage or cerebral infarction (acute inpatient EBM). Claims information is used to attribute the costs of the episode to a particular clinician or clinician group. While diagnostic neuroradiologists would not commonly be attributed patients, optimization of cost measures will require team-based approaches.

Conclusions
The development of EBMs by CMS relies heavily on input from clinicians and expert stakeholders. It is crucial neuroradiologists are aware and participate in the development process. We as radiologists who do not participate in the dialogue will be marginalized, and performance programs, utilization management, and best practice paradigms will be defined for us rather than led by us. Neuroradiologists therefore play an integral role in optimizing EBMs by operationalizing utilization control of advanced imaging and image-guided procedures, as well as incorporating best practice for follow-up.

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Evaluation of Clipped Cerebral Aneurysms with Gradient Modulated Pointwise Encoding Time Reduction with Radial Acquisition Sequence (GM-PETRA), A Preliminary Study

M Morikawa1, H Ishimaru1, Y Ikebe1, R Ideguchi2, M Uetani1, H Imai3, N Kobayashi4
1Nagasaki University Hospital, Nagasaki, Japan, 2Atomic Bomb Disease Institute, Nagasaki University, Nagasaki, Japan, 3Siemens Healthcare K.K, Tokyo, Japan, 4University of Minnesota Medical School, Minneapolis, MN

Purpose
The recent development of ultrashort TE imaging, such as pointwise encoding time reduction with radial acquisition sequence (PETRA), is known to decrease the susceptibility artifacts caused by the metallic devices of cerebral aneurysm treatment. Gradient modulated PETRA (GM-PETRA) is a new sequence, which samples k-space more quickly by increasing the gradient amplitude after excitation while keeping a relatively low excitation bandwidth, and can minimizes magnetic susceptibility artifact. In this study, we evaluate the visualization of cerebral arteries adjacent to surgical aneurysm clip with the GM-PETRA compared to conventional PETRA and 3D TOF MRA.

Materials and Methods
We used 3 Tesla scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) with a 20-channel head coil. GM-PETRA was optimized for 3 Tesla, and the technique was validated with healthy volunteers (n=3) under a local IRB approved protocol. GM-PETRA/conventional PETRA were acquired with the following protocol: FOV 256/200 mm3; isotropic 0.8/0.8 mm3; FA 6/6°; TR 4.0/3.3 msec; TE 0.07/0.07 msec; BW 490/400 Hz/pixel; total scan time 3:24/3:29. 3D TOF MRA acquired with the following protocol: FOV 200 mm3, 0.5x0.6x0.5 mm3; FA 18°; TR/TE 21/2.8 msec total scan time 5:40. We examined 5 cases with clipped cerebral aneurysm, evaluated visualization of the parent artery and signal changes around the clips.

Results
The scans and reconstructions of all 5 cases with clipped aneurysm were performed successfully. In all 5 cases, GM-PETRA (Fig. B, arrow) and conventional PETRA (Fig. A, arrow) were superior to 3D TOF MRA (Fig. C, arrow) in visualizing the parent artery patency adjacent to a surgical clip. GM-PETRA demonstrated the parent artery more clearly than conventional PETRA. Conventional PETRA showed marginal hyperintensity surrounding surgical clip (Fig A, arrowheads), which overlapped the parent artery inflow signal, and which may mislead residual aneurysm neck.

Conclusions
GM-PETRA provides decrease the susceptibility artifact caused by the metallic clips of treated cerebral aneurysms, and can demonstrate the parent artery patency adjacent to the surgical clip more clearly than conventional PETRA and 3D TOF MRA.
Evaluation of depth of invasion in tongue squamous cell carcinoma using contrast enhanced 3D-fast field echo MR imaging compared with intraoral ultrasonography.

Y Kawashima
1, O SAKAI
2
1Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Kagoshima, 2BOSTON UNIVERSITY SCHOOL OF MEDICINE, BOSTON, MA

Purpose
UICC 8th edition introduced the concept of depth of invasion (DOI) in the T classification of oral cancer. DOI in the oral cancer including tongue squamous cell carcinoma (SCC) is closely associated with cervical nodal metastasis. Therefore, it is important to assess DOI of tongue SCC preoperatively to plan the surgery. In the previous literature, MR imaging and intraoral ultrasonography (US) of the tongue have been reported to be useful to measure DOI. However, depending on the patient's condition, intraoral US may not be performed. In such a case, still DOI could be measured by MR imaging. Few studies have reported the usefulness of post-contrast 3D-fast field echo (FFE) MR imaging as a method for DOI measurement of tongue SCC. The purpose of this study was to evaluate the usefulness of post-contrast 3D-FFE MR imaging in DOI measurement in patients with tongue SCC compared to DOI measurement by intraoral US.

Materials and Methods
All patients with histopathologically diagnosed tongue SCC with documented DOI in the pathology report who underwent preoperative post-contrast 3D-FFE MR imaging and intraoral US at our institution were enrolled. DOI from the virtual normal basal mucosa to the deepest part of the tumor was measured on each modality. All MR imaging was performed at a 3 T MRI with a 20ch head neck coil. DOI measured by post-contrast 3D-FFE MR imaging and DOI on pathological specimen, DOI measured by intraoral US and DOI on pathological specimen were analyzed by Spearman's rank correlation analysis.

Results
Six men and three women with an average age of 71.6 years were enrolled in the study. The correlation coefficient between DOIs of post-contrast 3D-FFE and pathological specimen was 0.59, and the correlation coefficient between DOIs of intraoral US and histopathological diagnosis was 0.61. The DOIs of post-contrast 3D-FFE and intraoral US were equally positively correlated with the DOI on the pathological specimen.

Conclusions
The measurement of DOI on post-contrast 3D-FFE and intraoral US were almost equivalent. Our results indicate post-contrast 3D-FFE MR imaging provides DOI of tongue SCC with accuracy similar to intraoral US.

Evaluation of Metastatic Spinal Bone Marrow Response to Radiation Therapy Using T-1 weighted Dynamic Contrast-Enhanced Perfusion

N Brennan
1, K Peck
2, J Lyo
3, J Tisnado
3, E Lis
3, R Moreno
3, Y Yamada
1, A Holodny
3, S Karimi
3
1Memorial Sloan Kettering Cancer Center, New York, NY, SUNY Upstate Medical University, Syracuse, NY, 2Department of Medical Physics, Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, NY, 3Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, NY, 4Department of Radiation Oncology, Memorial Sloan Kettering Cancer Center, New York, NY

Purpose
The skeletal system is the third most frequent location of cancer metastasis, with the spine being the most commonly infiltrated...
skeletal structure (1). Our preliminary data indicate that T1 weighted (T1W) dynamic contrast enhancement (DCE) perfusion MRI technique can detect significant changes in the tumor vasculature one hour after radiation therapy (RT) and can be used as a noninvasive (2) imaging tool to monitor treatment effect. The purpose of this study is to investigate the effect of spinal stereotactic radiosurgery on DCE-MRI perfusion parameters, plasma volume (Vp) and vascular permeability (ktrans), in malignant spinal lesions. We hypothesized that there is a significant decrease in Vp and ktrans in post-RT treated patients, indicating that the treatment is effective.

Materials and Methods
14 patients (mean age = 60) with spinal metastases who underwent single high dose stereotactic radiosurgery (median dose 2400cGy) were included. The average time interval between the first DCE scan and first RT administration was 70.8 days, with an average time interval of 106.8 days between RT and the second DCE scan. Conventional MRI (1.5T scanner) and DCE perfusion were acquired. Voxel-by-voxel estimates of perfusion parameters, including ktrans and Vp, were determined using a Toft pharmacokinetic model analysis (3). MR signal intensity time curves were obtained from the enhanced lesion to measure the area under the curve (AUC). A Wilcoxon Signed-Rank Test was performed to quantify and compare the significances of the parameters between pre- and post-treatment.

Results
There was a significant decrease in Vp, ktrans, and T1W MR signal intensity between the pre-radiosurgery and post-radiosurgery scans of treated patients. Vp mean values are μ=3.13 pre-treatment and μ=0.58 post-treatment (p<0.01). Vp max values are μ=7.59 pre-treatment and μ=1.93 post-treatment (p<0.01). Ktrans mean values are μ=0.26 pre-treatment and μ=0.14 post-treatment (p<0.05). Ktrans max values are μ=0.66 pre-treatment and μ=0.29 post-treatment (p<0.01). AUC mean values are μ=169 pre-treatment and μ=97 post-treatment (p<0.05).

Conclusions
DCE MRI perfusion parameters, Vp and ktrans, are significantly decreased in post-radiosurgery patients. This suggests that DCE MRI can be effective in evaluating both tumor progression and response to radiation therapy in patients with spinal metastases.

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External Validation of Deep Learning–Based Artifact Correction on a Synthetic FLAIR image using Convolutional Deep Neural Network: Can it be a Promising Solution for Image Quality Improvement?

H Baek¹, K Ryu¹, S Gho², K Ryu², D Kim³
¹GNU Changwon Hospital, Changwon, Republic of Korea, 2GE Healthcare Korea, Seoul, Republic of Korea, 3Yonsei University, Seoul, Republic of Korea

Purpose
Although a synthetic fluid-attenuated inversion recovery (FLAIR) artifact is easily recognizable owing to its characteristic feature and location, it is a major factor limiting the effectiveness of synthetic MRI as a clinical routine neuroimaging protocol. This study was aimed to investigate the capability of the already trained deep learning (DL) model with convolutional neural network (CNN) to generalize a different scanning environment from the perspective of ameliorating the image quality of synthetic FLAIR images.

Materials and Methods
Three-hundred and nineteen patients who underwent synthetic brain MRI and conventional FLAIR imaging were retrospectively included. The acquired data were used as test sets for the DL model using CNN, which was already trained to correct the synthetic FLAIR images. Normalized root mean square (NRMSE), structural similarity (SSIM), and peak signal-to-noise ratio (PSNR) were calculated for native synthetic and DL-FLAIR images against conventional FLAIR images. Moreover, one attending neuroradiologist assessed the image quality and the degree of artifact for native synthetic and DL-FLAIR images.

Results
In quantitative assessment, the DL-FLAIR images showed significantly higher PSNR and SSIM, and lower NRMSE in all the individual tissue segments and the total intracranial tissues than those of native synthetic FLAIR images (all P<.0001). In qualitative assessment, the average mean scores of DL-FLAIR image quality were significantly higher than the image quality of the native synthetic FLAIR (4.68±0.48 vs. 3.46±0.67; P<.0001). The average mean scores of the degree of preserving the preexisting periventricular WM hyperintensities or lesion conspicuity was not statistically significant for DL-FLAIR and native synthetic FLAIR (4.35±0.56 vs. 4.41±0.45; P=.375). The mean scores of the typical synthetic FLAIR artifacts were identified for DL-FLAIR and native synthetic FLAIR images as follows: 1.32±0.48 vs. 3.36±0.69 (P<.0001). In addition, other artifacts that substantially degraded the image quality, such as flow artifacts, were also improved in DL-FLAIR rather than the native synthetic FLAIR: 1.21±0.42 vs. 2.77±0.76 (P<.0001).

Conclusions
In conclusion, the artifact correction with the already-trained DL algorithm led to the successful improvement of the image quality of the synthetic FLAIR images by using an external dataset on a different MR scanner with different scan environments. This was verified both qualitatively and quantitatively and compared with the conventional FLAIR images. Therefore, we believe that the DL-based approach can be a promising solution for improving the image quality of synthetic FLAIR image to broaden clinical use of synthetic MRI in the daily clinical practice.
Extraocular Silicone Oil Migration: A Rare Postsurgical Complication

D Martin¹, E Tranvinh²
¹Stanford Health Care, Stanford, CA, ²Stanford University, Stanford, CA

Purpose
Silicone oil is used as a tamponade agent following vitrectomy in the treatment of complex retinal detachment. Migration of silicone oil into the globe wall, optic nerve, and intracranially into the optic chiasm and ventricles has been described. Even less common is
Factors to Rank Neuroradiology Fellowship Candidates; What Program Directors Think?

E Beheshtian1, R Jalilianhasanpour2, S Sahraian3, D YOUSEM4

1Russell H Morgan Department of Radiology and Radiological Sciences, Johns Hopkins University School, Baltimore, MD, 2Johns Hopkins Medical Institution, Baltimore, MD, 3Johns Hopkins Medical Institution, Baltimore, MD, 4JOHNS HOPKINS MEDICAL INSTITUTION, OWINGS MILLS, MD

Purpose

The neuroradiology fellowship match has been in existence for about 20 years. However, the elements by which Neuroradiology fellowship program directors evaluate candidates have not been clearly elucidated. We sought to identify the factors that program directors use to rank neuroradiology fellowship applicants.

Materials and Methods

An anonymous Qualtrics online 5-question survey about educational credentials, personal traits, extracurricular activities, and demographic characteristics was sent to 72 neuroradiology program directors in April 2019. Each question required ranking of 10 factors based on different characteristics of fellowship candidates. Items included gender, nationality, USMLE scores, internal applicants, work and research experience, recommendation letters, residency program, medical school attended, and visa status. Program directors had the ability to list any new characteristics that were not included in the survey.

Results

68 (94.4%) of 72 Neuroradiology programs responded to the survey. The most important criteria by which candidates were assessed were: 1) Residency program attended for educational credential, 2) Personality as assessed by faculty at interviews for candidate personal traits, 3) Research performed for candidate's extracurricular activities, and 4) Likelihood of coming to and/or previous experience in fellowship geographic area. Neuroradiology program directors independently stressed residency program attended, personality assessed during the interview by faculty, internal candidate status, letters of recommendation and research activities as their top 5 criteria in ranking the candidates.

Conclusions

Multiple factors are weighed by neuroradiology fellowship program directors in selecting fellows, but recent experiences in residency, research, and faculty interactions are prioritized. The results of this study indicate the most important factors that Neuroradiology fellowship applicants should emphasize are the quality of his or her residency program, the interview, internal candidacy, becoming known to the fellowship program through potential away visitation, research, and LORs. Internal fellow candidates also have a striking advantage for staying. The implications of our study are that trainees would benefit by 1) considering observerships at programs they are interested in, 2) conducting mock interviews to improve their interviewing skills, 3) ensuring their letters of reference are unique and laudatory, 4) putting more emphasis on the USMLE tests prior to residency, engaging in research during residency, 5) strongly weighing internal programs for fellowship and 6) accepting leadership and teaching opportunities to optimize their fellowship candidacy.
Fast MRI for Pediatric Headaches. What a Relief!

L Hayes¹, T Chandra¹, P Watal², Z Barr³, S Palasis⁴
¹Nemours Children's Healthcare System, Orlando, FL, ²Nemours Children's Healthcare System, Orlando, FL, ³Nemours Children's Hospital, Orlando, FL, ⁴ANN AND ROBERT H. LURIE CHILDREN'S HOSPITAL OF CHICAGO, Chicago, IL

Purpose
To evaluate the utility and success of using a comprehensive but fast MRI brain protocol for children with recurrent headaches.

Materials and Methods
Over the course of 16 months, a total of 210 complete MRI scans of the brain in children with a chief complaint of recurrent headaches (without red flags) were performed. The first 66 scans were evaluated by 3 pediatric neuroradiologists for image quality, diagnosis, and need for additional images. Average patient age was 10 years with a range of 2-17 years. Approximately half were performed on a 1.5T scanner and half on 3T scanner (Philips). The protocol includes sagittal 3D T1 TFE (turbo field echo) with multi-planar reconstructions, axial DWI, axial T2 weighed sequence, axial 3D SWI, and coronal T2 weighted FLAIR imaging. This entire fast protocol was tailored to be completed in less than 8 minutes. Scan time reduction was achieved by utilizing parallel imaging techniques including Sense and more recently Compressed Sensing, as well as increasing voxel size by up 20% in comparison to our routine brain protocol, and acquiring 3D sequences at a higher slice thickness and then interpolating the thickness to half of the acquired value. Since recently implementing Compressed Sensing, scan times have been reduced. We have used the time savings to increase resolution and decrease slice thickness to more closely resemble to our routine high resolution brain protocol but at a greater than 50% time savings.

Results
Average scan time is 7 minutes. All patients successfully completed the exam. Twenty-three patients had additional images, usually to fill time during radiologist checks. Radiologists specifically requested additional images in 8 patients, usually FLAIR. One patient was
brought back for follow-up due to artifact early in the experience. Only 2 patients had significant abnormalities (a Chiari I deformity and an aneurysm.) There were 6 incidental pineal cysts, 1 small posterior fossa arachnoid cyst, and 1 small developmental venous abnormality, of no significance. All other studies were normal.

Conclusions
Overall, the images are comparable to their routine counterparts. The fast scans negate the need for sedation and reduce motion artifacts compared to routine, long studies. Our experience suggests that fast techniques including Sense and Compressed Sensing are successful tools for screening the brains of children with headaches. The time savings improves patient comfort and throughput to provide a more efficient and less stressful MRI department.
both enlarging and multiple new cerebral lesions. Neurosurgical biopsy demonstrated tissue necrosis and microhemorrhage, with a dense inflammatory infiltrate involving the meninges and cerebral paryenchyma in a perivascular distribution. Preliminary diagnosis was of an intracerebral abscess, although no definite organism was identified. Suspicion of an angioinvasive amebic infection was raised. Biopsy samples were sent to the CDC, which subsequently confirmed the presence of Balamuthia mandrillaris. Despite maximal therapy, the patient succumbed to the infection within two weeks after diagnosis.

Results
T2 FLAIR sequence demonstrated numerous areas of parenchymal edema throughout the entire brain and loss of CSF suppression in the subarachnoid spaces (A). Post-contrast imaging demonstrated a combination of both ring-like enhancement and faint diffuse intra-lesional enhancement. In addition, there was extensive leptomeningeal enhancement, most pronounced in the basilar cisterns (B). A number of the lesions demonstrated components of hemorrhage both internally and along the margins, which resulted in blooming artifact on GRE imaging (C) and associated intrinsic T1 hyperintense signal on noncontrast T1 weighted imaging (D).

Conclusions
Amebic meningoencephalitis due to Balamuthia mandrillaris is a rare but highly fatal disease that is challenging to diagnose, both with neuroimaging studies and on laboratory exam. We hope review of the imaging findings of this deadly entity can help aid the neuroradiologist in including amebic infection due to Balamuthia mandrillaris in the differential diagnosis when encountering challenging and complex cerebral infections.

(Filename: TCT_1209_Balamuthiafinal.jpg)
Feasibility of dual-layer spectral CT analyses for differentiation between spinal schwannoma and meningioma: A preliminary study

M Nakajo, K Kamimura, T Yoneyama, Y Fukukura, K Takumi, H Nagano, M Bohara, M Hayashi, T Yoshiura

Kagoshima University Medical and Dental School, Kagoshima, Select a State or Province, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Select a State or Province

Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Kagoshima, Kagoshima

Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Select a State or Province

KAGOSHIMA UNIVERSITY Graduate School of Medical and Dental Sciences, Kagoshima, Choose Any State/Province, Kagoshima University Hospital, Kagoshima, Kagoshima, Select a State or Province

Purpose
Schwannomas or meningiomas are among the most common spinal tumors. Although a vast majority of spinal schwannomas and meningioma are benign, an accurate diagnosis prior to surgery is important, because surgical procedures for schwannoma and meningioma are different. In recent years, it has been reported that dual-energy CT (DECT) analysis parameters, including effective atomic numbers (Z eff) and electron density (ED) may be useful for diagnoses for tumors in various organs. However, their utilities have never been reported for diagnosing spinal tumors. Our purpose was to assess the utility of dual-layer spectral CT analyses for differentiation between spinal schwannoma and meningioma.

Materials and Methods
Fifteen consecutive patients (mean age 61.2 years) with pathologically proven 16 spinal tumors (11 schwannomas and 5 meningiomas) were retrospectively included. For all patients, preoperative dual-layer spectral CT (DLCT) examination was performed using a Philips IQon spectral CT scanner between February 2018 and September 2019. ROIs were drawn to fill the solid parts within each tumor avoiding cystic and calcified areas with reference to conventional MR images, and placed onto exactly the same locations in Z eff, ED, and conventional CT images (120KeV). The CT, Z eff and ED values were compared between schwannomas and meningiomas using the Mann-Whitney U test. Receiver operating characteristic (ROC) curve analysis was carried out to assess the ability of CT and ED values for differentiating meningioma from schwannoma. Sensitivity and specificity were calculated with a threshold criterion that would maximize the average of sensitivity and specificity.

Results
The mean CT and ED values of schwannomas were significantly lower than those of meningiomas (p=0.008, 0.003, respectively), whereas no significant difference was shown in Z eff (p=0.112). The area under the ROC curve for diagnosing schwannomas, were 0.927 and 0.973 for the mean CT and ED values, respectively. With a cut-off value of 29.2HU and 103.2 %EDW, the sensitivity and specificity to predict schwannoma were 72.7% and 100% for the mean CT value and 81.8% and 100% for the mean ED, respectively.

Conclusions
The mean CT and ED values derived for DLCT may be useful for differentiation of schwannoma and meningioma.
Fetal MRI Diagnosis of Walker Warburg Syndrome at 3 Tesla

**Y LI**, M Norton, E Sherr, D Gano, O Glenn

*University of California, San Francisco, San Francisco, CA*

**Purpose**

Walker Warburg Syndrome (WWS) is a congenital muscular dystrophy (CMD) characterized by severe hypotonia, ocular abnormalities, and typically death by 3 years. Affected patients have absent alpha or beta-dystroglycan, which impairs linkage between radial glia and the pial limiting membrane with resultant gaps in the membrane and cobblestone lissencephaly. Several autosomal recessive genetic variants and multiple CNS malformations are reported with this disorder. We report 2 cases of prenatal diagnosis of WWS by fetal MRI.

**Materials and Methods**

Patient A underwent fetal MRI at 23+4 wks gestation due to ventriculomegaly. She had 2 prior infants with a different father, both died at <1 year, and one was blind. Fetal MRI was consistent with WWS. Postnatal imaging was also characteristic of WWS. The family declined genetic testing. In one prior pregnancy, a CMD panel including testing for WWS (POMT1, POMT2, POMTGN1, FKRP, FKNT, LARGE) was negative. The child is currently 2 years old, with severe hypotonia, global developmental delay and epilepsy. Patient B had fetal MRI at 23+4 wks gestation due to ventriculomegaly and a hypoplastic vermis. She terminated one prior pregnancy with similar findings without genetic testing. Fetal MRI identified features of WWS. Exome sequencing identified homozygosity for a p.R659Q variant in POMT2, inherited from the parents, consistent with autosomal recessive WWS. The same variants were subsequently identified in the prior affected pregnancy.

**Results**

The constellation of cobblestone lissencephaly and dysplastic brainstem on fetal MRI led to the diagnosis of WWS phenotype in both fetuses. In addition to lack of sulci, there was irregularity to the developing cortical surface most prominent in the occipital and frontal lobes, consistent with cobblestone lissencephaly. A "Z-shaped" dysplastic configuration of the brainstem was characterized by an elongated midbrain, a "kink" in the pontomesencephalic junction and a second "kink" at the cervicomedullary junction. Both fetuses also had hydrocephalus, hypogenesis of the corpus callosum, dysplastic and small vermis, and a thickened tectum.

**Conclusions**

WWS is a rare CMD with characteristic imaging. In particular, when performed at 3T, fetal MRI can detect cobblestone lissencephaly, which is specific to the dystroglycanopathies. Prenatal diagnosis by MRI and subsequent genetic testing informs counseling and care for current and future pregnancies.
Fractional Flow on Time-Of-Flight MRA as a Measure of Stroke Risk in Children with Intracranial Arterial Stenosis

P Muthusami¹, A Ibrahim², A Amirabadi², M Shroff³, N Dlamini⁴, P Dirks²
¹The Hospital for Sick Children, Toronto, OH, ²The Hospital for Sick Children, Toronto, Ontario, ³Hospital for Sick Children, Toronto, ON, ⁴The Hospital for Sick Children, TORONTO, Ontario

Purpose
Conventional angiography (CA) is the gold standard for measuring intracranial arterial stenosis. We evaluated signal intensity (SI) ratios from time-of-flight (TOF) MRA, as a measure of intracranial stenosis and infarct risk in pediatric stroke.

Materials and Methods
A retrospective study was undertaken in children with intracranial arterial stenosis, who had TOF-MRA and CA performed within 6-months. Arterial diameters were measured for %stenosis. Region-of-interest analysis on TOF-MRA measured SI in pre- and post-stenotic segments, with post/pre ratios calculated. Pearson correlation was used to compare % stenosis on MRA with CA, and SI-ratios with % stenosis; point biserial correlation for infarcts with % stenosis and SI-ratios. Sensitivity, specificity, positive and negative predictive values(PPV and NPV) were calculated for determining severe(≥70%) stenosis from MRA and SI-ratios against gold standard CA. P<0.05 was considered statistically significant.

Results
Seventy stenotic segments were present in 48 children(median age 11.0 years, range 5 months–17.0 years, M:F=26:22): 22/48(46%) bilateral, 14(29%) right and 12(25%) left. The most common site was the proximal middle cerebral artery(22/70, 31%). Moyamoya disease accounted for 32/48(66.7%). SI-ratios and CA-stenosis showed moderate negative correlation(R=−0.54, p< 0.00001). ROC statistics showed an AUC of 0.86 for using post/pre-carotid SI-ratios to determine severe(≥70%) stenosis, yielding a threshold of 1.00. Sensitivity, specificity, PPV and NPV for severe stenosis were: MRA: 42.8%, 58.8%, 30.0%, 71.4%; SI- ratio>1.00: 97.1%, 77.8%, 71.7% and 97.4% respectively. Mean SI-ratios decreased significantly with increasing grade of stenosis(none/mild-moderate/severe/complete, p<0.00001). SI-ratios were significantly less when associated with infarcts(0.81±0.52 vs. 1.31±0.55, p=0.0001, t-test), and were inversely correlated with risk of recurrent infarcts(rpb=-0.18, p=0.04).

Conclusions
SI-ratios measured from TOF-MRA can serve as a non-invasive measure of intracranial arterial stenosis and allow identification of high-risk lesions in pediatric stroke.
Fragile X-Associated Tremor/Ataxia Syndrome: An Under-Recognized and Relatively Common Disease with Characteristic Imaging Features

T Richards¹, K Salzman²
¹University of Utah School of Medicine, Salt Lake City, UT, ²UNIVERSITY OF UTAH, SALT LAKE CITY, UT

Purpose
We will demonstrate the classic symptomatology and imaging features of Fragile X-associated tremor/ataxia syndrome (FXTAS) so that radiologists can suggest the possibility of disease and prompt genetic testing in these patients when appropriate. We will discuss the key differentiating imaging features and clinical symptoms to distinguish FXTAS from other disease processes with similar imaging patterns including multiple system atrophy, progressive supranuclear palsy, and Wilson's disease.

Materials and Methods
65 year-old white male with uncontrolled hypertension and coronary artery disease that presented with 7 years of slightly worsening intention tremors in his hands, worse on the right compared to the left. The patient had been on propranolol, which had partially alleviated his symptoms. Upon further questioning, he also endorsed an impaired "wobbly" gait and worsening memory/cognitive function. He denied any other Parkinsonian symptoms including bradykinesia, rigidity, and hypophonia. His father also had a similar tremor and dementia. After suspicious MRI findings, the patient underwent laboratory testing for the Fragile X allele. The test revealed that he had 100 CGG repeats, which is in the premutation range. This in addition to his symptoms and imaging findings made the diagnosis of FXTAS.

Results
The imaging findings demonstrated volume loss and increase T2 signal in the middle cerebellar peduncles with extended around the dentate nuclei with relative sparing of the more lateral cerebellar hemispheric white matter. Importantly, there was no abnormal T2 signal within the thalami, which can help differentiate FXTAS from other neurodegenerative diseases. There was also thinning of the corpus callosum, volume loss of the cerebellar hemispheres and vermis, and diffuse cerebral hemispheric volume loss with dilatation of the ventricles.

Conclusions
Fragile X-associated tremor/ataxia syndrome is thought be vastly under-diagnosed due at least in part to lack of physician knowledge about the disease. Given that it has a characteristic imaging appearance, we as radiologists can suggest that the disease be considered when suspicious imaging features are present and help get these patients and their families the appropriate genetic testing and counseling that they need.
Purpose
Intractable epilepsy remains one of the most difficult conditions to diagnose and treat. Focal cortical dysplasia (FCD), one of the most common causes of epilepsy, is often undetected on MRI imaging, particularly Type I and II FCD. An atlas of the most common distribution of various forms of FCD can provide neuroradiologists a practical tool to increase sensitivity of MRI imaging.

Materials and Methods
Sixty three cases of pathologically proven FCD were analyzed, including 29 cases of Type I, 17 Type IIa and 17 Type IIb. Regions of interest (ROIs) were manually traced for all cases on T2 weighted images with the reference of hypometabolic areas on FDG-PET using the postprocessing software AFNI. The ROIs were spatially normalized and superimposed onto a 1.0-mm isotropic T1-weighted brain atlas. Distribution frequency of FCDs in each lobe was calculated. Subsequently, the distribution was corrected by the known percentage of the gray matter volume of the involved lobe to that of the whole brain, and volume-corrected distributions calculated.

Results
47.6% of all FCDs were localized to the temporal lobe (TL), 42.9% to the frontal lobe (FL), and a minority to the parietal and occipital lobes (6.4% and 3.2%). Volume-corrected distribution showed increased frequency in the temporal lobe overall (TL 58% vs. FL 28.4%). A substantial majority (80.3%) of Type I FCD involved the temporal lobe. Type IIa FCD was also more likely to involve the temporal lobe (TL 41.4% vs. FL 26.3%), while Type IIb more frequency involved the frontal lobe (TL 32.3% vs. FL 48.4%).

Conclusions
The vast majority of Type I FCD, which is typically subtle on imaging, involves the mesial temporal lobe. Type IIa is slightly more frequent in the temporal lobe, and Type IIb more frequently involves the frontal lobes. These findings suggest that an FCD atlas will further facilitate diagnostic sensitivity of preoperative MRI evaluation.

Figure 1. FCD Distribution Frequency Map as Axial Images in All FCD Cases

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Frequency, Extent, and Correlates of Superficial Siderosis and Ependymal Siderosis in Premature Infants with Germinal Matrix Hemorrhage: An SWI Study

M Albayram, M Weiss
University of Florida College of Medicine, Gainesville, FL

Purpose
Germinal matrix intraventricular hemorrhage (GM-IVH) is a common complication of prematurity. An underrecognized complication of GM-IVH is superficial siderosis (SS) and the clinical consequences of SS are not well known. We aimed to investigate the prevalence, anatomic distribution, and severity of SS and ependymal siderosis (ES) in premature infants with GM-IVH using susceptibility-weighted imaging (SWI).

Materials and Methods
In this retrospective study, we included 88 patients across all grades of GM-IVH who underwent MR imaging at term equivalent age. Images were evaluated for the presence, distribution, and severity of SS and ES. Univariate and multivariate logistic regression analyses were performed to determine factors associated with SS and ES. The agreement between T1, T2, and SWI sequences was examined.

Results
Seventy-two patients had brainstem SS and seventy-nine patients had ES. The presence, extent, and severity of SS and ES were closely related with grade of GM-IVH and intraventricular hematoma volume. Brainstem SS had a stronger correlation with intraventricular hemorrhage than with cerebellar hemorrhage. Compared with SWI, T1 and T2 sequences detected only small proportions of patients with SS (12.5% and 6.9%, respectively).

Conclusions
The incidence of SS and ES are very high in preterm infants with GM-IVH when assessed by SWI at term equivalent age. The presence and extent of SS and ES are closely related with GM-IVH grade and intraventricular hematoma volume. Additional prospective studies using SWI are needed to clearly determine the clinical consequences of GM-IVH with SS and ES.

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Frequency-Domain Resting State fMRI Analysis Demonstrates Language Lateralization in Healthy Controls

S Ahmed, M Jenabi, M Gene, R Moreno, K Peck, A Holodny
Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, NY

Purpose
Existing methods of resting state fMRI (rsfMRI) analysis are successful in localizing language function but are suboptimal for language lateralization. Most rsfMRI studies apply temporal correlation based analyses. The purpose of this study is to use a novel metric based on a 2D frequency domain power spectral analysis to determine hemispheric language lateralization from rsfMRI data.

Materials and Methods
We carried out a 2D Fourier analysis on three functional regions of interest (ROIs): 1) Broca's Area (BA), 2) Hand-motor cortex (HM) and 3) Primary Visual Cortex (VC), on the rsfMRI data of 21 healthy, right-handed subjects. rsfMRI data analysis was performed in AFNI and Matlab. Spike removal, motion correction, linear trend removal and spatial smoothing were applied. Spontaneous low-frequency fluctuations (0.01-0.1Hz) were filtered to enable functional integration. We conducted a comparison of the resulting power spectral plots between the left and right BA, with the corresponding HM and VC included as controls, for each participant. A novel metric, termed the Power Lateralization Index (PLI), was used to quantify the extent to which spectral power differed between the left and right hemispheres. PLI was defined as shown in Fig. 1. PLI for BA was subsequently compared to that of HM and VC. All reported z-statistics and p-values are from the Mann Whitney U-Test, to compare whether two sample means are significantly different. The Bonferroni correction was applied to counteract any potential issues with multiple comparisons.
Results
At the $\alpha=0.05$ level, BA showed statistically significantly greater power in the left hemisphere compared to the right hemisphere ($Z=2.69$, $P=0.0036$), while HM ($Z=1.03$, $P=0.1515$) and VC ($Z=-0.07$, $P=0.4681$) showed no significant difference between the hemispheres. PLI for BA was statistically significantly greater than VC ($Z=4.35$, $P<0.00001$) and HM ($Z=2.62$, $P=0.0044$). Both sets of findings are consistent with left-lateralization of language function.

Conclusions
Our method demonstrated left-lateralization of language in 21 right-handed healthy subjects based on rsfMRI data. Lateralization in the VC was symmetrical, as anticipated. HM showed a slight trend favoring left-lateralization that did not reach statistical significance, possibly due to right hand dominance. The outcome of this study supports the feasibility and validity of a 2D, ROI-based power-spectral analysis of rsfMRI data for language lateralization. We plan to validate this method in brain tumor patients.

$$PLI = \frac{P_{left} - P_{right}}{P_{left} + P_{right}}$$

where $P_{left} = \text{power metric for region in left hemisphere}$

$P_{right} = \text{power metric for region in right hemisphere}$

Fig. 1: Equation for PLI

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From Clivus to Coccyx and Anywhere in Between, a Case Presentation of a Mid-Cervical Chordoma.

M Bergquist$^1$, T Kennedy$^2$, J Yu$^3$

$^1$University of Wisconsin Hospitals and Clinics, Madison, WI, $^2$N/A, Middleton, WI, $^3$University of Wisconsin School of Medicine and Public Health, Madison, WI

Purpose
Review the imaging findings of a chordoma and correlate these with the embryologic origin of the lesion.

Materials and Methods
A female presenting with one year of bilateral upper extremity paresthesias worse with neck hyperflexion (Lhermitte's phenomenon), upper extremity hyperreflexia, and constant dull neck pain found to have an extradural mass at C3-5 originating from the lateral C4 vertebral body. Following imaging work-up, the patient underwent preoperative embolization of the left vertebral artery followed by resection, anterior cervical spinal fusion, and adjuvant radiation.

Results
MR cervical spine imaging revealed an avidly T2 hyperintense, T1 hypointense extra-dural mass with lobular contours arising from the lateral C4 vertebral body filling and expanding the left foramen transversarium (Figure A & C). This mass demonstrated uplifting of the posterior longitudinal ligament and caused severe canal stenosis displacing the thecal sac posteriorly. Post contrast images demonstrated ill-defined, minimal peripheral linear enhancement of the mass and with a patent left vertebral artery (Figure B). A CT myelogram performed demonstrated an extra-dural expansile lesion without any osseous matrix or intra-tumoral calcification along the posterolateral surface of the C3-5 vertebral bodies. There was significant expansion of the left foramen transversarium and encasement of the left vertebral artery without cortical disruption or osseous erosion (Figure D).

Conclusions
Chordoma's are slow growing tumors which arise from notochord remnants, which reside in the midline of the neuroaxis from the basio-occiput to the sacrum. These tumors characteristically contain physaliphorous ("bubble bearing") cells with vacuolated, lobular cytoplasm giving these lesions an expansile, avidly hyperintense T2 appearance with lobular contours. Both MR and CT are often needed to differentiate these lesions from chondrosarcomas which can have a similar MR appearance, but CT can differentiate the chondroid matrix seen in chondrosarcomas versus lytic destruction and resultant erosive calcification seen with chordomas. Historically thought be most common in the sacrum or clivus, chordomas are now known to be relatively equally distributed between the occiput, spine, and sacrum. This case illustrates the classic imaging appearance of a chordoma regardless of where it originates along the cranio-caudal axis in the spine.
Functional Evaluation Of The Lumbar Nerve Roots Before And After Pulsed Radio-Frequency Neuromodulation in patients affected by Chronic Radiculopathy: A Preliminary Study Using Diffusion Tensor Imaging And Fiber Tractography

A De Vivo1, H Alqatami2, M Bellini3, L Manfre4
1IOM, Catania, Italy, 2Institute of Hamad Medical Corporation, Doha, Qatar, 3UOC Neuroimmagini, Dipartimento di Neuroscienze, Azienda Ospedaliera Universitaria Senese, Siena, Italy, 4IOM, Catania, Italy

Purpose

The aim of this study is to compare the functional state of lumbar nerve roots, before and after the procedure of Pulsed radiofrequency (PRF) neuromodulation of dorsal root ganglion (DRG) in patients with chronic radiculopathy (CR) using Diffusion Tensor Imaging (DTI) and fiber tractography. Moreover, we want to define the relationship between DTI parameters and clinical outcomes.

Materials and Methods

From June 2019 patients with CR were evaluated. 31 patients were eligible for percutaneous CT-guided PRF of DRG. Inclusion criteria: mono-lateral CR (>6 months), failure of conventional therapies. Exclusion criteria: evidence of lumbar stenosis or foraminal stenosis or mechanical disc compression on MRI. All patients underwent: Pre- and post-op pain intensity rating using VAS score. Pre- and post-op MRI including DTI and fiber tractography. PRF was performed in a fully percutaneous CT-guided procedure using a two-electrode periganglial catheter (Easylode®, Bioampere) in local anesthesia.

Results

The FA values of the painful lumbar nerve roots were lower than the contralateral non-painful and the ADC values of painful lumbar nerve roots were significantly higher than the contralateral non-painful nerve roots. Moreover, a significant difference between the pre- and post-operative FA and ADC values was found.

Conclusions

Despite a larger group of patients is needed for a statistically significant correlation between variation of FA/ADC parameters and clinical outcomes after PRF procedure, DTI and fiber tractography can be a useful tool for detecting microstructural changes of lumbar nerve roots in patients affected by CR and for the follow-up after PRF neuromodulation procedure. Further studies are needed.

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Functional Whole-Brain Dynamics in Aging: Local-Global Integration and Metastable Substates

A Escrich1, G Deco1, C Biarnes2, S Pedraza3, J Vilanova3, R Pamplona3, M Essig4, J Garre4, J Puig4
1Center for Brain and Cognition, Universitat Pompeu Fabra, Barcelona, Barcelona, 2IDI-IDIBGI, Girona, Girona, 3University of Lleida-IRBLleida, Lleida, Lleida, 4University of Manitoba, Winnipeg, Manitoba, 5IDIBGI-IAS, Girona, Girona, 6IDI-IDIBGI, Girona, Spain

Purpose

Most studies on aging have examined the average resting-state functional connectivity despite functional connectivity is not static but exhibits nonstationary dynamic patterns across time. In this work, we explored age-related changes in whole-brain dynamics by using resting-state functional magnetic resonance imaging (rs-fMRI) from a large sample of healthy participants in a population-based study.

Materials and Methods

All imaging studies were obtained on a 1.5 T MRI system (Vantage Elan, Canon Medical Systems, Japan). We used two recently developed methods based on phase synchronization to study two homogeneous groups of participants (middle-aged adults: n = 310, age < 66; and older adults: n = 310, age ≥ 66). We applied the ‘intrinsic ignition framework’ to measure the influence of spontaneous local activation events on whole-brain integration, and the ‘Leading Eigenvector Dynamics Analysis’ (LEiDA) to obtain metastable substates across participants to determine their probability of occurrence and duration.

Results

First, using the intrinsic ignition framework, we found that the middle-aged participants showed a more dynamical repertoire across time (p < 0.001), but lower values of intrinsic ignition compared to the older group (p < 0.001). Second, using the LEiDA method, we found a significant metastable substate involving brain areas of the default mode network, as well as subcortical regions, in which middle-aged participants had a higher probability of occurrence (p < 0.05), and spent significantly more time than the older group (p < 0.05).

Conclusions

These results suggest age-related changes in functional whole-brain dynamics. Compared to older subjects, middle-aged subjects have more complex functional dynamics, probably due to more hierarchical brain organization. Characterizing the profile of functional whole-brain dynamic changes could provide insight into the precise nature of hierarchical information processing and imbalances in brain states in age-associated diseases.
Gossypiboma Mimicking a Glioblastoma Recurrence

S Khanpara¹, O Arevalo², M Bhattacharjee¹, E Bonfante-Mejia³, R Riascos⁴
¹The University of Texas Health Science Center, McGovern Medical School, Houston, TX, ²UNIV. OF TEXAS HEALTH SCIENCE MCGOVERN MEDICAL SCHOOL, HOUSTON, TX, ³Univ. Of Texas Health Science Center, Houston, TX, ⁴Univ. Of Texas - Houston, Houston, TX

Purpose
To report a case of Gossypiboma at the operative bed mimicking a Glioblastoma recurrence.

Materials and Methods
A 55-year-old female presented with complaints of weakness and confusion. She has a past medical history of Glioblastoma (IDH wild-type) within the left parietal lobe diagnosed 9 months ago. She had undergone a subtotal resection of the tumor followed by standard of treatment therapy including radiation and Temozolomide. During this time the resection cavity was decreasing in the size with shrinkage of the residual tumor. However, now she presents to the hospital with sudden onset of weakness and confusion. Imaging findings were consistent with tumor progression. After a multidisciplinary discussion, it was decided to resect out the assumed tumor. Later, pathological examination of the resected lesion demonstrated partially degraded hemostatic material surrounded by prominent inflammatory changes. There were few atypical cells that were consistent with infiltrating glial cells amidst the background of treatment changes. However, the overall findings were suggestive of a foreign body reaction to the hemostatic material found in the specimen.

Results
Figures A and B are the prior images for comparison. Fig. A demonstrate a shrinking resection cavity with T2-FLAIR signal along the adjacent white matter. The postcontrast image (Fig B) shows a relatively thick rim of enhancement along the resection cavity with a pattern that represents treatment changes. Present MRI (fig C and D) shows some heterogeneous signal intensity at the site of resection cavity with increase in the extent of the T2-FLAIR signal. Postcontrast image (Fig D) shows expansion of the resection cavity forming a round cystic contour with thick nodular enhancement. Two satellite enhancing nodules were also seen adjacent to the lesion. These findings favored a diagnosis of glioblastoma recurrence.

Conclusions
Gossypiboma are relatively common in the abdominal cavity. However, Gossypiboma in the brain is a rarely reported entity and can present as a diagnostic challenge. There is a reported case where a Gossypiboma mimics an abscess in the brain. Reports elsewhere in the body have shown that it can mimic a tumor recurrence.
Head and Neck Endovascular Repair of Vascular Malformations

W Yakes¹
¹The Yakes Vascular Malformation Center, Englewood, CO

Purpose
To determine the efficacy of ethanol embolotherapy of extracranial head and neck vascular malformations of all types, particularly after failure of other endovascular and surgical treatments.

Materials and Methods
One hundred and sixty-six patients (64 males, 102 females; mean age: 38 yrs) presented with extracranial arteriovenous malformations (AVMs) of the head and neck area. Over half of the patients had undergone previous failed therapies (Glue, Onyx, PVA, Coils). All patients underwent ethanol embolotherapy under general anesthesia. Forty-five patients had AVMs and 121 patients had venous malformations (VM).

Results
Of 45 AVM patients, 26 patients are cured (mean follow-up 2 ½ years); of 121 venous malformation patients, 65 are at end-therapy (mean follow-up 4 ½ years). The remaining patients are not at end-therapy and are being treated for their residual malformations. In
AVM follow-up, arteriography is the main imaging modality to determine cure or residual AVM as MR is less sensitive in the evaluation of residual AVM. In VM follow-up, MR is the main imaging tool, particularly with T-2 fat suppression and/or STIR imaging. All patients demonstrated improvement post-therapy. Complications were 4.5%, to include bleeding (self-limited), partial 7th nerve palsy (with recovery), skin injury (not requiring skin grafts), infection, and pain.

Conclusions
Ethanol has proven its consistent curative potential at long-term follow-up for high-flow AVMs and low-flow VM lesions at long-term follow-up as lesions in the periphery. Complication rates remain low. The procedures are tolerated well by the patients and done on an out-patient basis. Prior surgery and embolization procedures can cause difficulty in lesion access, but does not obviate further ethanol endovascular treatment.

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Herpes Simplex Virus Type 1 Associated with Vasculopathy, Stroke and Encephalitis: A Diagnostic Conundrum

I Russell¹, S Mathur²
¹Lancashire Teaching Hospitals, Preston, United Kingdom, ²Lancashire Teaching Hospitals, Preston, UK

Purpose
In neuroradiology there can be a wide range of presentations and mimics of stroke. Patients with acute neurological symptoms are often considered to have a vascular cause for their neurology, such as ischaemic stroke, dissection or intra-cranial haemorrhage. We wish to share a case of stroke followed by HSV-1 encephalitis and we feel this is an unusual presentation of HSV vasculopathy.

Materials and Methods
We present a rare case of Herpes Simplex Virus (HSV) vasculopathy in a young, 24 year old healthy male amateur rugby player, who presented with acute onset left sided weakness and headache. The initial MR imaging showed acute infarction in the right middle cerebral artery (MCA) territory. A clinical suspicion of dissection was raised due to the patient's background, however, the CT angiogram was negative. The patient was managed as an embolic ischaemic stroke and discharged. He represented a few weeks later with headache, fever and mild hypersomnolence. A repeat MR study demonstrated new signal changes within the anterior and medial aspect of the right temporal lobe with no restricted diffusion. MR angiogram demonstrated a focal narrowing of the distal M1 segment of the right MCA. A traumatic intracranial dissection of the right dissection of the right MCA was considered, however based on the distribution of the new changes, a diagnosis of herpes simplex encephalitis with associated vasculopathy was also suggested. CSF analysis showed lymphocytic pleocytosis and PCR analysis was positive for HSV type 1. The patient was treated with anti-virals and steroids, and a follow up MR angiogram demonstrated complete resolution of the previous MCA stenosis. The changes in the right temporal lobe also improved with residual gliosis.

Results
N/A

Conclusions
In summary, this case shows an unusual presentation of HSV-1 encephalitis, with associated HSV vasculopathy and infarction. Review of the initial imaging shows an acute MCA infarction which appeared to be embolic/related to a dissection in a young rugby player. However, Occam's razor would dispute the dual diagnosis of cryptogenic stroke followed by HSV-1 encephalitis and we feel this is an unusual presentation of HSV vasculopathy with the typical changes of encephalitis manifesting on subsequent imaging. We wish to share this interesting chain of events.
High resolution magnetic resonance imaging for carotid-cavernous fistula

Y Choi

Asan Medical Center, Seoul, Seoul

Purpose
The purpose of this retrospective study was to evaluate the diagnostic performance and possible imaging predictors for carotid-cavernous fistulas (CCFs) using high resolution MRI (HR-MRI) findings in the patients with clinically suspected CCF.

Materials and Methods
Between January 2006 and September 2018, 98 patients were finally enrolled, who were clinically suspected CCF according to their symptoms and physical examinations and underwent pretreatment HR-MRI and digital subtraction angiography (DSA). We evaluated diagnostic performance of HR-MRI and compared that of CTA and MR angiography (MRA) for the diagnosis of CCF with the reference standard of DSA. Univariate logistic regression analysis was performed to determine possible imaging predictors of CCF.

Results
Among 98 patients, 38 patients were confirmed as CCF on DSA. The overall accuracy, sensitivity, and specificity of HR-MRI were 88.8%, 97.4%, and 83.3%, respectively. The diagnostic performance of HR-MRI was not significantly different from those of CTA and MRA. Possible imaging predictors on HR-MRI included abnormal contour of cavernous sinus (odds ratio: 21.7), internal signal...
void of cavernous sinus (odds ratio: 15.3), prominent venous drainage flow (odds ratio: 54.0), and orbital/periorbital soft tissue swelling (odds ratio: 40.4).

Conclusions
HR-MRI provides high diagnostic performance and possible imaging predictors on CCF in the patients with clinically suspected CCF. HR-MRI protocols could help decide appropriate management plans in the patients who were clinically suspected CCF.

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**High-grade Glial Tumors Associated with ETV6-NTRK3 Gene Fusion: Imaging Appearance with Pathological Correlate**


Oregon Health & Science University, Portland, OR, University of Washington, Seattle, WA, Northwell Health, Long Island, NY, Children’s Hospital of Philadelphia, Philadelphia, PA, Children’s Hospital Los Angeles and Keck School of Medicine at University of Southern California, Los Angeles, CA, Legacy Health, Portland, OR

**Purpose**

High-grade glial tumors in the pediatric population associated with the ETV6-NTRK3 gene fusion are rare but treatable malignancies, with reports of response to first-generation TRK tyrosine kinase inhibitors. Although NTRK gene fusions are frequently described in other childhood tumors, there have been limited reports of imaging findings associated with high-grade glial tumors bearing NTRK3 rearrangements. We present the diagnostic and follow-up imaging findings of a case series of high-grade glial neoplasms associated with the ETV6-NTRK3 gene fusion.

**Materials and Methods**

Five pediatric patients (3 female and 2 male; age range, 11 days – 4 years) presenting with high-grade glial neoplasms associated with the ETV6-NTRK3 gene fusion were evaluated via MRI.

**Results**

The cases in this series revealed a heterogeneous imaging appearance of ETV6-NTRK3 fusion gliomas, with findings including mixed cystic and solid masses, irregular and nodular enhancement, neovascularity, and scattered foci of susceptibility artifact.

**Conclusions**

These data suggest that despite sharing a common genetic underpinning, imaging findings for ETV6-NTRK3 fusion gliomas are heterogeneous. Advances in understanding the evolution and subtypes of these tumors may enable radiologists to further differentiate these neoplasms based on imaging appearance.
How Does Head Position Affect Blood Flow in Neck Vessels and Cerebral Perfusion? Phase Contrast MRI and ASL Quantification in Healthy Volunteers

P Muthusami¹, S Bickford¹, L Kitamura¹, P Pezeshkpour², M Shroff³
¹The Hospital for Sick Children, Toronto, ON, ²The Hospital for Sick Children, Toronto, Ontario, ³Hospital for Sick Children, Toronto, ON

Purpose
The effect of head position on individual neck vessels is unknown. From angiographic knowledge, we know that there can be dampened flow in neck vessels upon head turning or bending. Objective: to determine and measure the extent of blood flow variation in individual extracranial carotid & vertebral arteries, and the effect on regional CBF, during non-neutral head positions in healthy volunteers. Primary Aim: To quantify blood flow changes in extracranial carotid and vertebral arteries with different head positions in healthy volunteers. (Hypothesis: There is no alteration of blood flow in the neck arteries with different head positions) Secondary Aim: To measure regional cerebral blood flow with different head positions in healthy volunteers. (Hypothesis: There is no alteration in regional CBF with different head positions)

Materials and Methods
Prospective IRB approved study, 20 healthy volunteers >18 years. Exclusions: neurological/spondylotic disorders, MRI contraindications. Awake MRI performed: PCMRI, TOF-MRA, ASL perfusion in the following head positions: 1. Neutral 2. turned right 30-45 degrees 3. turned right 75-90 degrees 4. turned left 30-45 degrees 5. turned left 75-90 degrees 6. Maximal flexion and 7. Maximal Extension. Age, weight, height documented; body surface area (BSA) calculated Post-processing performed by two blinded readers. Semi-automated region-of-interest (ROI) for obtaining flow curves, followed by flow quantification through the cardiac cycle, normalized to BSA, for each head position. ROI-based evaluation for rCBF on ASL maps in 14 defined brain regions. Interreader agreement calculated using ICC coefficient.

Results
Mean age (13F; 7M) = 38.6±10.8 (range 22-56) years. Mean blood flow, neutral position: (L/min/m²): RIJV: 0.19±0.11 ; LIJV: 0.14±0.08 ; RCCA: 0.19±0.04 ; LCCA: 0.19±0.05 ; RVA: 0.04±0.01 ; LVA: 0.05±0.02 No significant change in blood flow in the major neck arteries with variation in head position. The mean change was in the order of 0.001-0.010 L/min/m². Interreader agreement (ICC), R²=0.98

Conclusions
In the physiological state, there is no variation in blood flow in individual neck vessels with change of head position. Reductions of blood flow that are noted in the absence of intraluminal occlusion must therefore be considered to be pathological and due to extrinsic compression, for e.g. by a styloid process for carotid arteries or bone fusion anomalies in vertebral arterial insufficiency from Bow Hunter syndrome.
How varying arterial input function location affects automated CT perfusion posterior circulation Tmax values

A Goldman-Yassen¹, M Straka², S Dehkharghani³
¹Children’s Hospital of Philadelphia, Philadelphia, PA, ²SchemaView, Inc, Winterthur, Winterthur, ³New York University, New York, NY

Purpose
Perfusion-based patient selection facilitates late-time window therapy in patients with acute ischemic stroke (AIS). Endovascular trials have emphasized anterior circulation (predominately ICA and MCA) large vessel occlusion (LVO), and generalizability to posterior circulation LVO may not be straightforward due to relative delays in anatomic territories of the posterior circulation, the propensity for anatomical variation and asymmetries in the posterior circulation, and the delay sensitivity inherent to deconvolved time-to-maximum (Tmax) parametric maps. Despite the widespread adoption of delay-insensitive deconvolution algorithms, which mitigate cerebral blood flow (CBF) errors relating to arterial input function (AIF) selection, the inherent arrival time sensitivity of tissue Tmax would be anticipated to vary significantly as a function of AIF, for example, between the anterior and posterior circulations. We therefore sought to determine how varying AIF affects posterior circulation Tmax.

Materials and Methods
Patients undergoing CTP and CTA for presumed AIS were retrospectively identified by radiologic and clinical informatics query. Cases with final clinical or imaging evidence for acute stroke, or other acute intracranial pathology were excluded. CTP were analyzed using RAPID (iSchemaView, Menlo Park, CA) using automated AIF detection. AIF were then manually enforced so perfusion maps for the right and left MCA, ACA, and basilar AIF locations were generated. Tmax parametric maps were constrained into pre-defined vascular and anatomic territories of interest using ITK-SNAP. Median values for territorial average Tmax values were compared using the Wilcoxon signed-rank test.

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Results
Nine cases were assessed thus far. Average subject age is 68 years and 56% male. The median of territorial average Tmax values in all vascular territories (right and left anterior circulation, right and left PCA territory, right and left cerebellum, and brainstem) is lower when AIF is placed on basilar artery compared to when placed on the right MCA (p<0.05). Additionally, the average Tmax of the ipsilateral anterior circulation remains significantly lower than the posterior circulation territories through all AIF placements (p<0.05).

Conclusions
Territorial average Tmax values are significantly affected by AIF selection and AIF-based cutoff criteria may therefore be necessary in the setting of associated benign oligemic delays.

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Identification of MR Imaging Features for Prediction of Molecular Profiles in Newly Diagnosed Glioblastoma

S Ahn¹, S Cha², S Lee¹
¹Severance hospital, Seoul, Korea, ²University of California San Francisco, San Francisco, CA

Purpose
To predict molecular profiles in newly diagnosed glioblastoma using qualitative and quantitative MR imaging features and to explore the associations between imaging features and major molecular alterations comprehensively.

Materials and Methods
This retrospective study included 125 patients with newly diagnosed glioblastoma with next-generation sequencing results from one institution as a discovery cohort and 51 patients from another institution as a validation cohort. From preoperative MR imaging, Visually AcceSAble Rembrandt Images (VASARI) features, volumetric parameters, and apparent diffusion coefficient values from diffusion-weighted imaging were obtained (19 qualitative and 17 quantitative features). First, univariate random forest was performed to identify genes that can be predicted by imaging features with high accuracy and stability, namely high area under receiver operator characteristic curve (AUC) and low relative standard deviation (RDS). Next, multivariate random forest was trained to predict selected genes using a single classification model in the discovery cohort and was validated in the external cohort. To further explore the associations between imaging features and genes, univariable logistic regression was performed.

Results
According to univariate random forest, nine genes among 66 were predicted by imaging features with high AUC and low RSD; IDH mutation, PTPN11 mutation, ATRX loss, TERT mutation, PTEN loss, TP53 mutation, EGFR mutation, Trisomy 7 monosomy 10, CDKN2A/B deletion. The multivariate random forest model showed excellent performance to predict IDH and PTPN11 mutation in discovery cohort, which were validated in the external validation cohorts (AUCs, 0.855 for IDH and 0.88 for PTPN11). ATRX loss and EGFR mutation were predicted with AUCs of 0.753 and 0.739, respectively, whereas PTEN cannot be reliably predicted (AUC 0.339). Based on univariable logistic regression analyses, IDH, ATRX, and TP53 were clustered according to their shared imaging features, whereas EGFR and CDKN2A/B shared imaging features in the opposite direction from IDH/ATRX/TP53 cluster. PTPN11 mutation showed demonstrated distinct imaging features from other molecular alterations.

Conclusions
We demonstrated the potential of MR imaging features for predicting molecular profiles and identified imaging features that are related to specific molecular alterations in patients with newly diagnosed glioblastoma, which might be helpful for individualized treatment.

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Idiopathic Hypertrophic Spinal Pachymeningitis (IHSP)
Purpose
To show the clinical presentation and imaging findings in IHSP.
Materials and Methods
A 16-year-old female presented with back pain and lower limb paraparesis over a period of 2 months. The back pain started 15 months earlier, was mild and subsided in response to NSAIDs. However, pain increased in severity and the patient developed new lower limb paraparesis and dysesthesias 2 months prior to presentation.

Results
Axial and Sagittal T2WI of the lower thoracic spine show circumferential dural thickening, with low T2 signal intensity, causing narrowing of the spinal canal from T9 to L1 (A, B). Associated avid enhancement on post-contrast fat saturated sagittal T1WI(C).

Conclusions
Idiopathic Hypertrophic Pachymeningitis (IHP) is a chronic inflammatory disorder of the dura mater. The spinal form of IHP is extremely rare. It is a diagnosis of exclusion presenting on MR imaging as a dural-based mass of low T2 signal intensity extending over multiple levels, with strong post gadolinium enhancement.

Imaging Characteristics and Diagnostic accuracy of Combining 18F-FDOPA PET and MRI in treatment-naïve gliomas

H Tatekawa1, J Yao1, C Wang1, T Oughourlian1, C Raymond1, A Lai1, T Cloughesy1, L Liao1, N Salamon1, B Elingson1
1University of California, Los Angeles, Los Angeles, CA

Purpose
Magnetic resonance (MR) imaging, especially fluid-attenuated inversion recovery (FLAIR) imaging, contrast-enhanced imaging, diffusion tensor imaging (DTI), and perfusion imaging, clinically play a significant role in the morphologic and metabolic evaluation of gliomas. The use of 18F-FDOPA PET can provide metabolic information that can complement MR imaging. While there have been some studies that compared between MR imaging and FDOPA PET, few studies that combined images from these modalities were reported. The purpose of this study is to evaluate the characteristics and diagnostic accuracies of treatment naïve gliomas by combining FDOPA PET and MR imaging with functional sequences.

Materials and Methods
We retrospectively selected 56 glioma patients (WHO grade 2: N=24, grade 3: N=20, grade 4: N=12) who underwent FDOPA PET and MR perfusion and/or DTI examination before treatment between 2010 and 2019. We segmented FLAIR-ROI (FLAIR hyperintensity area) and FDOPA-ROI (18F-FDOPA hyper uptake area more than striatum within FLAIR-ROI), and evaluated cerebral blood volume (CBV), and apparent diffusion coefficient (ADC) low, defined as the mean of lower Gaussian curve (a mixed model with a double Gaussian distribution fitting to the histogram of ADC), within each ROI. ANOVA, t test, ROC curve, and Cox regression were used for statistical analyses.

Results
CBV and ADC low in FLAIR-ROI showed no significant differences among grade 2, 3, and 4. when we use FDOPA-ROI, CBV in grade 2 was significantly smaller than that in grade 3 and 4 (p=0.03 and 0.008, respectively) and ADC low in grade 2 was significantly higher than that in grade 4 (p=0.003). ROC analysis showed that CBV and ADC low could differentiate WHO grade 2 from 3 or 4 with higher sensitivity and specificity in FDOPA-ROI than in FLAIR-ROI (AUC for CBV with grade 2 vs 3 or 4, FLAIR-ROI, 0.62 and 0.75, FDOPA-ROI, 0.81 and 0.81; AUC for ADC low with grade 2 vs 3 or 4, FLAIR-ROI, 0.54 and 0.75, FDOPA-ROI, 0.71 and
0.88). Cox univariate regression analysis showed significant association between overall survival and sex (HR=1.063, p=0.007), IDH status (HR=0.066, p=0.009), EGFR status (HR=3.393, p=0.03), and FDOPA hyper uptake volume (HR=1.128, p<0.001).

Conclusions
To my knowledge, this is the first study that combined 18F-FDOPA PET and MR functional sequences. CBV and ADC low with ROI created using combined MR imaging and 18F-FDOPA PET can differentiate the WHO grade of treatment-naïve gliomas more accurately than those with ROI of only MR imaging.

Imaging Findings in Carbon Monoxide Exposed Patients

A Trent1, T Knoblauch2, C Vanier1, A Rodriguez3, T Snyder1
1Touro University Nevada, Henderson, NV, 2University of Nevada, Las Vegas, Las Vegas, NV, 3IMGEN LLC., Las Vegas, NV

Purpose
Carbon Monoxide (CO) poisoning accounts for approximately 50,000 Emergency Department visits every year. Previous studies on patients with CO poisoning have identified neuroradiological abnormalities associated with CO poisoning. We present imaging findings from 98 patients with CO poisoning.

Materials and Methods
3.0 Tesla MRI Brain imaging was performed including DTI, single and multi-voxel spectroscopy, and SWI on 98 patients with a history of CO exposure, ranging in age from 8 to 72 years (mean=41). A board-certified neuroradiologist interpreted the images, and the results were compiled into a database with emphasis on neuroradiologic findings described in CO poisoning. We describe lesions of the white matter, cortex, basal ganglia, hippocampal atrophy, spectroscopy and abnormal corpus callosum DTI. We characterized the population of poisoned patients relative to the neuropathological findings, and also looked at associations between abnormalities using Fisher's exact test.

Results
The most common location for white matter hyperintensities was subcortical. Approximately half of the patients had abnormal white matter findings. One of the most common neuroradiological abnormalities was hippocampal atrophy, affecting 71% of surveyed patients. We found abnormal DTI in 65%, and pineal cysts in 32% of patients. Other noted image abnormalities were lesions of the globus pallidus (13%), cerebral cortical lesions (5%), and empty sella (10%). Most abnormalities appeared to be independent of each other (P>0.10), with one exception: hippocampal atrophy and abnormal DTI findings were associated in patients 10% more frequently than expected by chance (p=0.021)

Conclusions
Our study shows many brain abnormalities likely due to CO poisoning, with hippocampal atrophy being the most common. The association between hippocampal atrophy and abnormal DTI findings has not been previously described and deserves further study.
Several abnormalities including pineal cysts and empty sella appear substantially more common in these CO exposed patients as compared to reported norms.

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 Imaging of the distal intracranial trigeminal nerve and central skull base neuroforamina: A comparison of 3D Constructive Interference in Steady State (CISS) and T2-weighted sampling perfection with application optimized contrasts using different flip angle evolution (SPACE)

L Chien¹, P Sharma¹, N Kinger¹, R Gravolet¹, A Aiken², K Baugnon³, X Wu⁴
¹Emory University, Atlanta, GA, ²Emory University Hospital, Atlanta, GA, ³EMORY UNIVERSITY, ATLANTA, GA, ⁴EMORY UNIV SCHOOL OF MEDICINE, ATLANTA, GA

Purpose
MRI accuracy for evaluation of perineural spread (PNS) in the head and neck, especially in clinically important central skull base neuroforaminal and proximal intradural locations, has been limited by technical challenges. Both 3D CISS and T2-SPACE imaging have demonstrated promise in the evaluation of cisternal neural structures, but their ability to evaluate the central skull base has not been evaluated. The purpose of this study is to assess the ability of these sequences to characterize the distal intracranial branches of the trigeminal nerve as well as the central skull base neuroforamina.

Materials and Methods
A HIPAA-compliant retrospective review identified 20 patients who underwent MRI of the internal auditory canals (1.5T Siemens Aera, 20-channel head coil). 10 patients underwent 3D CISS acquisitions (TR=5.47ms, TE=2.45ms, flip angle= 62°, FOV = 135x180mm², matrix= 256x192, scan time=2'49") while the other 10 underwent 3D T2-SPACE acquisitions (TR=1500ms, TE=119ms, flip angle= 150°, FOV = 218x218mm², matrix= 256x256, scan time=4'). Two radiologists (XW & LC, 8 & 3 years of experience) evaluated the axial images for visualization of anatomic structures including Meckel's caves, foramen rotundum, intracranial mandibular nerve (V3), foramen ovale, and extracranial V3. A 3-point scoring scale was utilized, ranging from 0 (indistinguishable from surrounding structures) to 2 (clearly visible). Unpaired T-test and inter-observer variability assessment were performed.

Results
The following anatomic locations were significantly better scored in the T2-SPACE sequence when compared to CISS for both raters: intracranial V3 (p<0.05), foramen ovale (p<0.05), extracranial V3 (p<0.001). The average scores for the anterior Meckel's cave and foramen rotundum were higher for the SPACE than the CISS sequence, although not significantly so. Interobserver agreement ranged from 30-80% for the different anatomic locations on the CISS sequence, and ranged from 70-100% for the SPACE sequence.

Conclusions
This study demonstrates that, when compared to CISS, T2-SPACE offers superior visualization of nearly all the central skull base structures evaluated, especially of V3 in the region surrounding the foramen ovale, with overall better interobserver agreement. Given that this area is crucial in the determination of whether a patient is eligible for surgical treatment in the setting of PNS, 3D T2-SPACE may play a valuable role in the evaluation of perineural disease in the future.
Improving Longitudinal Transversal Relaxation Of Gadolinium Chelate Using Silica Coating Magnetite Nanoparticles

k xu
\textsuperscript{1}Daping Hospital, Army Medical University, Chongqing, China

Purpose

Precisely and sensitively diagnosing diseases especially early and accurate tumor diagnosis in clinical magnetic resonance (MR) scanner is a highly demanding but challenging task. Gadolinium (Gd) chelate is the most common T1 magnetic resonance imaging (MRI) contrast agent at present. However, traditional Gd-chelates are suffering from low relaxivity, which hampers its application in clinical diagnosis. Currently, the development of nano-sized Gd based T1 contrast agent, such as incorporating gadolinium chelate into nanocarriers, is an attractive and feasible strategy to enhance the T1 contrast capacity of Gd chelate. The objective of this study is...
to improve the T1 contrast ability of Gdchelate by synthesizing nanoparticles (NPs) for accurate and early diagnosis in clinical diseases

Materials and Methods
Reverse microemulsion method was used to coat iron oxide (IO) with tunable silica shell and form cores of NPs IO@SiO2 at step one, then Gd-chelate was loaded on the surface of silica-coated iron oxide NPs. Finally, Gd-based silica coating magnetite NPs IO@SiO2-DTPA-Gd was developed and tested the ability to detect tumor cells on the cellular and in vivo level.

Results
The $r_1$ value of IO@SiO2-DTPA-Gd NPs with the silica shell thickness of 12 nm was about 33.6 mM$^{-1}$s$^{-1}$, which was approximately 6 times higher than Gd-DTPA, and based on its high T1 contrast ability, IO@SiO2-DTPA-Gd NPs could effectively detect tumor cells on the cellular and in vivo level.

Conclusions
Our findings revealed the improvement of T1 relaxation was not only because of the increase of molecular tumbling time caused by the IO@SiO2 nanocarrier but also the generated magnetic field caused by the IO core. This nanostructure with high T1 contrast ability may open a new approach to construct high-performance T1 contrast agent.

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Improving Performance for Diagnosing Malignant Parotid Gland Tumors using Hybrid Multi-features Based on Diffusion-weighted Magnetic Resonance Imaging

C Juan$^1$, T Huang$^2$

$^1$China Medical University Hsinchu Hospital, Hsinchu County, Taiwan, $^2$National Taiwan University of Science and Technology, Taipei, N.A.

Purpose
To evaluate the performance of machine learning in diagnosing malignant parotid gland tumors using clinical, tumor and peritumor ADC features.

Materials and Methods
Three ROIs encompassing parotid tumor, peritumor parotid gland, and contralateral parotid gland were manually contoured for 20 MTs, 42 WTs, and 30 PMAAs from 78 patients. Mean and standard deviation of ADC for each ROI were calculated. Gender and age recorded. Machine learning using random forests was applied to diagnose MT as well as WT and PMA. Statistical analysis was performed to compare the diagnostic performance among different models with a P value less than 0.05 as statistically significant.

Results
Mean ADC (ADCm) alone performed poorer in diagnosing MT with AUC (0.632) significantly lower than WT (0.851) and PMA (0.878) (P < 0.05). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy in diagnosing MT was 0.350, 0.875, 0.438, 0.829, and 0.761, respectively. Random forests regressor models achieved significantly higher AUC in diagnosing MT (0.870) using 5 features including ADC_Tm, ADC Ts, ADC Plm, gender and age (P = 0.004) and WT (0.957) using 4 features including ADC_Tm, ADC Ts, gender and age (P = 0.005). The corresponding sensitivity, specificity, PPV, NPV, and accuracy was 0.400, 0.931, 0.615, 0.848, and 0.815 for MT, and, 0.905, 0.940, 0.927, 0.922, and 0.924 for WT, respectively.

Conclusions
Machine learning helps improve performance for diagnosing MT using combined clinical, tumor and peritumor ADC features.
Incidence and Timing of Conversion to Hyper-Response to Clopidogrel in Patients Undergoing Pipeline Embolization Device Treatment of Intracranial Aneurysms

T Miller1, H De Paula Carvalho1, G JINDAL1, D Gandhi1
1University of Maryland School of Medicine, Baltimore, MD

Purpose
Similar to prior investigators, we have noted that patients undergoing flow diversion treatment of an intracranial aneurysm(s) with the Pipeline Embolization Device who initially demonstrate a moderate amount of platelet inhibition while on clopidogrel may convert to a so-called hyper-response with high levels of platelet inhibition in the first few days to weeks following treatment. This is despite patients being maintained on a consistent dose of the drug. As hemorrhagic complications have been associated with high levels of platelet inhibition, we elected to investigate the frequency and timing of this conversion to hyper-response.

Materials and Methods
We retrospectively analyzed all patients undergoing Pipeline embolization of an unruptured intracranial aneurysm(s) at our institution from November 2011-August 2018 who were within our target range of platelet inhibition on the treatment day as measured by the VerifyNow P2Y12 platelet function test assay (60-200 reaction units). Patients with P2Y12 values outside the target range, those that
had received a glycoprotein (GP) IIb/IIIa receptor inhibitor, as well as patients without follow up platelet inhibition testing, were excluded.

Results
287 Pipeline embolization device treatments for one or more non-ruptured intracranial aneurysms were performed at our institution during the study period. Of these, a GP IIb/IIIa receptor inhibitor was utilized during 26 procedures for low-levels of platelet inhibition or acute platelet aggregation following Pipeline placement. In the remaining 261 cases, 190 patients were initially in our target range of platelet inhibition on the day of the procedure. 30 of these cases were excluded due to lack of follow up platelet inhibition testing. The average time from Pipeline placement to hyper-response conversion was 9.6 days (median 7 days).

Conclusions
In patients undergoing Pipeline flow diversion treatment of intracranial aneurysms, conversion from moderate to high levels of platelet inhibition with clopidogrel is common and typically occurs in the first few weeks following embolization. Careful monitoring of platelet inhibition levels following Pipeline placement is recommended to detect conversion to hyper-response so clopidogrel dosing may be appropriately titrated.

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Incidence and Treatment of Carotid Artery Stenosis in the United States: Trends and Complications over Two Decades

P Golnari1, P Nazari2, S Baisiwala3, S Ansari4, A Shaibani5, M Hurley4, M Potts6, B Jahromi6
1Northwestern University, Feinberg School of Medicine, Chicago, IL, 2Northwestern University, Chicago, IL, 3Northwestern University, Chicago, IL, 4Northwestern University Feinberg School of Medicine, Chicago, IL, 5Northwestern University Feinberg School of Medicine, Chicago, IL, 6Northwestern University - Feinberg School of Medicine, Chicago, IL

Purpose
Carotid endarterectomy (CEA) and carotid artery stenting (CAS) are frequently performed to prevent stroke, with CAS gaining popularity over the past decade as an alternative to CEA because of its less invasive nature. However recent high-quality randomized trials including CREST (Carotid Revascularization Endarterectomy vs Stenting Trial) have shown higher perioperative stroke rates and lower MI rates with CAS when compared with CEA. The impact of these trials on procedural volumes in the USA, as well as rates of stroke and MI after CEA versus CAS in real-world practice, remains unclear.

Materials and Methods
National (Nationwide) Inpatient Sample datasets from 1997 to 2015 were obtained and data were extracted using ICD-9-CM codes for the diagnosis of stenosis of carotid artery with cerebral infarction or TIA, and procedural treatments including CEA and CAS. Age-standardized incidence rates of diagnosis and treatment of symptomatic carotid artery stenosis were estimated. Trends in time were assessed utilizing annual percentage change (APC) across the entire time period.

Results
Age-adjusted incidence of symptomatic carotid stenosis significantly decreased from 1997 to 2002 (from 21.8 to 15.8 per 100,000 person; APC: -6.3%; 95% CI: 9.5% to -2.7%; p<0.001) and then remained stable until 2015 (15.3 per 100,000; APC: 0.5%; 95% CI: 0.3% to 1.4%; p=0.20). CEA decreased throughout the study period, steeply from 1997 to 2004 (from 5.1 to 2.9 in per 100,000; APC: -7.7%; 95% CI: 9.0% to -6.3%; p<0.001) and then more gradually until 2015 (2.5 per 100,000 person; APC: -1.2%; 95% CI: 2.0% to 3.2%; p=0.01). In contrast, CAS increased steeply from 1997 to 2008 (from 0.1 to 0.6 per 100,000 person; APC: 20.7%; 95% CI: 15.6% to 25.9%; p=0.001) and then more gradually until 2015 (0.7 per 100,000 person; APC: 5.0%; 95% CI: 0.8% to 9.4%; p=0.02). In-hospital mortality (4.8% vs. 1.1%; p<0.001), iatrogenic stroke (4.3% vs. 2.3%; p<0.001) and cardiac complications (1.4% vs. 1.1%; p=0.001) were higher in CAS versus CEA throughout the study period.

Conclusions
Stroke rates in real world practice confirm the relative advantage of CEA over CAS (2.3% vs. 4.3%) found in CREST study (2.3% vs. 4.1%). However unlike CREST, we also found fewer cardiac complications after CEA versus CAS (1.4% vs 3.2%). Despite these data, CAS is increasing in frequency and CEA is becoming less frequent. Our data suggest a reappraisal of decision-making in carotid revascularization in the United States may be justified.
Figure 1. Trends and annual percentage change (APC) of age-adjusted incidence rate for diagnosis (A) and treatments (B) of symptomatic carotid artery stenosis in the United States, 1997-2015.

^ p<0.05

(Filename: TCT_2774_Figure1.jpg)
Integrating Computer Aided Detection in Every Day Multiple Sclerosis Follow-up Preserves Lesion Detection Accuracy Between Radiology Trainees and Neuroradiologists

A Dahan¹, C Malpas², F Gaillard²
¹Austin Health, Heidelberg, Victoria, ²Royal Melbourne Hospital, Parkville, Victoria

Purpose
There is growing evidence computer aided detection software can improve interpretation or categorization of various disease processes. Importantly, there is some evidence that these systems also reduce the performance gap between radiology trainees, general radiologists and subspecialty trained radiologists. VisTarsier, one such software which compares volumetric FLAIR sequences, has shown this in retrospective studies on patients with multiple sclerosis (MS), but whether this is reproducible in a real-life setting remains to be shown prospectively.

Materials and Methods
For every MS patient assessed with a new brain MRI having already had an older, similarly labeled and protocolled study, VisTarsier attempted to construct colour-mapped images as additional series for reporting. The number of studies with new lesions reported with software assistance by fellowship-trained radiologists was compared to that co-reported by accredited radiology trainees in a generalized linear mixed model adjusting for patient age, gender, disability and disease activity.

Results
760 study pairs from 431 patients over two years were included. The semiautomated software was used in all study pairs. 528 (69.5%) of studies were reported by a staff radiologist alone and 232 (30.5%) were co-reported. Of these, 110 (20.8%) studies reported by staff alone and 43 (18.5%) co-reported studies found new lesions. This difference was not statistically significant (P = 0.18).

Conclusions
Once implemented in real world clinical practice, the ability of assistive software to bridge the expertise gap between radiology trainees and staff radiologists in new demyelinating lesion detection is preserved.

Intra-procedural rupture of aneurysm during endovascular treatment: two centers experience

H JEONG¹, Y HEO¹, J Baek¹, D Kim¹, S KIM², J SEO², S Jin³
¹INJE UNIVERSITY, BUSAN PAIK HOSPITAL, BUSAN, Korea, Republic of, ²INJE UNIVERSITY, BUSAN PAIK HOSPITAL, BUSAN, KOREA, Republic of, ³INJE UNIVERSITY, HAEUNDAE PAIK HOSPITAL, BUSAN, Korea, Republic of

Purpose
The purpose of this study was to report our clinical experience of Intra-procedural rupture (IPR) during endovascular treatment of cerebral aneurysm.

Materials and Methods
Between January 2010 and October 2018, 19 times of IPR occurred in two center during endovascular treatment of cerebral aneurysm. Thirteen patients were women. Mean age was 57.1 years-old ranging from 26 to 77. Eleven cases were ruptured condition. Mean size of the aneurysms was 4.86mm ranging from 2.3 to 7.52mm.

Results
The most common location of IPR was anterior communicating artery (n=9). IPR developed at the procedural steps of coil framing (n=5), further coil packing (n=7), coil packing under stent jailing (n=6), and removal of coil delivery microcatheter after coiling (n=1). The locations of IPR were dome (n=9), bleb of the dome (n=5), neck (n=3), and trunk of dissecting aneurysm (n=2). In 5 cases, IPR occurred when the marker of coil delivery wire passed the proximal marker of the microcatheter. In 4 cases, the microcatheter protruded into subarachnoid space when packing coils into the aneurysm. IV heparin was used in 13 cases. Protamine sulfate for reversing heparin was in 4 cases. All cases of rescue management after IPR were performed without balloon occlusion. Additional stent was deployed in 2 cases. In all cases, angiographic occlusion of the aneurysm was eventually achieved. Compare with initial finding, change of hemodynamics in final angiography after coil embolization did not detected in any case. Mean contrast leakage time was 11.1 minutes ranging from 1 to 31 minutes. Immediate radiologic outcome was complete (n=12), residual neck (n=5), and residual sac (n=2). IPR related with focal neurological deficits developed in 2 patients all of who suffered from temporary motor weakness (grade IV). To control IICP or acute hydrocephalus, temporary external ventricular drain was performed in 8 cases (42.1%) but permanent VP shunt was performed in 2 cases presented initially with subarachnoid hemorrhage.

Conclusions
In our series, favorable clinical outcome may probably be expected if suitable rescue manage could be performed after IPR.
Intracranial arterial wall thickness is elevated and increases with reducing hematocrit in patients with sickle cell disease

S Yuan, L Davis, P COGSWELL, S Waddle, L Jordan, M Donahue

Vanderbilt University Medical Center, Nashville, TN, MAYO CLINIC, ROCHESTER, MN, Vanderbilt University, Nashville, TN, N/A, N/A

Purpose
Sickle cell disease (SCD) is a monogenetic disorder with a high risk of intracranial vasculopathy and stroke. While hematological measures of anemia and Doppler measures of intracranial flow velocity provide coarse metrics of disease severity, sensitive radiological indicators of cerebrovascular disease severity are needed to aid in treatment planning. We hypothesized that intracranial vessel wall imaging (VWI), which has been applied for characterization of intracranial plaque, could be applied to patients with SCD, and that reduced hematocrit and elevated flow velocity lead to concentric vessel wall thickening.

Materials and Methods
SCD patients (n=83; age (range)=19.4±8.2 (6-39) yrs; sex=36/47 M/F) and age-matched controls (n=38; age (range)=22.2±8.9 (8-39) yrs; sex=19/19 M/F) were consented and underwent a 3T brain MRI with anatomical imaging, time-of-flight angiography, VWI (3D turbo-spin-echo; TR/TE=1500/33 ms; refocusing sweep=40-120°; 0.5x0.5x1 mm). Images were reformatted in a plane orthogonal to the vessel course (Figure A,B) to measure mid basilar artery and bilateral supraclinoid internal carotid arteries (ICA) lumen and wall. Hematocrit was measured within 7 days of MRI. Variables were compared using a Student's t-test or Pearson's correlation. Regression analyses were performed using vessel wall thickness as the dependent variable and age, sex, vasculopathy extent, and hematocrit as explanatory variables (significance: two-sided p<0.05).

Results
Basilar wall thickness was significantly higher (p<0.001) in SCD patients (1.08 +/- 0.17 mm) compared to age-matched controls (0.90 +/- 0.10 mm) and was inversely related to hematocrit (p=0.028) (Figure C,D). On linear regression, an inverse relationship was found between basilar wall thickness and hematocrit (p=0.046) after controlling for age, sex, and vasculopathy. These finding were not significant when considering ICA wall thickness.

Conclusions
Hematocrit is inversely related to basilar vessel wall thickness in SCD, consistent with increased flow velocities and wall stress leading to concentric wall thickening. ICA vessel walls did not meet criteria for significance, possibly due to variable CSF signal suppression in these regions. Vessel wall thickness, which can be measured using non-invasive 3T VWI MRI, may provide a marker of cerebrovascular impairment in SCD patients.
Intradural venous varix: A rare spinal lesion.

S Patel
Hospital of University of Pennsylvania, Philadelphia, PA

Purpose
To describe a case of a rare entity of a serpiginous lesion in the lumbar spine which can mimic a tumor such as a nerve sheath tumor or ependymoma. To present the imaging findings of this entity to distinguish among the differential diagnoses considered for an intradural extramedullary spinal lesion.

Materials and Methods
A 58 year-old-man presented with a one-year history of low back pain and right hip and leg pain. He reports pain radiating through posterior thigh and leg provoked by sitting and leg raise. He denied any significant weakness, sensory changes or bowel/bladder dysfunction. He denies any prior relevant surgical history or trauma to the back. On neurologic examination, there is normal strength, bulk and tone as well as sensation in both lower extremities. Deep tendon reflexes are normal at the knee and ankle. Nerve conduction studies reveal normal right sural and superficial peroneal sensory responses and normal right peroneal and tibial motor response. Mild chronic denervation of the L5-innervated muscles was noted on EMG. Epidural steroid injections have only minimally relieved the symptoms. A lumbar spine MRI and MRA was obtained on further workup.

Results
Obtained as part of further workup, a MRI and multiphase MRA of the lumbar spine demonstrated a well-defined linear intradural extramedullary serpiginous lesion extending from L1-L3. The lesion was isointense to the spinal cord on T1-weighted sequences and demonstrated central high signal and peripheral low signal on T2-weighted sequences, representing the previously described "donut sign". On the MRA, there is homogenous enhancement in the venous phase (Fig 1 a-d). There was mild multilevel degenerative spondylotic changes of the lumbar spine without significant spinal canal stenosis, cord edema, cauda equina nerve root impingement or perimedullary flow voids. Fig 1. Sagittal pre-contrast T1 (a), T2 (b), and venous phase MRA (c) images illustrate a serpiginous intradural extra medullary lesion (arrows) extending from L1 to L3. Lesion demonstrates isointense signal to spinal cord on T1-weighted images, peripheral hypointensity and central hyperintensity on T2-weighted images (d, arrow).

Conclusions
Although spinal epidural varicosities are well-described in the radiologic literature, intradural venous varix is a rare entity and should be considered in the differential diagnosis of the serpiginous intradural lesions. Venous phase of enhancement and "donut" sign of T2 signal pattern can be important distinguishing imaging features.

(Filename: TCT_1838_Stitchedgraphic.gif)

Intraprocedural MRI during Acute Ischemic Stroke Intervention to Optimize Patient Safety in a Dedicated XMR Suite

K Narsinh1, D Cooke1, J Vitt1, K Mueller2, A Copelan1, D Murph1, S Hetts1
Purpose
To demonstrate that integration of MRI into the x-ray neuroangiography suite can provide vital information regarding cerebral infarct volume and location that can alter the plan for reperfusion therapy.

Materials and Methods
During mechanical thrombectomy to recanalize a right middle cerebral artery (MCA) occlusion causing an acute ischemic stroke, intracranial atherosclerotic disease causing MCA stenosis was discovered. Intracranial stenosis is often treated with stenting, which carries a higher risk of intracranial hemorrhage compared to mechanical thrombectomy alone. Therefore, determining the presence and extent of viable brain tissue in the right MCA territory became of critical importance to intraprocedural decision-making. Intracranial stenting could only be considered if there remained a large volume of viable brain tissue in the right MCA territory beyond the persistent high grade stenosis. An intraprocedural MRI was obtained to determine the extent of core infarct. Specifically, diffusion-weighted MRI (b-value=1000 s/mm²) was obtained and compared to intraprocedural cone beam flat panel CT and CT perfusion data. The intraprocedural MRI ultimately supported stopping further intervention that would have increased the patient's risk of intracerebral reperfusion hemorrhage, without substantial clinical benefit.

Results
Figure 1: Unenhanced head CT demonstrating multiple areas of subtle hypoattenuation in the right middle cerebral artery distribution (ASPECTS score of 6). Figure 2: CT perfusion maps demonstrating a large area of tissue at-risk in the right MCA territory. Figure 3: Right common carotid arteriogram prior to attempted thrombectomy demonstrates occlusion of the distal M1 segment of the right MCA (TICI 0). Figure 4: Right internal carotid arteriogram after three thrombectomy passes demonstrates antegrade flow through a high-grade stenosis in the right distal M1 MCA, with antegrade flow into the posterior M2 division but persistent occlusion of the anterior M2 division of the right MCA. Figure 5: Axial DWI and ADC map demonstrates a large region of reduced diffusion in the right MCA territory, compatible with cytotoxic edema due to acute infarct. (ADC=403 x 10⁻⁶ mm²/s). Figure 6: One-Stop Neurovascular Diagnosis and Intervention: Combined X-Ray and MR (XMR) Suite Workflow.

Conclusions
Hybrid angiography-MRI units offer a unique capability to inform neurointerventionalists of the viability of the tissue they are attempting to salvage during complex cerebrovascular interventions.
Introducing a logfile-based MR workflow analysis and efficacy analysis of Compressed SENSE acceleration

T. Boppel¹, A. Frydrychowicz², P. Schramm³, J. Barkhausen², T. Amthor⁴, J. Borgert⁴
¹University hospital Schleswig-Holstein, Luebeck, Germany; ²University hospital Schleswig-Holstein, Luebeck, SH, ³Institute of Neuroradiology, Luebeck, SH, ⁴Philips Research Europe, Hamburg, HH

Purpose
Optimization of radiology workflow requires a good understanding of operational characteristics of imaging systems, such as the true MR scanner usage times or idle time distribution. This information is usually not readily available. Here, we introduce a log file-based analysis to determine operational parameters and investigate the impact of introducing Compressed SENSE (CS) acceleration (Lustig et al 2007) to a clinical workflow.

Materials and Methods
Analyses were performed on data retrieved from a 3T MR scanner (Ingenia, R5.4, Philips, Best, NL). Anonymized logfiles were automatically and continuously analyzed to extract a plethora of information. For analytic purposes, the total exam duration (Texam) defined as the time span from the first to the last patient table motion for each exam, the net scan time (Tscan) defined as the total time the scanner is actively acquiring images, and the number of exams per slot (n) were extracted. To quantify the effect of CS acceleration, data before and after introduction of CS to two frequently used, standardized protocols ("metastasis", MET; "large FOV neurography" NGR) performed during a 4-hour slot every day were analyzed over an analysis period of 2 months. Results are given as means and standard deviations of all parameters, as well as box plots.
Results
The logfile analysis was successfully introduced and performed over the entire analysis period. CS resulted in a reduction of the average Texam of NGR by 21% (81.1±14.6min to 64.4±12.3min, p=0.023) and of MET by 31% (32.0±9.2min to 22.0±5.4min, p=0.001). Tscan was decreased by 24.0% (20.2±2.7min to 15.4±4.1min, p=0.0004) and 25.6% (50.4±4.8min to 37.5±8.1min, p=0.001), respectively. The number of exams per day within the slots increased from 3.7±0.8 to 5.0±1.2.

Conclusions
We have successfully introduced a logfile-based analysis tool allowing analysis of the MR workflow. Specifically, the effect of introducing the image acceleration technique Compressed SENSE was analyzed indicating the potential of such methods to scan more efficiently. The tool will be expanded to fully appreciate the complex information available through a logfile analysis.

(Filename: TCT_1415_Figure1_new.gif)

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Investigating the MIPS Value Pathways Potential Impact on Neuroradiology

O Schoeck1, M Chen2, L Golding3, K Wang4, J Hirsch5, G Nicola6, R Lee1
1Albert Einstein Medical Center, Philadelphia, PA, 2MD Anderson Cancer Center, Houston, TX, 3N/A, N/A, 4Baylor College of Medicine, Houston, TX, 5Massachusetts General Hospital, Boston, MA, 6Hackensack Radiology Group, Hackensack, NJ

Purpose
The 2020 Medicare Physician Fee Schedule Notice of Proposed Rulemaking introduced the MIPS Value Pathways (MVP), a significant modification of the current implementation of the Merit-based Incentive Program (MIPS). Whereas each category in MIPS is a discrete entity that is measured separately, the proposed framework of MVP revolves around aligning performance categories with a specific specialty or condition. The purpose of this project is to explore the potential role for neuroradiologists in these pathways.

Materials and Methods
The components of MVP as proposed in the 2020 Medicare Physician Fee Schedule will be discussed and analyzed based on the Medicare Physician Fee Schedule Notice of Proposed Rulemaking and 2020 Medicare Physician Fee Schedule Final Rule. We will propose how neuroradiologists can participate and partner with other physicians in these pathways.

Results
The rationale behind the proposed MVP concept is to develop measures for clinicians more relevant to specific specialties or conditions as well as to reduce complexity and burden of reporting to ease the pathway towards alternative payment models. To that end, a disease specific pathway which incorporates the core principles of MVP may be an opportunity for neuroradiologists to engage in multidisciplinary care to reduce costs by ensuring accurate diagnosis of disease processes, developing imaging parameters to predict best treatment outcomes for patients, and decreasing inappropriate use of imaging.

Conclusions
The MVP framework utilizes the basic concepts of the Merit-based Incentive Pathway and aims to make the measurements more relevant to specific diseases or conditions. Neuroradiologists must engage with their health system, referring providers and patients to...
help reduce costs and improve outcomes. MVPs are a potential mechanism for neuroradiologists to demonstrate their value and provide higher quality, lower cost care for their patients.

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Ischemic optic neuropathy, an unfortunate case

K Raghuram1, R Chaudhary1, T Shestopalova2
1University of Texas Medical Branch, Galveston, TX, 2UTMB, Galveston, TX

Purpose
Sudden blindness after operative procedures like spinal, abdominal and cardiac surgery resulting in significant blood loss but ischemic optic neuropathy following craniotomy has been less often described. This mishap is usually anticipated in older patients who have multiple cardiac and vascular comorbidities. We present a case of young patient with recurrent meningiomas who developed bilateral visual loss following craniotomy.

Materials and Methods
Case: A 25 year old male with prior craniotomy for resection of extensive meningioma had recurrence of frontoparietal meningioma with hyperostosis as well as bone destruction and involvement of superior sagittal sinus on follow up imaging. Patient had no visual symptoms prior to surgery. Surgery was uneventful except for fluctuation in blood pressure and heart rate due to which operation had to be staged for a later date. Echocardiogram showed ventricular hypertrophy and hemohydrothorax. Patient developed diplopia, eye pain, blurry vision 12 days after surgery on left side and after 3 weeks on right side. There was notable pain with upwards and lateral gaze, bilaterally. There was progressive loss of vision which did not improve over follow up period of two weeks.

Results
Non arteritic anterior ischemic optic neuropathy is a commonly encountered predominantly in patients older than 60 years with other cardiovascular comorbidities following abdominal or spine surgery. Ischemic optic neuropathy have been reported to occur after uncomplicated craniotomy. Significant proportions of patients without cardiovascular risk factors have also been occasionally associated with non arteritic ischemic optic neuropathy. Migraine has been associated with this in young patient. Hypotensive drugs have been held culprit in some cases. Patient can also present days to weeks after the inciting event.

Conclusions
Ischemic optic neuropathy can be a complication few weeks following craniotomy even in young patient.
Isolated Cortical Vein Thrombosis Presenting as a Mass-like Lesion Near Eloquent Cortex with Atypical Findings on CTV and MRV

M Maher\(^1\), O Rapalino\(^1\)

\(^1\)Massachusetts General Hospital, Boston, MA

Purpose
The purpose of this case report is to review imaging characteristics of isolated cortical vein thrombosis and highlight the importance of a high index of suspicion when evaluating a cortical/subcortical mass-like lesion.

Materials and Methods
After a transatlantic trip, a 63-year-old woman developed expressive aphasia, right upper extremity weakness and right facial twitching followed by a tonic-clonic seizure. On physical examination, she had expressive hesitancy, dysarthria, and right facial weakness. Routine labs, CSF analysis, infectious and autoimmune studies were normal.

Results
On initial MRI, there was a T2 hyperintense, expansile mass-like lesion centered on the left subcentral cortex and subcortical white matter.
matter. There was susceptibility signal and curvilinear enhancement within the lesion without abnormal restricted diffusion. Five days later, the T2 hyperintense lesion had increased in size, and the patient was referred to our institution for further evaluation. On admission, there was no dural venous sinus or certain cortical vein filling defects on CTV and MRV, although nonspecific narrowing and irregularity of left frontoparietal cortical veins could only be appreciated retrospectively. MRI showed increased parenchymal and leptomeningeal enhancement. There was also increased T1 hyperintensity and prominent susceptibility signal in the left subcentral gyrus, adjacent left frontoparietal opercula, and left posterior subcentral sulcus. The lesion had decreased cerebral blood volume and cerebral blood flow on DSC perfusion. MRS showed decreased Cho/Cr ratios, preserved Cho/NAA ratios and prominent lipid/lactate peaks within the left opercular lesion. On follow up imaging, the left frontal lesion spontaneously decreased in size and showed new linear asymmetric susceptibility and T1 hyperintense signal within a more rostrally located cortical vein, which extended to the superior sagittal sinus confirming the diagnosis of cortical vein thrombosis.

Conclusions
Isolated cortical venous thrombosis is an uncommon cause of infarcts and hemorrhage, often affecting young individuals. The mass-like presentation can be confusing and trigger additional diagnostic studies and invasive procedures. Cortical pattern of hemorrhage with surrounding parenchymal edema, abnormal susceptibility signal within an adjacent sulcus or cortical veins, decreased cerebral blood flow, and relatively preserved Cho/Cr ratios with prominent lactate peaks can help increase our diagnostic confidence.

(Filename: TCT_2732_MaherExcerpta.jpg)

1601

Isomorphic Diffuse Glioma: A Rare Epileptogenic Neoplasm

B Burkett1, C Giannini1, K Miller1, I Parney1, J Morris2
1Mayo Clinic, Rochester, MN, 2N/A, N/A

Purpose
To present the imaging characteristics of a rare temporal lobe neoplasm, discuss the differential diagnosis, correlate with final pathology, and review the literature of this distinct entity, which has implications for prognosis and treatment.

Materials and Methods
A 20 year-old patient with a nearly life-long history of seizure-like episodes experienced an acute spell of dizziness, left sided tingling, and an electrical sensation in her neck. An imaging workup revealed an abnormality in the right temporal lobe. Video-EEG monitoring demonstrated right temporal lobe epileptiform discharges. Early resection of the lesion was performed, including a limited anterior hippocampectomy along with a limited amygdala resection, felt to be the intervention most likely to preserve long-term quality of life, limit the subsequent anti-epileptic treatment required, and increase long-term survival. She tolerated the procedure well.

Results
Anterior right temporal lobe lesion predominantly within the subcortical white matter, with homogeneous T2-hyperintensity, mild mass effect, and subtle involvement of the anterior inferior temporal gyrus cortex (Image A and B). The lesion demonstrated diffusion restriction (not pictured), with no contrast enhancement (Image C). The imaging presentation favored a low-grade glioma versus focal cortical dysplasia.

Conclusions
Final pathology demonstrated oligodendroglial-like cells primarily in the white matter and extending to the overlying cortex,
suggestive of an extremely low-grade diffuse glioma (Image D). Molecular studies revealed a MYBL1-MAML2 (exon 9:exon 3) fusion. This MYBL1-altered glioma is consistent with an unusual and rare entity, an isomorphic diffuse glioma subtype, which contains recurrent MYBL1-MAML2 gene fusions. This molecular glioma subtype differs significantly from other diffuse gliomas (WHO grade II). Despite the diffuse growth pattern, the isomorphic subtype behaves as WHO grade I tumor with low proliferation and a distinctly favorable clinical course. As illustrated in this case, this tumor is associated with long-term epilepsy and can occur in children and adults. Following resection, 89% of patients remain seizure-free, with favorable long-term survival. The imaging features of this case are typical of this entity, with homogenous T2/T2 FLAIR hyperintensity, T1 hypointensity, mass effect, and the absence of contrast enhancement.

(Filename: TCT_1601_IsomorphicDiffuseGliomaAbstractFigure.gif)

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Low Tube Voltage in Cerebral Computed Tomographic Angiography: a quantitative and qualitative comparison with addition of New Adaptive Statistical Iterative Reconstruction-V (ASIR-V)

P LAI

1DEPARTMENT OF RADIOLOGY, KAOSHIUNG VETERANS GENERAL HOSPITAL, KAOSHIUNG, Taiwan

Purpose

To compare the image quality and radiation dose under a 70-kVp protocol with the effect of New Adaptive Statistical Iterative Reconstruction (ASiR-V) and contrast amount in a 160mm coverage axial scan mode.

Materials and Methods

A total of 121 healthy individuals were enrolled and divided to one of three groups: group A: 70 kVp, 60 mL of CM, filtered back-projection reconstruction (FBP); group B: 70 kVp, 60 mL of CM, 50% ASiR-V; group C: 70 kVp, 45 mL of CM, 50% ASiR-V. All of these three groups were scanned in a 160mm axial scan mode 256-slice CT. Objective (Hounsfield units, signal-to-noise ratio [SNR], and contrast-to-noise ratio [CNR] of cerebral arteries) and subjective image quality as well as radiation dose (volume CT dose index [CTDlvol], dose-length product [DLP], and minisievert [mSv]) were compared among these three groups. The objective parameters were analyzed by student’s t-test. Two experienced radiologists independently evaluated the subjective image quality, and inter-rater reliability was calculated using kappa (k) analysis. For all statistical analyses, P value < 0.05 was considered significant.

Results

In objective image quality including arterial attenuation, SNR and CNR, there was no statistically significant difference between group A and B. However, the CTDIvol, DLP and mSv of group B were more than half lower than those of group A. The arterial
attenuation, SNR, CNR of group B were better than those of group C. In subjective image quality, no statistical significance was found between group A and B. The inter-rater reliability was excellent, with a k value of 0.81.

Conclusions
In low tube voltage protocol associated with new adaptive statistical iterative reconstruction of cerebral computed tomographic angiography, the radiation dose was much lower than filtered back-projection reconstruction and the objective and subjective image quality had no significant difference.

1953
Low yield of Vascular Findings in patients with Transient ischemic attack (TIA) and Minor Stroke undergoing CTA Head and Neck imaging in the Emergency Department

Y. Salam1, J. Mandzia2, A. Haghighat3, P. Ohorodnyk4, A. Para4, S. Fridman5, M. Jurkiewicz6, A. Leung6

Purpose
There is a 10% risk of recurrent stroke within 90 days after a TIA or minor stroke, with the majority of these occurring within 48 hours of their TIA(1-3). It is therefore imperative to urgently identify the high risk patients and to implement early, appropriate treatment(4).

Conclusions
Early vascular imaging is recommended by stroke guidelines in patients with TIA and minor stroke within 24 hours of acute symptoms. Despite a high number of patients being diagnosed as a vascular event clinically, pick-up rate for symptomatic vascular disease was low. Future analyses will determine which are the most likely symptoms and patient characteristics which predict large vessel disease which warrant initial CTA in TIA/minor stroke patients first assessed by ED physicians.

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Machine Learning Based Detection of Infiltrative Tumor within Non-Enhancing Peritumoral Regions

R. Wujek1, M. Prah1, K. Schmainda1
1Medical College of Wisconsin, Milwaukee, WI

Purpose
Glioblastoma is an especially aggressive form of brain tumor with a median overall survival of 15 months[1]. Tumor extent is typically identified by T1 weighted contrast enhancement, with the assumption that peritumoral FLAIR hyperintensity, or non-enhancing lesion (NEL), is edema alone. However, NEL may include infiltrative tumor that is undetectable on standard imaging. In the current study, a convolutional neural network (CNN) is trained using multiparametric MR inputs as predictive features and biopsy ground truths to classify voxels as tumor or non-tumor within NEL.

Materials and Methods
Dataset: This study used samples from 78 brain tumor patients with pre-operative MRI (T1, T1+C, T2, FLAIR, DWI, and DSC). Tissue samples were collected from patients with invasive brain tumor and samples in NEL were co-localized to imaging (n=72). To achieve a balanced class representation, "virtual biopsies" in NEL were sampled from patients with meningioma (n=1) and metastasis (n=5), and assumed non-infiltrative. 232 samples total were used in this study (TABLE1). Imaging was resampled to 1mm3, bias
corrected using N4ITK[2], and normalized to white matter[3]. ADC, nRCBV, and nRCBF maps were extracted from DWI and DSC. 3D patches centered at biopsy sites were extracted from imaging. Model/Training: A 3D CNN capped with fully connected layers (FIGURE1) was trained to discriminate between tumor and non-tumor tissue using the previously described imaging as inputs and corresponding pathology as outputs. Softmax cross entropy with an L2 regularization penalty ($\lambda=1e^{-4}$) was used for the loss function and RMSProp ($lr=1e^{-3}$, decay=.9, momentum=.9) was used for the optimizer. k-fold cross validation methods (k=10) were used to reduce bias in model evaluation, and data augmentation methods (rotation/flip) were used to increase the training dataset size. The model was trained on a single Nvidia Tesla K40 gpu.

Results
Cross validation results are given in TABLE2. Without alternative methods for comparison, performance would be compared to random guess over 232 samples, shown in TABLE3. All metrics range from .83-.89 for the proposed method, beating the random guess.

Conclusions
These preliminary results demonstrate potential for CNNs to identify infiltrating tumor in peritumoral NEL and provide motivation for continued investigation. In future iterations, this voxel-wise method can be expanded to generate predictive infiltrative tumor burden maps without the need for invasive biopsies. Clinically, such a map would improve patient outcome by guiding treatment plans.
### TABLE 1. Dataset Description.

<table>
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<th>Biopsy Type</th>
<th>Sample Classification</th>
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<tbody>
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<td></td>
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<td>16</td>
<td>80</td>
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<tr>
<td>Virtual Biopsies</td>
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<tr>
<td></td>
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FIGURE 1. Model Architecture. The network consists of 4 convolutional layers, 2 pooling layers, and 2 fully connected layers as schematized above. A softmax function applied to the output determines tumor vs non-tumor.

### TABLE 2. Cross-Validation Results. Results are averaged over each fold of training.

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### TABLE 3. Random Guess Results.

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Medicare for All Legislation: Potential Financial Implications for Neuroradiologists.

T Nguyen 1, J Hirsch 2, J Savoie 1, J Milburn 1
1Ochsner Clinic Foundation, New Orleans, LA, 2Massachusetts General Hospital, Boston, MA

Purpose
Recently, Medicare for All (MFA) has become the subject of national debate and two MFA bills have been formally introduced to Congress. The fundamental objectives of the Medicare for All Acts of 2019 are summarized in Figure 1. To examine financial implications for neuroradiologists in moving to the MFA system, a model scenario was created to estimate the change in professional component (PC) reimbursements for a case mix of head CTs and MRIs.

Materials and Methods
CPT codes for head CTs and MRIs were used to obtained volumes of those procedures in 2018 across 12 centers within a large health system in Louisiana. Medicare PC fees were obtained from the Physician Fee Schedule database for 2018. Two scenarios are presented for Medicaid fees. One uses LA Medicaid fees for non-hospital services in 2018, which are published on the LA Medicaid website. Hospital-based Medicaid fees are not published and vary based on hospital cost-to-charge ratios. We derived Medicaid fees for each CPT using an averaged Medicaid to Medicare reimbursement ratio for radiology procedures performed at our institution, which was 0.9. A third scenario was modeled with an inpatient payer mix since the general population's insurance coverage may not accurately reflect the payer mix of patients undergoing imaging. Commercial insurance fees were estimated as 200% of Medicare based on data from the Congressional Budget Office (CBO) and Health Care Cost Institute (HCCI).

Results
The neuroradiology case mix of head CTs and MRIs in a large health system in LA comprised of 72% CT and 28% MRI (further stratification by contrast in Table 2). If all uninsured, Medicaid, and privately insured patients in LA are transitioned to Medicare, we project a 20-36% reduction in PC fees for this case mix. The change is smaller in the inpatient model since Medicare is more prevalent in this population.

Conclusions
As key stakeholders in healthcare, physicians should carefully scrutinize emerging legislation. Transitioning from the current privately and publicly funded system to the proposed MFA model could result in significant reductions in neuroradiology reimbursements. Further research is needed to examine other factors, e.g. cost savings opportunities, in evaluating MFA’s impact on radiology. Another limitation of this study is the commercial insurance fees are estimates. Further research is being conducted utilizing actual claims data from IMB Watson MarketScan database suggesting commercial reimbursements may be less than initial projections.

(Filename: TCT_2223_ASNR_figure2.jpg)
Methotrexate-Induced Encephalopathy in a Pediatric Patient with Crohn’s Disease Complicated by Psychiatric Illness

M Barry¹, N Karr²
¹Vidant Medical Center/Brody School of Medicine, Greenville, NC, ²East Caroline University/Brody School of Medicine, Greenville, NC

Purpose
To describe a case of methotrexate-induced encephalopathy in a pediatric patient with Crohn's disease complicated by a psychiatric illness.

Materials and Methods
The patient is a 13 year old female with a history of Crohn's disease and mental illness who presented with progressively worsening intermittent ataxia, dizziness, diplopia, somnolence and dysphagia over three weeks. She had 3 separate emergency room visits in the prior 2 weeks for similar symptoms and was treated for exacerbation of her mental illness. She had several psychiatric diagnoses including Asperger's syndrome, ADHD, ODD, bipolar disorder, depression and anxiety. She was on several medications including methotrexate for Crohn's disease and 4 medications for her psychiatric illnesses. She took a multivitamin and folate. Her physical examination was unremarkable. Lab values were within normal limits. CT demonstrated low attenuation in the basal ganglia but was otherwise negative. Results of an LP were essentially negative. MRI demonstrated symmetric bilateral T2 hyperintensity in the corpus callosum, putamen and caudate, mammillary bodies and dorsal midbrain. There was mild, patchy enhancement in the basal ganglia and mammillary bodies. The likely diagnoses presented by the radiologist were Wernicke's encephalopathy or metronidazole-induced encephalopathy. The patient's thiamine level was normal and therefore, a diagnosis of methotrexate toxicity was suspected. Metronidazole was discontinued, symptoms resolved and repeat MRI in 6 weeks was normal.

Results
There was bilateral, symmetric increased T2 signal in T2 and FLAIR image sequences in the mammillary bodies, putamen and caudate nuclei, the dorsal midbrain and the corpus callosum. There was no associated restricted diffusion.

Conclusions
There are no previously reported cases of metronidazole induced encephalopathy in a pediatric patient with a history of inflammatory bowel disease. This patient's diagnosis was complicated by a psychiatric history which delayed the diagnosis. Methotrexate is a relatively safe and effective drug used to treat several infectious and inflammatory diseases. Neurotoxicity is a rare complication. Metronidazole-induced encephalopathy is not dose-dependent nor correlated with duration of drug exposure. In this patient, the history of psychiatric illness likely delayed the diagnosis due to bias/diagnostic overshadowing. The radiologist is in the unique position to first diagnosis this rare disease and if diagnosed early, is potentially reversible.
Micro-CT and electron-microscopy of the extracted clot in human stroke

K Lovblad\textsuperscript{1}, d botta\textsuperscript{2}, D Dumitriu LaGrange\textsuperscript{2}, M Vargas\textsuperscript{3}, p machi\textsuperscript{4}, g bernava\textsuperscript{3}

\textsuperscript{1}N/A, N/A, \textsuperscript{2}HUG, geneva, geneva, \textsuperscript{3}geneva university hospitals, geneva, geneva, \textsuperscript{4}Geneva University Hospitals, geneva, geneva

Purpose
Thrombectomy is performed more and more in first intention with a variety of devices. In order to facilitate extraction, knowledge of the red blood cell vs fibrin composition could be helpful. The aim of this abstract is to investigate the composition of extracted human clots with dual-source CT, micro-CT and electron microscopy.

Materials and Methods
20 patients (ages: 34-90) who were referred to our institution for acute stroke underwent dual-source CT in the emergency department. After thrombectomy, the clots were examined on a micro-CT unit (Quantum GX) and then prepared and examined using electron microscopy. For the analysis of the clinical and micro CT, the images were uploaded to a computer using OsiriX.

Results
There was concordance between the Hounsfield units found on the Dual CT images and the values on the micro-CT. Denser clots were found to have a higher red blood cell content on electron microscopy than white clots. Electron microscopy was able to identify the different components of the clot (red blood cells, white blood cells, fibrin) as well as demonstrate interaction between the stent and the clot in 3 cases where the stent was examined with the clot both on micro-CT and electron microscopy.

Conclusions
Micro-CT and electron microscopy confirm that clinical CT can identify clots with various components. This may allow in the future to determine what type of treatment is to be undertaken (aspiration, stentriever use or even fibrinolysis).

Microstructural Changes in Major White Matter Tracts are Associated with Symptomatic Disease Progression in Autosomal Dominant Familial Alzheimer's Disease

J Prescott\textsuperscript{1}, K Roy Choudhury\textsuperscript{2}, J PETRELLA\textsuperscript{3}
\textsuperscript{1}Case Western Reserve University, MetroHealth Medical Center, Cleveland, OH, \textsuperscript{2}Duke University, Durham, NC, \textsuperscript{3}DUKE UNIVERSITY MEDICAL CENTER, DURHAM, NC

Purpose
To evaluate diffusion changes in major white matter tracts in subjects with (M+) and without (M-) autosomal dominant familial Alzheimer's disease, and to determine whether these changes correlate with mutation carrier status and, for carriers, estimated years until symptom onset and diagnostic group.

Materials and Methods
We studied subjects enrolled in the Dominantly Inherited Alzheimer's Network (DIAN) who had T1-weighted MRI and diffusion tensor (DT) imaging MRI at baseline. Diagnostic groups were normal cognition (NC), mild cognitive impairment (MCI), and Alzheimer's dementia (AD). Eighteen major white matter tracts were automatically extracted from DT images using FreeSurfer's TRACULA software. Average fractional anisotropy (FA), mean diffusivity (MD), axial diffusivity (AxD), and radial diffusivity (RD) were calculated per subject for each tract. Adjusting for age, sex, years of education, and MMSE score, a general linear model was used to assess the tract metrics as a function of the following: 1) diagnostic group (AD, MCI, NC) among M+ subjects, 2) EYO among M+ subjects, and 3) mutation status (M+ or M-) among cognitively normal subjects. All analyses were corrected for multiple comparisons using false discovery rate adjustment.

Results
There were 106 subjects analyzed: 62 M+ and 44 M- (see Table 1 for subject characteristics). Tract metrics significantly changed in most major white matter tracts in M+ subjects as they progressed from NC to MCI to AD, generally with increasing RD, AxD, MD and decreasing FA (Table 2). There was no significant change in tract metrics with EYO in M+ subjects. There was no significant difference in tract metrics between cognitively normal M+ and M- subjects.

Conclusions
There are significant changes in diffusion metrics in large white matter tracts in M+ ADAD subjects with progression from NC to MCI to AD. These changes are consistent with microstructural breakdown along these tracts with symptomatic progression of disease.
MR Imaging Features of Spinal Cord Cavernous Malformations with a Focus on Intramedullary Hemorrhage at Initial Presentation

A Panda¹, F Diehn¹, D Kim¹, M Bydon¹, A Goyal¹, J Benson¹, C Carr¹, L Rinaldo¹, K Flemming¹, G Lanzino²

¹Mayo Clinic, Rochester, MN, ²Mayo, Rochester, MN

Purpose
There is a relative paucity of radiologic literature on intramedullary spinal cord cavernous malformations (SCMs). Adjacent intramedullary hemorrhage (IMH) is an important clinical feature in SCM but has not been well evaluated on imaging. We aimed to review MR imaging features of SCMs with a focus on adjacent IMH at the time of initial presentation.

Materials and Methods
MRI of 78 SCMs in 76 patients diagnosed either on imaging or pathology at our hospital between 1995 and 2016 were retrospectively evaluated for size, longitudinal and axial location, cord expansion, exophytic component, popcorn morphology, signal characteristics.
including rim of peripheral signal in T1w and T2w, blood-fluid levels and adjacent IMH. Adjacent IMH was defined as T2w hypointense linear or flame-shaped signal intensity extending from the SCMs in one or both directions on sagittal images. The axial location was noted as eccentric/central or both.

Results
A majority of SCMs (45%, 35/78) were located in the cervical spine, 63% (49/78) measured less than 1 cm in length, 65% (51/78) were expansile, 21% (17/78) were deep within the cord, 78% (61/78) extended to the cord surface, and 32% (25/78) were exophytic. Most lesions were heterogeneous (79%, 62/78) on T1w and on T2w (83%, 65/78). However, popcorn morphology was seen in only 15% (12/78) on T1w and 22% (17/78) on T2w. Internal blood-fluid levels were evident in 4% (3/78) of SCMs. While 69% (54/78) had T2w hypointense rims, the T2w rims were complete/near-complete in only 37% (29/78). On T1w, rims around lesions were visible in 49% (38/78), of which 22 were T1w hyperintense and the remaining T1w hypointense. Adjacent IMH was seen in 56% (44/78), of which seven were flame-shaped while 37 were linear in morphology. These blood-products were seen on T2w in 41 SCMs; in the remaining 3, blood products were identified only on gradient-echo images (n = 2), or on gradient-echo and T1w images (n = 1). In addition to T2w images, adjacent IMH was also visible on T1w images in 27 cases, signaling T1w hyperintense in 33% (9/27) and T1w hypointense in the remaining 67% (18/27). Adjacent IMH was most commonly bidirectional in 66% (29/44) and eccentric in 68% (30/44). Cord edema was seen in 22% (17/78), and 43% (7/17) among these had IMH with edema.

Conclusions
The classically described popcorn morphology and blood-fluid levels were seen in minority of SCMs, 22% and 4% respectively. A complete T2w rim was also not very prevalent (37%). Adjacent intramedullary hemorrhage was commonly observed (56%), typically bidirectional (66%) and eccentric (68%) within the cord.

Sagittal T1w (A), T2w (B) and gradient-echo (C) images show an eccentric T1w isointense (black arrow, A) and T2w hyperintense (black arrow, B) cavernous malformation with an incomplete T1w hypointense rim, near complete T2w hypointense hemosiderin rim and flame-shaped intramedullary hemorrhage extending superriorly and inferiorly (white arrows, B, C). The intramedullary hemorrhage is also visible as hypointensity on T1w (A). On the axial T2w (D) image, the hemorrhage is eccentric in location and abuts the dorsal cord surface (dotted white arrow).

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MRI finding of spinal decompression illness

A Sakata
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1Japanese Red Cross Wakayama Medical Center, Wakayama, Wakayama

Purpose
To describe a case of severe spinal decompression illness with emphasis on the appearance on MRI.

Materials and Methods
A 63-year old man was transferred to our hospital because of a scuba diving accident: he reportedly went up very fast from a depth of 20 meter. He developed bilateral leg weakness, numbness and dyskinesia 2 hour later. Initially, his symptoms waxed and waned, then gradually worsened. Diagnosis of decompression sickness was made, and immediate hyperbaric oxygen therapy was initiated, followed by infusion therapy and administration of steroid. Despite the treatment, he developed paraplegia on day 2. Spinal MRI on day 2 showed abnormal swelling as well as increased signal intensity affecting the whole spinal cord. The lesions were in the dorsal part of the white matter as well as in the gray matter. Brain MRI detected old ischemic change only. Although hyperbaric oxygen therapy was continued, there was little improvement in his symptom. He was transferred to other hospital for further treatment.

Results
CT on day 1 revealed fine air bubble in the retroperitoneum, which was consistent with decompression sickness. Thoracic MRI showed extensive increased signal in the entire spinal cord on T2-weighted image. Axial T2-weighted image demonstrated abnormal signal in the gray matter as well as dorsal white matter.

Conclusions
As recreational diving has become more popular, diving-related complication are more frequent. Decompression illness results from sudden reduction in the pressure to which the body is subjected during rapid ascent. Symptoms result from gas babbles causing microembolic events which leads to local hypoxia and ischemia. Spinal involvement occurs in 10-30% of cases, but the incidence of MRI documented abnormality is relatively low. In this case, we found extensive lesion affecting both gray and white matters of the entire spinal cord. Considering the difference of arterial supply between cervical and thoracic and/or lumber spinal cord, this case suggest that mere arterial infarction was unlikely pathophysiology of decompression sickness of spinal cord.

MRI TIA Protocol Order Change Reduces Cost and Redundant MR Angiographic Imaging

I Dragusin1, H Dearborn2, I Sanford3, D Belgam2, R Galindo2, A Betts2
1San Antonio Uniformed Services Health Education Consortium, San Antonio, TX, 2San Antonio Uniformed Services Health Education Consortium, Fort Sam Houston, TX

Purpose
Brain MRI and cross sectional angiography of the brain and neck following transient ischemic attack (TIA) is standard of care
according to the American College of Radiology (ACR) appropriateness criteria with CT angiography (CTA) equivalent to MR angiography (MRA). Our EMR order lead to redundancy because there was no option to tailor the degree of MRA with brain MR in patients who already had CTA which exposed patients to unnecessary testing and wasted resources. Our objective was to determine if changing the EMR order and providing clinician training for vascular imaging would save hospital resources and reduce redundant vascular imaging during the care of TIA patients.

Materials and Methods

We implemented a new EMR order set of TIA imaging and provided training using an imaging algorithm for the internal medicine department. The order set was named MR TIA 1 (MR brain only without contrast), MR TIA 2 (MR brain + MRA brain + MRA neck without contrast) and MR TIA 3 (MR brain + MRA brain + MRA neck, with and without contrast). We replaced the classic MR TIA protocol (cMR TIA) which is equivalent to MR TIA 3. The change in the EHR and clinician training was implemented in October 2018. Using paired t test the cMR TIA from October 2017 to February 2018 was compared to the new MR TIA 1,2, and 3 from October 2018 to February 2019 to test for difference in monthly mean number of orders, scanner time and billable cost. We used current procedural terminology (CPT) codes to calculate the Centers for Medicare & Medicaid Services (CMS) billable cost of TIA imaging in our region of the United States.

Results

Following the order set change and training the total mean billable cost per month was reduced by 38.3% saving $31,120.20 per month. The mean number of MR TIA 3 compared with cMR TIA orders per month was reduced by 55.6%. The sum of mean numbers of MR TIA 2 and MR TIA 3 compared with cMR TIA per month was reduced by 35.9%. These findings were statistically significant. The sum of mean numbers of MR TIA 1,2 and 3 compared with cMR TIA was not significantly different.

Conclusions

Redundant vascular imaging does not add value to patient care and is a waste of resources. Our data suggests that replacing a single MR TIA order set with multiple options and training providers may ameliorate this. This intervention resulted in significant reduction in MRA cost while the total number of brain MRI has not changed thus maintaining standard of care for TIA patients.

1519

Myofibroblastic Pseudotumor of the Neuraxis

A Kanwar1, B Branstetter2
1UPMC, Pittsburgh, PA, 2UPMC, Wexford, PA

Purpose

Myofibroblastic pseudotumor (also known as inflammatory pseudotumor or plasma cell granuloma) is an uncommon, benign mass consisting of inflammatory cells and a fibrous stroma, generally described in the breast, lung, liver and gastrointestinal tract. These masses are rarely seen in the spinal cord. The first instance of a spinal cord myofibroblastic pseudotumor was reported in 1978 and only a handful of histologically-proven cases have been published since that time. We present a case of a myofibroblastic pseudotumor of the lumbosacral spine with leptomeningeal enhancement in the brainstem, cervical spine and thoracic spine.

Materials and Methods

A 39-year-old male presented with one year of worsening low back pain that radiated to his thighs. The patient's medical history was notable for hepatitis C and blunt trauma to the neck several years prior to the development of low back pain. The patient denied any
bowel or bladder dysfunction associated with his low back pain. Physical examination demonstrated reproducible back pain with movement but no motor or sensory deficits. Lumbar puncture was unrevealing.

Results
MR of the lumbar spine revealed thecal sac enhancement at the L5 level extending caudally, as well as enhancement of the L5 and S1 nerve roots. MR examination of the brain and cervicothoracic spine demonstrated leptomeningeal enhancement around the brainstem and upper cervical spinal cord as well as enhancement of cranial nerves III through XII. A differential of leptomeningeal carcinomatosis, neurosarcoidosis and atypical infection (e.g. tuberculosis) was given. CT of chest, abdomen and pelvis showed no evidence of a primary malignancy. Biopsy with L5-S1 laminectomy was performed, with a histologic diagnosis of dense fibrosis with lymphoplasmacytic inflammation, consistent with inflammatory myofibroblastic pseudotumor. The patient experienced marked symptomatic improvement with intravenous steroids.

Conclusions
Myofibroblastic pseudotumor is an exceptionally rare lesion in the central nervous system but should be considered in the differential diagnosis for spinal canal mass lesions with multifocal leptomeningeal enhancement.
although similar, remain distinct from the more common cortical DNETs (1,2). The importance of recognizing septal DNET on diagnostic imaging is highlighted by the fact that these neoplasms are often mistaken for glial neoplasms on histologic examination (3). We report three cases of septal DNET with a distinct botryoidal or "grape-like" appearance on magnetic resonance imaging MRI scans.

Materials and Methods
A 27-year-old, right-handed, healthy male with no significant previous medical history presented with generalized tonic-clonic seizures. His neurological exam was intact. Initial imaging (not available) showed a non-enhancing left frontal lobe mass. He underwent an open biopsy, which was initially pathologically diagnosed as oligodendroglioma, grade 2. No further treatment of the brain tumor was undertaken.

Results
Subsequent MRI showed a non-enhancing left frontal lobe mass in the medial and inferior left frontal lobe. Coronal images demonstrate an "L" or hockey stick shape, with tumor extending laterally from the inferior aspect of the medial component of the mass (Figure 1a). Multiple areas showed high signal on T2-weighted (T2W) images (Figure 1b, arrows). On fluid-attenuated inversion recovery (FLAIR) images, these areas showed low signal internally with a bright rim (Figure 1c, arrows). This has been termed the FLAIR ring sign, which should be differentiated from the similar T2-FLAIR mismatch sign seen in 1p/19q non-codeleted astrocytomas (4,5). In this relatively large tumor, several areas of FLAIR hyperintense rim clustered to form a "grape-like" or botryoidal appearance. Two additional companion cases with similar imaging findings will be presented.

Conclusions
Septal DNETs are slow growing neural neoplasms of young adults and children which may involve the septum pellucidum or the infraseptal region (2). All cases displayed characteristic T2W image hyperintensity with low signal on FLAIR images (Figures 1b, 1c). Further, all three cases, which were fairly large tumors, demonstrated multiple adjacent areas of "T2-FLAIR mismatch," each with its own rim or margin of FLAIR image high signal (Figures 1c). We describe these areas as "grape-like" or botryoidal. Additionally, large septal DNETs can show an "L" or hockey stick shape on coronal images.

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Obstructive Hydrocephalus Due to Aqueductal Stenosis From Developmental Venous Anomaly Draining Bilateral Medial Thalami

Z Xian1, M Nakawah1, S Fung1
1Houston Methodist Hospital, Houston, TX

Purpose
Developmental venous anomaly (DVA) is a common benign and usually asymptomatic congenital cerebrovascular malformation. In extremely rare circumstances, it can precipitate mechanical CSF flow-related complications. We describe a case of a DVA draining bilateral thalami with a common collector vein that causes aqueductal stenosis and obstructive hydrocephalus.

Materials and Methods
A 47 year-old man presents with progressive short-term memory impairment over 5 years, manifested by forgetfulness, misplacing items, and repeating self in conversations. Symptoms were exacerbated by stress and fatigue. His medical history was only remarkable for a fall in his early 20's resulting in concussion with brief loss of consciousness and CSF otorrhea which was treated conservatively. He was reportedly diagnosed with hydrocephalus over 15 years ago and underwent lumbar puncture with large-volume CSF drainage trial but was lost to follow-up.

Results
Brain MRI shows marked dilation of the lateral and third ventricles, non-enlarged fourth ventricle, and proximal narrowing of the cerebral aqueduct with absent CSF flow void, consistent with obstructive hydrocephalus at the level of cerebral aqueduct. Post-contrast imaging shows a DVA draining bilateral medial thalami converging to a prominent anomalous central vein that runs midline along the floor of the third ventricle and ultimately drains posteriorly into the vein of Galen. The central draining vein bridges across the proximal orifice of the cerebral aqueduct, resulting in aqueductal stenosis and severe obstructive hydrocephalus.
Conclusions
Hydrocephalus usually results from either blockage of CSF flow within the ventricles (obstructive) or impaired CSF absorption (communicating). Common causes of obstructive hydrocephalus include aqueductal stenosis from congenital narrowing, septum, web, forking, post-inflammatory gliosis, and midbrain tumors, and can be associated with Chiari and Dandy-Walker malformations. DVA is the most common intracranial vascular malformation, occurring in up to 5% of the general population, and can be associated with other vascular malformations such as cavernous malformation; however, they are usually asymptomatic. In very rare circumstances, DVA can impede CSF flow through a critical structure such as the cerebral aqueduct in this case and become symptomatic. Despite the frequency with which hydrocephalus and DVA present independently, it is unusual for DVA to cause obstructive hydrocephalus.

Orbital floor trapdoor fractures in children: CT findings

S Kandemiri1, Z Yazici2, B Yazici2, F Palabiyik3
1University of Iowa, Iowa City, IA, 2Uludag University Faculty of Medicine, Bursa, NA, 3University of Health Sciences, Bakirkoy Dr. Sadi Konuk Research and Training Hospital, Istanbul, NA

Purpose
Orbital floor trapdoor fractures are mainly seen in children; the radiologic and clinical findings may be subtle and variable, and they may be overlooked. This study reviews the correlation of clinical and computed tomographic findings in pediatric cases with pure orbital floor trapdoor fractures.
Materials and Methods
Data of consecutive pediatric patients with pure orbital floor trapdoor fractures, presenting over a 14-year period were retrospectively analyzed.

Results
A total of 29 patients were included in the study (5 female, 24 male; age range, 2-18 years; median age, 12 years). All patients had a history of blunt trauma; 22 of them had diplopia with ocular motility restriction. On CT examination, orbital floor fracture was medial to infraorbital groove in all cases. Five patients had only periorbital tissue herniation through the fracture into the maxillary sinus with normal inferior rectus muscle. These patients had normal ocular motility without diplopia and were normal at follow-up. Six patients demonstrated herniation and entrapment of the periorbital tissue and inferior rectus muscle together. All these patients had diplopia with ocular motility restriction and were operated, confirming muscle entrapment in all. In remaining 18 patients, there were periorbital tissue herniation with abnormal alignment, rounding and increased thickness of inferior rectus muscle without overt herniation, which we called as tethered muscle. Sixteen of them had diplopia and ocular motility restriction; 14 were operated and two refused treatment and were lost to follow up.

Conclusions
When assessing pediatric cases with blunt trauma to the orbit, special attention to the orbital floor and maxillary sinus roof for fracture and soft tissue entrapment should be paid. Alignment and shape of the inferior rectus muscle should be carefully assessed in comparison to the contralateral side. In pediatric orbital floor trapdoor fractures, tethered or entrapped inferior rectus muscle is correlated with ocular dysmotility and this may help surgical decision-making.

1755

OsteoCool RF Ablation and Vertebral Augmentation Hybrid Treatment in Spinal Metastases Management

F Massari¹, K de Macedo Rodrigues¹, J Singh¹, A Kuhn¹, A Puri¹
¹UMASS Medical School, Worcester, MA

Purpose
The purpose of the study is to evaluate the efficacy and safety of combined use of the OsteoCool™ RadioFrequency Thermal Ablation devices and Kyphoplasty for the palliative treatment of spinal bone metastases.

Materials and Methods
Hybrid Treatments have been widely and efficiently used in pain management of terminally ill or not surgical candidate patients with spinal bone metastases. Our Institution is the only medical center in the Northeastern United States to be part of an International Trial regarding the use of the new generation of spinal RF Ablation devices for metastatic spinal tumors management. Patients referred to our institution for symptomatic malignant fractures were treated, during the same session, with bipolar RFA, performed with the OsteoCool RF ablation system (Medtronic), able to generate a constant temperature of 70 C° within the core of the neoplastic lesion, followed by cement injection. Clinical outcomes were evaluated by review of the electronic medical record (EMR) and clinical visit F/U. Pre and post-procedural pain scores were documented in order to determine the degree of pain relief.

Results
Patients clinical data and procedural technical aspects were retrospectively reviewed. All were technically successful without morbidity or mortality. There was a significantly reduced rate of posterior and venous cement leaks when RFA was used prior to KP. Pain scores in the RFA assisted group decreased significantly post procedure with no unanticipated neuropathic events.

Conclusions
The new generation of RadioFrequency Thermal Ablation devices (OsteoCool) using a bipolar device, coupled with Vertebral Augmentation, have demonstrated an increased efficacy in achieving pain relief and VB stabilization in spinal metastases management, allowing a controlled injection of cement into a preformed thermal cavity with a significant decrease in venous and posterior cement leaks.

1595

Outcomes of Patients with Acute Kidney Injury Who Undergo Endovascular Intervention for Acute Ischemic Stroke

S Ross¹, D Pandya²
¹Northwestern University, Chicago, IL, ²Northwestern Medicine, Winfield, IL

Purpose
Over 691,000 patients in the United States have an ischemic stroke annually. The indication for treatment with endovascular intervention using contrast continues to grow. At the same time, it has been noted that many patients who present with stroke have decreased kidney function, whether due to chronic kidney disease (CKD), acute kidney injury (AKI), or both. There is often clinical hesitation in giving contrast to patients with CKD or AKI due to the risk of developing contrast-induced nephropathy (CIN), despite newer research demonstrating its low incidence. Due to the important potential clinical benefit of endovascular intervention, it is
important to consider the clinical significance of decreased kidney function due to AKI for patients presenting with acute ischemic stroke.

Materials and Methods
A retrospective chart review was conducted over one year at our institution for patients who underwent endovascular intervention for acute ischemic stroke. The kidney function before and after receiving contrast was recorded. For comparison, over the same time period, all patients presenting for endovascular intervention for any other emergent or elective indication were reviewed.

Results
Over a one-year period, 147 patients presenting for endovascular intervention had acute ischemic stroke, and 156 patients had other indications. There were 17 patients with acute ischemic stroke who presented with AKI (11.6%). There were 19 patients with other diagnoses who presented with AKI (12.2%). There was no statistically significant difference in the incidence of AKI (p >0.87). All 17 patients with acute ischemic stroke with AKI who then received contrast during endovascular intervention had return of renal function to baseline on follow up. All 19 patients with other diagnoses with AKI who had endovascular intervention had return of renal function to baseline on follow up. This included 11 patients with chronic kidney disease (CKD). Two of the patients with AKI presented with profoundly low GFR (16 and 20 respectively), and renal function returned baseline at follow-up. Two patients with acute ischemic stroke who presented with AKI developed CIN after receiving contrast material. These patients had renal function return to baseline at follow-up.

Conclusions
Acute kidney injury at presentation is common in patients with acute ischemic stroke undergoing endovascular intervention. This study demonstrates that patients with AKI who then receive contrast material can have return to baseline renal function.

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Parametric maps of abnormal metabolism in mesial temporal lobe epilepsy

C Leiva Salinas¹, J Puig², P Latorre Brajovic³, L Flors⁴
¹University of Missouri, Los Angeles, CA, ²Hospital Josep Trueta, Gerona, AK, ³University of Missouri, Columbia, MO, ⁴University of Southern California, Los Angeles, CA

Purpose
Mesial temporal sclerosis (MTS) is the most common structural substrate in patients with temporal lobe epilepsy (MTLE). The epileptic networks hypothesized to account for failures in epilepsy surgery may extend beyond the mesial structures most commonly identified by current functional brain mapping techniques. Our goal is to obtain accurate parametric maps of the distribution of abnormal glucose metabolism after statistical parametric mapping at FDG-PET in patients with MTS.

Materials and Methods
We studied 19 patients with MTS on postoperative histology that obtained 2 year seizure free status following anterior temporal lobectomy. Activity from each brain voxel of the brain FDG-PET examinations was compared between MTLE patients and cohort of 43 control patients using statistical model contained in MIMNeuro. We obtained color-coded clusters of hypometabolism and overlaid those to PET and MRI MP-RAGE T1 weighted images. After validation of optimal threshold cut-off to define abnormal glucose metabolism.
metabolism as compared to normal, we we generated parametric maps of abnormal metabolism, averaged for the entire cohort, and superimposed to and average morphologic template based on MRI MP-RAGE images.

Results
We generated parametric maps of abnormal metabolism, averaged for the entire cohort. Average volume of significantly hypometabolic brain tissue as compared to healthy individuals was 34.3 ± 29.8 ml. As usually observed in clinical practice, most patients with MTS show some degree of ipsilateral inferolateral temporal metabolic impairment. A small proportion of patients showed contralateral temporal lobe and ipsilateral thalamus and internal capsule hypometabolism.

Conclusions
We generated a parametric map of most common regions of hypometabolism in patients with MTS/MTLE. We hypothesize the parametric map could provide a standard template or pattern to be used when interpreting studies of patients with mesial temporal lobe epilepsy and potentially help navigate surgical planning when applicable.

Peritumoral Edema Volume of Meningioma Correlates with Tumor Cerebral Blood Volume

Y He¹, T Siow², Y KANG³, W Toh⁴, M Castillo⁵
¹Chang Gung Memorial Hospital at Linkou, Taoyuan, Taiwan, ²Chang Gung Memorial Hospital at Linkou, Taoyuan, -- SELECT --, ³Inje University Haeundae Paik Hospital, BUSAN, Busan, ⁴Taipei American School, Taipei, -- SELECT --, ⁵University of North Carolina at Chapel Hill, Chapel Hill, NC

Purpose
The pathogenesis of peritumoral edema of meningioma remains unclear. We aimed to investigate if dynamic susceptibility contrast-enhanced (DSC) perfusion MRI predicts peritumoral edema of volume of meningiomas.

Materials and Methods
This study was approved by institutional review board. Consecutive 80 patients with meningiomas who had preoperative DSC perfusion MRI were retrospectively included. Clinical information including age, gender, tumor locations, tumor grades and histologic subtypes was collected. Volumes of tumor and peritumoral edema were measured by manual segmentation. Cerebral blood volume (CBV), leakage-corrected CBV and leakage coefficient K2 were measured in enhancing tumors and normal appearing white matter (NAWM). The CBV and corrected CBV were normalized by dividing the values in the enhancing tumors to those of NAWM. Correlations between peritumoral edema volume with clinical and imaging variables were assessed with the Pearson correlation coefficient. The predictive values of clinical and imaging variables on peritumoral edema volume were evaluated with multiple linear regression.

Results
Peritumoral edema volume correlated significantly with gender (P = 0.35), CBV (P = 0.009), leakage-corrected CBV (P = 0.012) and K2 (P = 0.043). Conversely, patient age, tumor size and locations and histologic subtypes did not correlate with edema volume. On multiple linear regression, CBV was the only factor predictive of peritumoral edema volume.

Conclusions
CBV of meningioma positively correlates with peritumoral edema volume. Meningioma tissue properties may contribute in peritumoral edema formation.
Perivascular spaces in multiple sclerosis point towards neuroinflammation more than neurodegeneration.

L Garcia¹, N Yu², F Boonstra³, M Clough¹, S Kolbe⁴, M Law⁵
¹Alfred Hospital, Melbourne, VIC, ²The Nanjing Brain Hospital Affiliated to Nanjing Medical University, Nanjing, Nanjing, ³Monash University, Melbourne, VIC, ⁴Monash University, Melbourne, Vic, ⁵ALFRED HEALTH, Melbourne, VIC

Purpose
Perivascular space are pial-lined, fluid-filled structures surrounding vessels entering or leaving brain tissue (1). Normally they are visible on MRI in three characteristic locations: entering basal ganglia, entering the subcortical white matter and in the midbrain (1). Previously, they were classed as incidental findings or related to ageing (2), but more recently have been proposed neurodegeneration markers (3). Previous MS studies have demonstrated an increased number of PVS, associated with new onset of disease, lesions load, clinical disability and brain atrophy (4), but the clinical significance is still unknown. Here, we correlated the relationship between the number and location of perivascular spaces, and lesion load, brain atrophy, disease duration and axonal fiber density.

Materials and Methods
In a 3T MRI (Siemens Trio), 59 MS patients were scanned, with axial T1 pre- and post-gadolinium, 3D FLAIR, SWI and 30-direction DWI (b=3000s/mm²). A neuroradiologist (LG) and a neurologist (NY) quantified manually and graded PVS numbers as in the scale proposed by Potter et al.5 in subcortical white matter (3 slices), basal ganglia (3 slices) and midbrain (1 slice). Lesion volume and brain parenchymal fraction (BPF) were calculated using 3D FLAIR scans with Lesion Segmentation Tool and SPM12. Axonal fibre density was calculated using the fixel based analysis pipeline in MRtrix 3.0. PVS number for each location was correlated with lesion volume, BPF, fibre density, disease duration and expanded disability status scale (EDSS).

Results
We found a mean (SD) of 73.9 (26.7) PVS in the subcortical white matter, 62.5 (21.9) in the basal ganglia, and 5.6 (2.9) in the midbrain. For basal ganglia PVS there was a correlation with age (R=0.44, p=0.0004), lesion load (R=0.44, p=0.0004) and axonal fibre density (R=-0.36, p=0.003) (Figure 1), but not disease duration, BPF or EDSS.

Conclusions
We found a relationship between the number of visible PVS and the volume of MS lesions but not brain volume. This finding suggests that PVS in MS could be a marker of inflammation in the brain due to the infiltration of inflammatory cells in the PVS. We also found a loss of axonal fiber density in regions where PVS are prominent, possibly related to increased CSF partial volume in the diffusion MRI signal due to enlarged PVS.

FIGURE 1. Scatterplots showing relationships between PVS number and A. age B. lesion fraction and C. white matter fibre density.

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2366

Plexiform Neurofibroma: A Diagnostic Dilemma In a Patient with NF1.

L Leonhardt¹
¹Hartford Hospital, Hartford, CT

Purpose
Plexiform neurofibromas are uncommon benign neoplasms that, when found in combination with multiple localized neurofibromas, are virtually pathognomonic for neurofibromatosis type 1 (NF1). These neoplasms are found in nearly 30% of patients diagnosed with NF1, along with other more nonspecific findings such as spinal deformities, neoplastic and non-neoplastic brain lesions, and cutaneous stigmata. In this case review, we describe a plexiform neurofibroma in a patient without other major or minor criteria of NF1 at the time of the study. We propose that without other features of NF1, imaging characteristics of plexiform neurofibroma may not immediately generate the correct diagnosis, and may be a diagnostic dilemma, as was our case.
Materials and Methods
We review a case of a 2-week-old girl who presented to the ED with mom complaining of increased left-sided facial swelling and decreased PO intake. Physical exam revealed a firm mass at the angle of the mandible. Mom stated that an out-patient ultrasound of the facial swelling was performed earlier, which was described as a vascular mass, likely a hemangioma. Finally, an MRI was obtained.

Results
There is a heterogeneously enhancing, poorly defined left facial mass that extends across multiple anatomic compartments. The majority of the enhancing disease is centered within the left parotid gland. There is perineural extension of disease with nodular enhancement along the mandibular division of the left trigeminal nerve. Nodular enhancement is seen extending into the intracranial compartment through foramen ovale and expanding Meckel's cave. The primary diagnosis was suggested to be a malignant angiosarcoma, with alternatives including MSPNST, lymphoma, mucoepidermoid carcinoma or a sialoblastoma. Biopsy unequivocally revealed a plexiform neurofibroma, and on repeat physical exam, multiple cafe-au-lait spots were identified, generating the diagnosis of NF1.

Conclusions
In the absence of major and minor criteria of a syndrome, correct diagnoses on imaging of an uncommon neoplasm is a challenge. Our case of plexiform neurofibroma maintained the typical MR characteristics associated with neoplasm, however without mention of cafe-au-lait spots in the patient's history and without multiple localized neurofibromas, this posed as a diagnostic dilemma, delaying the patient's diagnosis. As radiologists, communication with our clinicians is an essential diagnostic tool, and this case of an uncommon tumor in a common presentation, is no different.

(Filename: TCT_2366_Plexiformneurofibroma.jpg)

2499

Posterior Fossa Decompression for Acquired Chiari Deformity in Chronic Shunting

C Shah1, A Hassankhani2, J Woo1

1University of Pennsylvania, Philadelphia, PA, 2Hospital of the University of Pennsylvania, Philadelphia, PA
Purpose
In patients with ventriculoperitoneal shunts (VPS), intracranial hypotension (IH) can develop if CSF-flow settings are too high. The imaging appearance has overlapping features with a Chiari 1 malformation. Acquired Chiari 1-type deformity is also a known late complication of chronic shunting in children [1], proposed to be related to gradual cranial vault thickening [1,2]. Surgical management may include posterior fossa decompression [3]. We were surprised to have encountered an adult case for which posterior fossa decompression was performed, and describe the case in this report in order to bring attention to this entity and the surgical options for management.

Materials and Methods
A 36 year old patient presented for headaches. She had an indwelling VPS placed 13 years prior in the setting of subarachnoid hemorrhage. A brain MRI demonstrated findings suggesting IH, new from an MRI of 13 years prior. One year later, the patient had persistent headaches and underwent shunt revision to a programmable system. Over the following 6 months, she had persistent headaches, requiring adjustments of shunt settings. Two nuclear medicine studies demonstrated shunt patency, and documented an opening pressure of 18 cm H2O. Five months after shunt revision, a brain MRI showed persistent findings of IH. She underwent VPS revision at an outside institution. Two months later, a cervical spine MRI showed a persistent Chiari 1 type deformity with syrinx. The patient subsequently underwent a posterior fossa decompression at an outside institution, with improvement in symptoms. Three months after decompression, the patient remained headache-free. Follow up MRI of the cervical spine 3 months later demonstrated improvement in the tonsillar herniation and decreased size of the syrinx.

Results
Figure 1 demonstrates sagittal T1 weighted images of the brain over time, which show progressive findings of IH. In Figure 2, sagittal STIR images of the cervical spine over time show improvement in the cervical cord syrinx and tonsillar herniation after posterior fossa decompression.

Conclusions
In patients with VPS, new findings of cerebellar tonsillar herniation could indicate shunt malfunction or IH. In patients with persistent symptoms in whom shunt malfunction has been excluded or addressed, there may be a persistent acquired Chiari 1 type deformity. These patients may benefit from posterior fossa decompression, although long-term results are not known, particularly in adults.
**Figure 1.** Sagittal T1-weighted brain MRI images over time. (A) 13 years prior to presentation, after initial VP shunt placement. No overt findings of intracranial hypotension (ICH) or Chiari malformation are seen. (B) At presentation. New findings suggesting ICH, including cerebellar tonsillar descent, engorgement of the pituitary gland and dural venous sinuses, sagging of the brainstem and effacement of the prepontine cistern with flattening of the ventral pons. (C) 17 months after presentation, 5 months after VP shunt revision. Progressive findings including increased tonsillar herniation and new cervical cord syrinx.

**Figure 2.** Sagittal STIR cervical spine MRI images over time. (A) 19 month follow up, 1 month after 2nd shunt revision. Persistent cerebellar tonsillar herniation and a cervical cord syrinx with adjacent cord edema. (B) 22 month follow up, 3 months after posterior fossa decompression. Improved tonsillar herniation, decreased size of cervical cord syrinx, and resolution of adjacent cord edema.
Pre and Post-Natal Imaging of a Patient with Dandy-Walker Malformation in Combination with Pontine Tegmental Cap Dysplasia: Novel Case and Possible Etiology

R Kelsch¹, A Krishnan², L Goncalves³
¹Beaumont Health, Royal Oak, Oxford, MI, ²Beaumont Health, Royal Oak, Royal Oak, MI, ³Pheonix Children’s, Pheonix, AZ

Purpose
The purpose of this presentation is to present a novel case of Dandy-Walker malformation in combination with pontine tegmental cap dysplasia. This case will be used to illustrate the common imaging findings for each disease entity and how they might relate in etiology. Multimodality pre-natal and post-natal imaging with both be reviewed.

Materials and Methods
The mother of the patient presented to our institution as a 35yo G4P2012 for concerning findings on fetal ultrasound. In-utero the patient was suspected to have Dandy-Walker malformation via ultrasound and then underwent a fetal MRI. The patient was followed with serial ultrasounds and had a subsequent delivery via cesarean section. The patient was found to have multiple congenital abnormalities with the VACTERL association. Neurologically the patient was found to have bilateral sensorineural hearing loss, feeding difficulties, and partial symptomatic epilepsy with complex partial seizures. The patient was managed with a ventriculoperitoneal shunt and is on antiepileptic medications, and is being followed by neurology and neurosurgery.

Results
Prenatal US: Posterior fossa large cyst (Image A), hypoplastic cerebellar hemispheres, ventriculomegaly, rib fusions, penile abnormality, no anal dimple. Prenatal MRI: Large posterior fossa cyst, elevation of torcula, severely hypoplastic vermis (Image B, red arrow), hypoplastic pons with posterior deformity (Image B, blue arrow), ventriculomegaly, partial absence of cavum septi pallucidi, high anorectal malformation. Hypospadias, lumbar spine segmentation abnormalities, and rib fusion abnormalities were also seen. Postnatal Head US: Posterior fossa cyst, hydrocephalus, diminutive pons. Postnatal MRI: Malrotated and severely hypoplastic cerebellar vermis (Image C/D, red arrow), cystic enlargement of posterior fossa, torcular inversion, posterior deformity of pons consistent with tegmental cap dysplasia (Image C/D, blue arrow), hypoplastic middle cerebral peduncles, suggestion of hypoplasia of cranial nerves VII/VIII with hypoplastic internal auditory canals

Conclusions
The combination of Dandy-Walker malformation and pontine tegmental cap dysplasia is a novel combination of pathologies which may be explained by the common rhombencephalon origin of the structures involved. During rhombencephalon development, improper cell migration and folding of structures may lead to both abnormalities.
Prediction of leptomeningeal collateral recruitment in experimental acute ischemic stroke by cerebrovascular reactivity to carbon dioxide.

G Christoforidis\textsuperscript{1}, N SAADAT\textsuperscript{2}, Y Jeong\textsuperscript{1}, M Liu\textsuperscript{1}, S Roth\textsuperscript{3}, T Carroll\textsuperscript{1}

\textsuperscript{1}University of Chicago, Chicago, IL, \textsuperscript{2}UNIVERSITY OF CHICAGO MEDICAL CENTER, CHICAGO, IL, \textsuperscript{3}University of Illinois College of Medicine, Chicago, IL
Purpose
Immediate pial collateral recruitment during acute ischemic stroke is an endogenous response limiting permanent tissue damage due to proximal cerebral artery occlusion. There is presently no known way to predict the degree of pial collateral recruitment. This work sought to determine if cerebrovascular reactivity (CVR) to CO2 predicts pial collateral recruitment in an experimental model of cerebral ischemia.

Materials and Methods
Ten mongrel dogs underwent cerebral blood flow (CBF) measurements using stable isotope neutron activated microspheres during normocapnia (PaCO2 30-35mmHg) using medical air, and subsequently during hypercapnia (PaCO2 60-70mmHg) using 7% CO2. Anesthesia (propofol, remifentanil, rocuronium and 1% isofluorane) and normal range physiologic parameters were maintained to avoid undue influence on CO2 reactivity. Animals underwent middle cerebral artery occlusion using a previously described endovascular method. Pial collateral recruitment was angiographically assessed using a previously published 11-point scale. Animals subsequently underwent MRI to derive 4-hour infarct volumes calculated using an automated threshold technique using mean diffusivity maps. Bivariate linear fit analyses were used to assess correlations between CVR versus pial collateral score and infarct volume.

Results
CBF values derived from cortical gray matter during simultaneous CO2 challenge demonstrate a statistically significant correlation to infarct volumes (p=0.0041, r²= 0.663) and pial collateral recruitment (p=0.0004, r²= 0.811) (figure 1).

Conclusions
Preliminary data presented suggest that cerebrovascular reactivity to CO2 may be predictive of pial collateral recruitment and infarct volumes during acute ischemic stroke.

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2361

Prediction of Pseudoprogression from MR Imaging Features Across Multiple Timepoints

N Wang¹, A Rao¹, J Bapuraj²
¹University of Michigan, Ann Arbor, MI, ²University Of Michigan, Ann Arbor, MI

Purpose
Apparent tumor growth in the context of high-grade gliomas can be either true progression or pseudoprogression. If the lesion reduces in size or stabilizes without change in treatment, it is considered to be pseudoprogression. On magnetic resonance imaging (MRI) if there is a region of new contrast enhancement, standard structural MRI is not considered sufficient for a radiologist to diagnose whether it is true progression. The uncertainty of pseudoprogression can lead physicians to err on the side of resection or treatment when the apparent lesion growth might have subsided with time.

Materials and Methods
A set of 155 brain MRI studies from 48 University of Michigan patients with gliomas which had been previously resected were collected. Each of these patients had at least three scans between their first resection and a follow-up operation. These patients had apparent lesion growth on MRI which could have been either true or pseudoprogression. The three time points for scans varied, with time-point -1 (the latest time point and closest to second resection) occurring approximately a month before the operation. Time-points -2 and -3 were further before surgery, and these scans were acquired to monitor the residual tumor imaging characteristics and volume after initial resection. An outside set of MRI studies from the BRATS 2017 challenge was used to filter out unstable or scan dependent imaging features. Scan parameters such as echo and repetition time, manufacturer and magnetic field were evaluated for correlation with imaging features. Texture, topological(TDA), and CNN features were used to measure the tumor for both the UM and external scans. 3–5
Results
Random forests were used to predict pseudoprogression using this filtered set of features. The AUROCs of the models ranged from .739 to .612 across the three timepoints of the UM dataset. The relative power of the filtered and unfiltered feature sets was similar suggesting no significant loss of power while excluding features that are correlated with scan acquisition.

Conclusions
For this population, for a patient, the closer in time a study was to surgery, the more predictive the model was. The models predicted pseudoprogression somewhat well, but the task of predicting pseudoprogression remains difficult. Limitations of this dataset include the limited cases and the inconsistent timing of the scans. To be more widely applicable, scan parameters were used to filter the large set of features into a more robust feature set.

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Predictive Value of Perfusions-Imaging regarding Hemorrhagic Transformation in Acute Ischemic Stroke after Endovascular Treatment

F AUSTEIN<sup>1</sup>, A Fischer<sup>2</sup>, P Langguth<sup>3</sup>, O Jansen<sup>4</sup>

<sup>1</sup>UNIVERSITY HOSPITAL KIEL, KIEL, SCHLESWIG-HOLSTEIN, 2University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Schleswig-Holstein, 3University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Germany, Kiel, Schleswig-Holstein, 4University Hospital Schleswig-Holstein, Campus Kiel, Ki, Kiel, Schleswig-Holstein

Purpose
In this retrospective monocentric study, we investigate the predictive power of CTP parameters concerning hemorrhagic transformation (HT) in patients receiving EVT.

Materials and Methods
We analyzed 392 patients with anterior circulation LVO who attended to our clinic between 2010-2017 and underwent multimodal CT imaging (NCCT, CTA and CTP), followed by EVT. CTP-parameters (CBF, CBV, MTT, Tmax und FED) were manually assessed for the modified ASPECTS regions and additionally infarct core and hypoperfusion volume were automatically calculated using the RAPID-Software and compared between patients with no bleeding, hemorrhagic infarction (HI) and parenchymal hematoma (PH) as well as selected demographic characteristics, clinical, treatment-associated and imaging variables. The correlation to the functional result after 90 days was also evaluated. HT was assessed at follow-up imaging, defined according to ECASS II-criteria and broken down by affected ASPECTS regions.

Results
Of 392 patients with LVO, 168 additionally received IV lysis and 115 developed HT (29.3%), of which 74 were classified as HI and 41 as PH. There was no significant difference between patients without bleeding, with HI and PH with respect to age, NIHSS, time from symptom onset to admission, IV lysis and successful recanalization (TICI 2b/3). Patients with HI and PH had significantly lower ASPECTS than patients without bleeding and significantly worse functional outcome after 90 days; p<0.05. Patients with PH had significantly worse outcome than patients with HI. In 102 of 115 patients with HT, the basal ganglia were affected. The cortical regions were affected markedly less often. In the basal ganglia, there were significant differences between patients without bleeding, with HI and with PH regarding the CBV and the FED relative to the contralateral hemisphere (p<0.05). However, there was a relatively large statistical scattering of the results. Patients with PH showed significantly larger infarct core than patients without HT (p<0.01).

Conclusions
Due to the small number of cases with HT and the large statistical scattering, there is a high probability to exaggerate the size of the
effect of a single CTP parameter regarding the prediction of HT. Therefore, none of the examined single CTP parameters was found to be a good predictor of HT. But ASPECTS and infarct core volume may be useful and also more practicable to assess the risk of bleeding after EVT.

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Predictor of Clinical and Imaging Outcomes after Pipeline Embolization Device (PED): A Single Center Experience

S Lee¹, D Altschul², R Zampolin³, N Haranhalli¹, B Chulpayev³, A Brook⁴
¹Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY, ²Montefiore Medical Center, New York, NY, ³Montefiore Medical Center, Bronx, NY, ⁴N/A, N/A

Purpose
To identify clinical, procedural and aneurysm related risk factors for imaging and clinical outcomes in a single high volume center.

Materials and Methods
Intracranial aneurysms treated with PED between 2016 and 2018 were retrospectively reviewed. Number of PED used, follow up angiographic features such as the degree of angiographic aneurysm occlusion, luminal stenosis, and clinical information such as antiplatelet usage, the degree of platelet activity, systolic blood pressure as well as mRS. A modified Rankin Scale (mRS) > 2 and incomplete aneurysm occlusion were considered as poor outcomes for multivariate analysis.

Results
Eight four patients with a total of 92 treated aneurysms were included. Average age was 53.94 years and 84.5% were females. 20 aneurysms (24.1%) were ruptured and 63 (75.9%) were unruptured aneurysms. Complete aneurysm occlusion rate at 6 months was 70.7% and it increased to 74% in subsequent radiographic follow-up between 6 to 18 months. 8.4% of patients had poor clinical outcomes (mRS > 2) on the last outpatient follow-up examination. Independent risk factor for incomplete aneurysms occlusion at 6 months (OR=4.137, 95% CI=1.034-16.559, p=.045) was single device usage. Aneurysm rupture was not an independent risk factor. Clopidogrel hyporesponder (OR=29.382, 95% CI=1.677-514.87, p=.021) and high systolic blood pressure (OR=15.525, 95% CI=1.33-180.83, p=.029) are independent risk factors for poor clinical outcomes. Thromboembolic complications were noted in 8.4% and hemorrhagic complications were found in 1.2% of patients.

Conclusions
Single PED usage was independently associated with incomplete aneurysm occlusion. Clopidogrel hyporesponder and increasing systolic blood pressure was independently associated with poor clinical outcomes. Endovascular management for both ruptured and unruptured aneurysm using PED appears to be safe and effective.

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Prevalence of Significant Pathology on Neuroimaging of Ophthalmology Outpatients in a Tertiary Referral Centre in Ireland

A Haughey¹, R Killeen²
¹St. Vincent's University Hospital, Co. Dublin, Europe, ²St. Vincent's University Hospital, Dublin, Ireland

Purpose
The aim of this study was to determine the utility of MRI studies of the brains and orbits (MRBO) in the assessment of patients referred for investigation of visual disturbance from a tertiary ophthalmology centre in Ireland. We set out to assess the frequency and variety of abnormalities detected on MRI studies of the brains and orbits (MRBO), in this patient cohort.

Materials and Methods
This is a retrospective study of 135 consecutive MRBO performed for the work up of visual disturbance, between March 2015 and March 2016. Studies were included if the patient was over 18 years of age, had a visual disturbance of unknown aetiology and if it was their first episode of visual disturbance in an outpatient setting. The MRBO were read by a fellowship-trained diagnostic neuroradiologist or a radiologist with a special interest in ophthalmology.

Results
A total of 135 MRBO examinations between March 2015 and March 2016 met the inclusion criteria. Abnormalities were identified on 86 of the 135 examinations (63.7%; 95% CI: 55.3% to 71.3%). Nonspecific white matter T2 hyperintensities were identified in 27 (20%) of the examinations. Excluding those studies where the only abnormality was nonspecific white matter T2 hyperintensities, abnormalities were detected on 59 (43.7%) (95% CI: 35.2% to 52.1%) of MRBOs. 13 (9.6%) MRBOs had parenchymal brain findings suggestive of demyelination and 11 (8.1%) showed optic neuropathy.

Conclusions
A broad range of pathologies were identified on the MRBO performed in our cohort of patients presenting with visual disturbance. There was a high incidence of pathology detected in those referred, with significant imaging abnormalities identified in 43.7% of patients. We conclude that MRBO is a useful investigation in the assessment of patients presenting with visual disturbance.
Prognosticating Functional Outcome After Intracerebral Hemorrhage

J. Puig\(^1\), C. Biarnes\(^2\), M. Terceño\(^3\), V. Cuba Camasca\(^4\), J. Serena\(^3\), S. Pedraza\(^2\), Y. Silva\(^1\)

\(^1\)IDI-IDIBGI, Girona, Spain, \(^2\)IDI-IDIBGI, Girona, Girona, \(^3\)Stroke Unit, Hospital Universitari Dr Josep Trueta, IDIBGI, Girona, Girona, \(^4\)Hospital Clinic of Barcelona, Barcelona, Catalonia

**Purpose**

Intracerebral hemorrhage (ICH) (10%–15% of strokes) is a leading cause of stroke-related morbidity and mortality. Although various models have been developed to grade ICH and predict outcome, none is consistently used in routine practice. We propose a model based on clinical and imaging parameters to predict functional outcome 3 months after ICH: the ICHO score.

**Materials and Methods**

We evaluated 280 consecutive patients (201 men; median age 69 IQR[58-76]) with acute ICH, recording demographics, vascular risk factors, stroke severity (National Institutes of Health Stroke Scale [NIHSS] score), location, midline shift, and volumes of hematoma and of perihematomal edema (PHE) at baseline, 24 h, and 72 h (Olea Sphere 3.0, La Ciotat, France). Functional outcome, assessed at 3 months with the modified Rankin scale (mRS), was classified as favorable (mRS ≤2) or unfavorable (mRS >2). Independent predictors of poor outcome were identified by multiple regression analysis. The best model was selected by Bayesian information criterion.

**Results**

Patients with poor outcome (66%) were older (72 (61-78) vs. 64(54-74), p<0.001), had higher NIHSS scores at admission [17 (12-19] vs. 5 (3-9), p<0.001]; higher systolic pressure [148 (134-164) vs. 143 (128-152.5), p=0.02]; higher glucose [114(101-139) vs. 105(95-116.5), p=0.011]; larger hematoma volume at baseline [24.28 (10.1-43.3) vs. 6.81 (2.46-12.02), p<0.001], 24h [28.95 (14.85-52.34) vs. 7.22 (2.82-13.16), p<0.001], and 72h [28.75 (12.35-56.17) vs. 7.13(3.4-12.66), p<0.001]; greater PHE volume at baseline [11.39 (5.1-24.7) vs. 4.6 (1.38-8.92), p<0.001], 24 h [19.72 (9.01-40.15) vs. 6.76 (3.08-12.43), p<0.001], and 72h [29.97 (14.48-53.27) vs. 10.29 (4.95-17.42), p<0.001]; greater involvement of basal ganglia (p=0.001); and more frequent midline shift (p<0.001). The best predictors were age, 24h-NIHSS, and hematoma volume at 72h. The ICHO score was determined as: mRS at 3 months= -0.837 + (0.032 x age) + (0.152 x 24h-NIHSS) + 0.011 x 72h-hematoma volume).

**Conclusions**

The ICHO score might be a valid clinical grading scale for 3-month functional outcome after ICH; further validation in different populations is needed.
Punctate Pattern & T2/FLAIR Mismatch as findings in PML Related to Rituximab: Beyond Natalizumab-PML

E Ruiz Romagnoli¹, C Besada², M Perez Akly³, L Miquelini³
¹Hospital Italiano de Buenos Aires, Buenos Aires, Buenos Aires, ²Hospital Italiano de Buenos Aires, CABA, Argentina, ³Hospital Italiano de Buenos Aires, CABA, CABA

Purpose
To describe the T2/FLAIR mismatch and Punctate Pattern as different stage lesions related to progressive multifocal leukoencephalopathy in a patient under rituximab treatment. To highlight the value of Punctate Pattern as a sign in presymptomatic stage not only related to natalizumab, but also present with use of rituximab.

Materials and Methods
A 72-year-old woman was diagnosed with a high grade MALT lymphoma. She had previous history of hypertension, Wells syndrome and proliferative kidney disease. At the time of diagnosis, patient had bone marrow infiltration and high grade prognostic index (MIPI). Due to severity, monthly applications of rituximab (375 mg/m²) plus bendamustine (90 mg/m²), were indicated. After the fourth cycle, patient started with anorexia and repetitive falls. At admission, vital signs were normal and in physical exam she obeyed simple orders and had a right brachio-crural paresis. Previous PET-CT scan showed high metabolism in lymphatic nodes (supra and infradiaphragmatic) and spleen. The patient's white blood cell count showed leukopenia (2425 mill/mm³) with a normal lymphocyte count. In this context, brain MRI was done.

Results
MRI showed asymmetric multifocal supratentorial lesions involving subcortical white matter in frontal lobes. Left frontal lobe show slightly swollen lesion without mass-effect and peripheral edema in spite of its size. This lesion has defined edges towards cortex with diffuse limits towards white matter. Note the T2 hyperintensity and FLAIR attenuation at core, we call this mismatch T2/FLAIR, because resembles the recently mismatch sign published in IDH mutant-non codeleted 1p19q low-grade gliomas (LGG). In addition, MRI shows a less common finding described in early-stage disease. T2 and FLAIR demonstrate punctiform hyperintense lesions involving the pons, right middle cerebellar peduncle and right cerebellar hemisphere. This feature is known as "punctate pattern".

Conclusions
Evolving MRI signs have been described for PML. Punctate Pattern seems to be highly sensitive and specific for natalizumab-PML, but may also be present in patients under rituximab treatment. To our best knowledge, this is the first report related to this monoclonal antibody. Mismatch T2/FLAIR may be an additional sign to determine the evolution of lesions. We need be aware of new findings like mismatch T2/FLAIR and Punctate Pattern, that might help in early diagnosis and hopefully improve patients survival.

Radio-pathologic review of a rare benign nasal cavity tumor: A case report of angioleiomyoma of the nasomaxillary junction

A Nada¹, F Salik¹, A Humera¹
¹University of Missouri, Columbia, MO

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Purpose
Angioleiomyoma of the nasal cavity is a rare benign tumor of the nasal cavity. We present a case of a pathologically angioleiomyoma of the nasomaxillary junction review the characteristic imaging findings of the angioleiomyoma of nasal cavity and correlate with clinicopathological data.

Materials and Methods
69-year-old male presented for evaluation of a 10-year history of worsening left sided fullness of the cheek and left nares. He first noticed intermittent pain in his left jaw and along his teeth; thought to be related to sinusitis. The patient's symptoms didn't improve on treatment. The physical examination revealed a large submucosal mass emanating from the left maxilla and obstructing left anterior nasal cavity. Flexible endoscopic laryngopharyngoscopy was done and confirmed that the large submucosal mass arising from lower left lateral wall of the nose. The patient underwent local excision of this mass.

Results
CT sinus and MRI of the maxillofacial region were performed and showed a large lobulated avidly enhancing mass centered on the left naso-maxillary junction. The mass involves the anterior portions of middle and inferior turbinates. This mass extends into the anterior maxillary alveolus, hard palate and root of central/lateral maxillary incisor teeth. It has a mild mass effect on the bony nasal septum without infiltration. Mild cortical irregularities and bone demineralization of adjacent medial wall of the left maxilla noted. No evidence of gross bone destruction, posterior nasal/nasopharyngeal, intra-maxillary or intra-oral extension.

Conclusions
Angioleiomyoma of the nasal cavity is a rare benign tumor. This tumor has significant T2 hyperintensity and avid post-contrast enhancement. These may resemble venous malformation. They lack the significant signal void characteristic of arterio-venous malformation and aggressive behavior of malignant nasal cavity neoplasms.
Radiology Practice Consolidation; Effect on Graduates of 2020 Class Employment

M Georgy¹
Ohio State College of Medicine, Columbus, OH

Purpose
Radiology practice consolidation has become a reality for the future of radiology. The 2018 ACR commission on human resources workforce survey estimated that 6% of the total available radiology jobs are corporate employee (1). In this study we are evaluating the actual job market share of corporate employee by in depth analysis of the radiology jobs advertised in different sources with special attention to Neuroradiologists vacancies.

Materials and Methods
Review of the ACR employment and Radworking.com job listings were performed. Those results were compared to individual major corporate listings including Radiology Partners, MEDNAX Radiology Solutions, Envision Physician Services, Radnet and Aris Radiology. Duplicate listings were eliminated. Our review included all full and part time jobs.

Results
ACR listings are still the most comprehensive and accurate source. Radworking.com contains more recruiters than direct employer listings. In mid-October, there were 1127 radiology jobs listed in the ACR website (225 Neuroradiology), and 160 jobs on Radiology partners (20 Neuroradiology). Envision Physician services (a multispecialty group) advertised for 64 positions, including 9 Neuroradiology. MEDNAX Radiology Solutions had around 26 jobs advertised, 3 of which are neuroradiology positions. Aris Radiology had 7 jobs and Radnet had 3 jobs posted. The total number of corporate Radiology jobs was 256 (22% of the total jobs advertised) at that time of the year. Of those 256 jobs, 32 Neuroradiology positions were available (12.5%). A similar analysis will be performed during May 2020 (end of job season) and the results will be presented and compared to the ACR workforce survey results for the year of 2019.

Conclusions
These results suggest that the number of corporate radiology posts available for graduates of class of 2020, as of mid-October 2019, are much higher than what was reported by the ACR 2018 workforce survey (22% compared to 6%). This could be related to more recent acquisition since the last survey or due to under reporting by different groups. We will report any trends seen after our analysis of the same data set during May 2020 and compare it with the newest ACR survey. Corporate radiology may be less likely to hire subspecialty trained neuroradiologists compared to the other employers.

Rare Fetal-Type Posterior Communicating Artery Vessel Occlusion: Intravenous tPA and/or Endovascular Therapy?

I Ikuta¹, A Abou Karam², A Malhotra³
YALE UNIVERSITY SCHOOL OF MEDICINE, MILFORD, CT, Yale Medicine, New Haven, CT, Yale University School of Medicine, New Canaan, CT

Purpose
Excellent evidence-based medicine supporting stroke thrombectomy has advanced the field of interventional neuroradiology. However, the landmark studies do not take into account fetal-type posterior communicating artery occlusion. We provide a case of left fetal-type posterior communicating artery occlusion, and discuss the pros and cons of treatment with IV tPA and endovascular mechanical thrombectomy.

Materials and Methods
A female patient in her early 80's presented with acute onset aphasia and right-sided weakness, NIHSS = 9. CTA demonstrated left fetal-type posterior communicating artery occlusion. CT perfusion demonstrated a 12 mL volume of Tmax > 6 seconds in the left PCA distribution, with no CBV reduction to suggest infarction. As intravenous tPA was being administered, the patient's NIHSS improved to 4, and decision was made to not pursue mechanical thrombectomy. However, the patient's NIHSS would vary between 4-8 over the next several hours, and MRI/MRA demonstrated a small acute infarction in the left thalamus, consistent with a tuberothalamic artery distribution (a branch of the posterior communicating artery). The patient did have improved clinical picture at hospital discharge towards baseline.

Results
CTA cross-sectional and 3D images demonstrate a fetal-type left posterior communicating artery with diameter of 2.1 mm with abrupt occlusion. CT perfusion demonstrates a small volume of oligemia in the left posterior cerebral artery distribution, without cerebral blood volume reduction to suggest acute infarction. Later MRI brain demonstrates left thalamic acute infarction in the distribution of the tuberothalamic artery (a branch of the posterior communicating artery).

Conclusions
There is a paucity of research evidence regarding mechanical thrombectomy for fetal-type posterior communicating artery occlusion. A previous case report pursuing mechanical thrombectomy had an improved clinical outcome, as did our case of intravenous tPA without mechanical thrombectomy. Given the rare occurrence of fetal-type posterior communicating artery occlusion, clinical practice
may be without the guidance of excellent evidence like we have for large vessel occlusion, and dependent more upon case reports until sufficient numbers are available for meta-analysis.

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Role of Pseudocontinuous Arterial Spin Labeling (pc-ASL) with Multiple Post-labeling delays in Evaluation of resting State Cerebral Perfusion Assessment Before and After Carotid Artery Stenting

P Balasundaram¹, S GAIKWAD², A Garg³, L Sebastian⁴
¹AIIMS, New Delhi, ²ALL INDIA INSTITUTE OF MEDICAL SCIENCES, new delhi, delhi, ³AIIMS New Delhi, New Delhi, Delhi, ⁴All India Institute of Medical Sciences, NEW DELHI, Delhi

Purpose
Patients with carotid artery stenosis are at an increased risk of stroke, either perfusion related or embolic. With the demonstration of the importance of hemodynamic changes in the development of infarcts, it is essential to study the hemodynamic changes in patients with CAS and to even include the hemodynamic alterations as a criterion in decision making. With the conventional single delay ASL, only cerebral perfusion can be quantified, whereas with multiple post-labeling delays (PLD) more information regarding the dynamics of cerebral circulation can be acquired including arrival time. This study aims to demonstrate the hemodynamic changes before and after CAS.

Materials and Methods
From June 2016 to Dec 2018, 47 consecutive adult patients (35-95yrs) with moderate to severe carotid artery stenosis (> 50%), planned for CAS were included in the study. Brain perfusion was measured using the pc-ASL technique before and after the procedure, with multiple post labeling delays. Carotid artery stenting was performed for all patients with self-expanding nitinol open cell stents (Protégé, 8mmx40mm). Processing of ASL images were performed with oxford_asl tool from FSL, using modified Buxton model. All images were transformed into standard space (MNI 2mm brain template). ROIs for MCA territory, external watershed zone and internal watershed zone for affected and normal sides were recorded for ASL perfusion parameters (perfusion, normalized_perfusion, spatial coefficient of variation, arrival time, weighted delay and perfusion ratio). Descriptive statistics and student's paired t-test is used to compare pre and post CAS perfusion parameters.

Results
Mean age and stenosis of patients was 59.3(10.8) and 78.4%(8.3). Arterial transit artifacts(ATA) were seen in 30 patients before CAS, which resolved in 24 of those post-stenting. Grading of ATA was also better after CAS. Paired t-test for ASL parameters showed significant difference between the affected and normal side before CAS indicating that hemodynamic changes (low perfusion) exist even in resting state. Paired t-test for ASL parameters showed reversal of significant difference between the affected and normal side indicating the effectiveness of CAS.

Conclusions
ASL with multi-delay gives more information about cerebral hemodynamics than routine ASL. CAS is effective, as evidenced by better perfusion post procedure. ATA and its indirect measurement, coefficient of variation are useful markers to evaluate the changes post procedure, than cerebral perfusion.
Spinal Cord MRI Findings in Sjogren's Ganglionopathy

N Gopal¹, V GUPTA¹, A Bhatt¹, A Desai¹, E Middlebrooks¹
¹Mayo Clinic, Jacksonville, FL

Purpose
Sjogren's ganglionopathy is an uncommon complication of Sjogren's syndrome that is commonly under-recognized. In this study, we characterize the spinal cord MRI findings in Sjogren's ganglionopathy.

Materials and Methods
We retrospectively reviewed our patient database for adult patients up to the year 2019 with a concurrent diagnosis of primary Sjogren's syndrome with peripheral neuronopathy and abnormal spinal MRI. Demographics, clinical signs and symptoms, laboratory evaluations, and radiological findings were extracted from the medical records.

Results
Nine patients met our inclusion criteria. The mean age of presentation was 52.5±27 years and all of the patients were female. Deep tendon reflexes were absent in 7/9 patients and hypoactive in 2/9 patients. Vibration and proprioception were diminished in 7/9 patients. Anti-Ro/SSA and/or anti-La/SSB antibodies were present in 8/9 patients. Labial salivary gland biopsy was positive for focal lymphocytic sialadenitis in 4/7 patients. Vitamin B12 and copper levels were normal in all the patients. MRI of the spine showed hyperintensities in fasciculus cuneatus and fasciculus gracilis, bilaterally, in 7/9 patients. Unilateral involvement of the fasciculus gracilis was present in one patient, and unilateral involvement of the fasciculus cuneatus was present in another. In 2/9 patients, the hyperintensities were confined to the cervical spinal cord, whereas in 7/9 patients it extended into the thoracic spinal cord. Foci of hyperintensity within the bilateral lateral spinothalamic tracts were present in 2/9 patients.

Conclusions
Dorsal column hyperintensities in cervical spinal cord have been previously reported in Sjogren's ganglionopathy; however, involvement of thoracic spinal cord and lateral spinothalamic tract has not been previously reported. When present, these findings should prompt consideration of Sjogren's syndrome as a potential differential diagnosis.
Structural findings before, during, and after laser ablation of a hypothalamic hamartoma.

C Adams\textsuperscript{1}, D Gomez-Hassan\textsuperscript{1}

\textsuperscript{1}University of Michigan, Ann Arbor, MI

Purpose
Hypothalamic hamartomas (HH) are benign tumors associated with central precocious puberty (CPP) and/or refractory epilepsy. The majority express gonadotropin-releasing hormone (GnRH), however, it is structure that predicts clinical syndrome: HH with contact to the infundibulum are associated with CPP, while those in contact with mammillary bodies are associated with seizures. The former is treated with GnRH agonists, and the latter with anti-epileptics or resection. LITT is a minimally invasive therapy offering an alternative approach to open resection for patients with HH, however, the intra- and post-operative image findings are poorly defined.

Materials and Methods
A 22-year-old male with history of precocious puberty at age 4 presented with seizures starting at age 19 years. MR imaging at age four years showed a right hypothalamic hamartoma and he was treated with leuprolide from ages 4 to 14. At age 19, patient began to have seizures that were refractory to medical management. Seizures were characterized by a loud ictal cry followed by bilateral arm tonic movements and then clonic movements for a total of approximately five minutes. LTM EEG revealed likely focal onset seizures from a right frontal focus with rapid secondary generalization. Patient underwent LITT for ablation of his hamartoma and has since been seizure free for one year.

Results
Pre-operative MR images demonstrated space-occupying T1 isointense, non-enhancing, well circumscribed lesion consistent with HH which measured 8.0 x 7.9 x 8.2 mm. For treatment, the lesion was targeted using LITT. Intra-operative imaging demonstrated proper trajectory of the laser fiber from a superior lateral entry through the right frontal cortex, proceeding inferiorly and medially through soft tissue, to end in region anterior to the mamillary bodies and superior to the hypothalamus. Immediate post-contrast, post-ablation imaging demonstrated small amounts of internal enhancement within the superior part of the hypothalamic lesion now estimated to be 6.5 x 8.5 x 10.1 mm. Post-operative MR imaging was obtained at five months and showed isointense, well circumscribed lesion that had decreased in size to 6.5 x 6.5 x 6.0 mm. No restricted diffusion, internal enhancement, or peripheral edema were noted.

Conclusions
Laser ablation therapy is successful for treating epilepsy in patients with HH, possibly due to disruption of excitatory networks within the hamartoma, or disrupted contacts between the hamartoma and limbic structures.
Substantia Nigra Signal Abnormalities: Signposts to a Diagnosis of West Nile Encephalitis?

K Riley,1 Y ANZAI2, J McNally3, K Salzman4
1The University of Utah, Salt Lake City, UT, 2UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT, 3University Of Utah, Salt Lake City, UT, 4UNIVERSITY OF UTAH, SALT LAKE CITY, UT

Purpose
Viral encephalitides are a relatively uncommon cause of encephalopathy in the United States, although in the last several decades West Nile Virus (WNV) infection has been growing in incidence. CNS involvement of WNV is estimated to occur in just 1 out of 150 cases. Classic imaging features of viral encephalitis are fairly non-specific and include signal abnormalities within the basal ganglia and thalami, making it difficult to distinguish a viral encephalitis from other infectious, toxic/metabolic, lymphoproliferative, or inflammatory/vasculitic processes. The purpose of this presentation is to discuss how the finding of marked signal abnormality in the substantia nigra may be helpful in making a diagnosis of a viral encephalitis such as WNV neuroinvasive disease or St. Louis encephalitis.

Materials and Methods
An elderly female with extensive past medical history presented to an ED with several days of progressive encephalopathy preceded by febrile illness. Of note, the patient had traveled to the mountain west but lived near multiple wetlands with a large mosquito population. Her mental status steadily declined and was intubated shortly thereafter. An EEG at that time was concerning for status epilepticus. Lumbar puncture was performed and CSF analysis revealed elevated WBC and positive IgM antibody for West Nile Virus (WNV) indicating an acute infection.

Results
Axial FLAIR showed striking hyperintensity within the bilateral substantial nigra (Panel A) as well as hyperintensity within the thalami, right greater than left (Panel B). Corresponding bright signal on DWI (Panel C) and dark signal on the ADC map (not shown) were also noted within the thalami indicating true restricted diffusion, a finding that has been frequently described in cases of West Nile encephalitis. Multiple foci of restricted diffusion were also noted within the cerebellar hemispheres and vermis (Panel D) suggestive of acute infarcts secondary to perivascular inflammation, a documented pathologic finding in WNV encephalitis.

Conclusions
The imaging features of viral encephalitides are often non-specific and overlap with multiple other causes of encephalopathy including toxic/metabolic, inflammatory, or lymphoproliferative etiologies. Striking involvement of the substantia nigra has been reported in West Nile and St. Louis encephalitis and may be a useful imaging feature in making a difficult diagnosis. Perivascular inflammation leading to acute infarcts are another potential complication of this disease.
The Amazing "Ears of the Linx". A Hallmark Sign in Hereditary Spastic Paraplegia with Thinning of the Corpus Callosum

C Besada¹, E Ruiz Romagnoli², M Perez Akly³, M Miquelini³, A Cardenas Osorio³, J La Mura¹, T Gillanders³, J Funes³
¹Hospital Italiano de Buenos Aires, CABA, Argentina, ²Hospital Italiano de Buenos Aires, Buenos Aires, Buenos Aires, ³Hospital Italiano de Buenos Aires, CABA, CABA

Purpose
To review clinical findings and outline specific imaging signs related to Hereditary Spastic Paraplegia with thinning of the corpus callosum (HSP-TCC). To emphasize the signs of the ears of the lynx and the atrophy of the rostral corpus callosum as hallmarks of HSP-TCC related to mutations in the SPG11 and SPG15. To guide clinicians into these degenerative disorders in order to reach a correct diagnosis and to provide patients a faster symptomatic treatment.

Materials and Methods
Hereditary Spastic Paraplegia is a heterogeneous group of hereditary disorders characterized by progressive degeneration of the corticospinal tracts and posterior columns of the spinal cord. The specific thinning of the corpus callosum associated has been classified as an independent disease entity. Mutations in the human SPG 11 gene, which map to chromosome 15q21.1 have been found to be responsible for autosomal recessive HSP-TCC. We present the case of a 20 years old man diagnosed with hereditary spastic paraplegia type 11 by exome genetic testing. He started early with attention deficit disorder and then progressed with stiffness, muscle cramps along with some limitation in deambulation and a tendency to fall. Three years later, the clinical picture was predominantly cognitive decline, dysarthria and paraplegia. Upon physical examination he had spastic paraplegia, bilateral clonus and hyperreflexia. Early and subsequent brain MRI were performed.
Results
Radiologic findings in HSP include nonspecific brain anomalies such as brain and spinal cord atrophy and white matter lesions. In the case presented we found a severe early atrophy of the rostral corpus callosum, from the first images performed. We also detected some particularly funny white matter lesions at the frontal periventricular areas that resembled the ears of the lynx; a kind of long tuft of hair present on the tips of the ears of these felines. When this sign is present, it highly correlates to the most common genetic subtype of HSP-TCC, as was lately diagnosed in our patient.

Conclusions
HSP-TCC is an independent entity into a wide group of progressive degenerative disorders. The presence of the sign described as the "ears of the lynx" in the context of an atrophy of the rostral corpus callosum are the major hallmarks of autosomal recessive HSP-TCC. When this radiologic sign is depicted there is a high likelihood of a genetic mutation associated with SPG 11 or SPG15. Hopefully these findings may help to unveil the unknown pathogenesis involved in these diseases.

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2302

The Glass Ceiling in Career Progression for Female Academic Neuroradiologists

M Wood1, N Tenenholtz2
1Massachusetts General Hospital, Boston, MA, 2Microsoft Research, Cambridge, MA

Purpose
In this work, we quantify the gender disparity that exists beyond the rank of new hire within the academic neuroradiology community, highlighting that although women advance proportionally within neuroradiology divisions, they struggle to attain the role of department chair.

Materials and Methods
A sample of American neuroradiology divisions was taken by selecting the top 35 diagnostic radiology residency programs, by reputation, as ranked by Doximity (www.doximity.com). The genders of radiology department chairs as well as neuroradiology section chiefs, fellowship directors, professors, and associate professors were recorded with three programs excluded due to unavailability of data. These roles were selected due to their public nature as well as the breadth of responsibilities they encompass. Sample validity was assessed by comparing to previously reported data where available, and two-sided Barnard's tests were then performed to assess for differences in female prevalence.

Results
Female representation within the aforementioned neuroradiology roles ranged from 26% to 32%, which exceeds the ACGME-reported prevalence of women in neuroradiology fellowship programs (18% to 23% over the trailing five years) and is not significantly different than the prevalence of women in these departments (28%). This level of female advancement uniformly exceeded that observed at the department chair level in our sample (9%) as well as in the ACR Workforce Survey (6%), with significant differences at the roles of fellowship director (t=2.28; p=0.025), professor (t=2.00; p=0.047), and associate professor (t=2.38; p=0.025). The difference for the position of section chief did not reach statistical significance (t=1.99; p=0.053). Comparisons between the various roles within neuroradiology yielded no significant differences with all p-values exceeding 0.5.
While improved from previous levels of 13% and 18% female representation in 1990 and 2003 respectively, radiology remains a male-dominated specialty with approximately 25% female representation. Despite the personal and professional challenges that such a gender imbalance presents, women remain proportionately represented within academic neuroradiology, suggesting the presence of promising career opportunities for the increasing share of young female radiologists. The disproportionate female representation at the department chair level, and its significant deviation from expected values, is more troubling and warrants further investigation.

**Figure 1**: While proportionally represented within academic neuroradiology, females largely fail to attain the role of department chair.

(Filename: TCT_2302_FemalesInNeuroradiology.jpg)

The preliminary study of the endovascular management of brain arteriovenous malformations by ethanol sclerotherapy

Y He¹, T Li², Y He²
¹Henan Provincial People's Hospital, Zhengzhou, Henan Province, ²Henan Provincial People's Hospital, Zhengzhou, Henan

**Purpose**

To explore the safety of the endovascular management of brain arteriovenous malformations (bAVMs) with ethanol.

**Materials and Methods**

Between November 2018 and September 2019, the clinical and imaging data of 29 patients with bAVMs treated by endovascular embolization with ethanol was collected. Rotational 3D angiography images with volumetric reconstruction were generated to further display the exact location of surgical target, which usually were aneurysms or arteriovenous fistulas, to determine the working projections. Different concentrations of mixture of ethanol and iohexol 320 was injected, which was selected according to different target types. All perioperative adverse events related to surgery were recorded.

**Results**

Target lesions were embolized with ethanol in 29 patients. Twenty target aneurysms and fifteen arteriovenous fistulas were performed. Twenty-one target lesions were cured with only ethanol embolization, seven target lesions with ethanol and Onxy embolization. One patient was cured of the bAVMs with ethanol embolization plus transvenous endovascular embolization. Five target lesions with ethanol and coil embolization. One target aneurysm was still slightly residual after operation. There were ten patients suffered encephaledeama, and seven of them had cerebral infarction at the same time after operation, however, only one patient, who clinical symptom was more severe at discharge than preoperative.

**Conclusions**

The embolization technique is feasible for bAVMs patients and the safety seems acceptable. But the safety and effect of the ethanol still need more research.
The Role of MR Angiography in Pediatric Sickle Cell Disease Patients with Normal Transcranial Doppler Velocities

P Muthusami¹, E Alshehri², A Dmytriw³, G Chavhan³, A Amirabadi², M Shroff⁴, S Williams²
¹The Hospital for Sick Children, Toronto, OH, ²The Hospital for Sick Children, Toronto, Ontario, ³The Hospital for Sick Children, Toronto, Ontario, ⁴Hospital for Sick Children, Toronto, ON

Purpose
To determine the additional information provided by MRA in pediatric SCD patients with normal TCD examinations

Materials and Methods
IRB approved retrospective study included pediatric Sickle Cell Disease (SCD) patients over an 18-year period who had no history of stroke, had normal transcranial doppler (TCD) examinations and subsequently underwent MRA. Clinical data: age, sex, hemoglobinopathy genotype, clinical presentation and history of chronic transfusion or hydroxyurea. MRI with MRA was performed on a 3T magnet. Images and reports reviewed on radiology PACS by two pediatric neuroradiologists in consensus. Data from brain MRI/MRA examinations: silent infarcts, vascular abnormality including vascular tortuosity, intracranial arterial narrowing/steno-occlusion and aneurysms. These parameters were reassessed on follow-up MRI/MRA, if available. TCD velocities recorded from original reports on PACS. Descriptive statistical analysis was performed: normally distributed continuous variables were described as mean and standard deviation (±SD), and non-normally distributed continuous variable as median and interquartile range (IQR). Comparison between asymptomatic and symptomatic groups was performed using chi square test in regard to SCI status. Point biserial correlation was used to determine whether there is an association between average of MCA velocities and silent infarcts.

Results
87 children (45 female; mean age 8.7±3.5years) included, 77 patients (88.5%) with Hb-SS disease, one (1.1%) with Hb-SC disease, and nine (10.3%) with HB-beta-thalassemia. All patients had normal TAMMV (<170 cm/s) on TCD. 76/87 (87%) patients had one or more velocity readings <70 cm/s, none in MCA. Posterior cerebral arteries had lowest velocities, <70 cm/s in 51.7% (right) and 60.9% (left). All patients had MRI with MRA within six months (mean 84.5±57.8 days) of TCD. Silent MRI infarcts seen in 27/87 (31%) patients. No new lesions on follow-up MRI. Mild vascular tortuosity in 31/87 (35.6%). No steno-occlusive lesions in the circle of Willis, no aneurysms. No statistically significant association of SCI between asymptomatic and symptomatic groups (Chi-square test, p=0.49).

Conclusions
Our results suggest that in children with SCD and no history of TIA or stroke, with normal TCD velocities, MRA does not add information that would alter clinical management. However, a third of these children still develop silent brain infarcts, which points to an underlying process that needs to be better understood.
The Use of Texture Analysis to differentiate Tumor and Inflammatory Lymph nodes In Computed Tomography

F Reis1, A Alves2, F Reis3, D de Pina2
1Unicamp, Campinas, SAO PAULO, 2Universidade Estadual de São Paulo, Botucatu, Sao Paulo, 3Universidade Estadual de Campinas, Campinas, Sao Paulo

Purpose
Changes in lymph nodes are very common in both infectious/inflammatory and tumoral processes. Differentiating inflammatory from tumoral etiologies often represents a diagnostic challenge. Diagnostic imaging methods, such as computed tomography (CT), have greater accuracy than physical palpation exams. However, the differentiation of occult metastases and inflammatory still provides interpretation difficulties and may lead to misdiagnosis. Texture analysis associated with machine learning approaches demonstrated potential as a strategy for classification. The aim of this work was to use a computational tool capable of differentiating tumoral from inflammatory lymph nodes.

Materials and Methods
Database was composed by 120 images of patients with confirmed diagnosis of metastasis (60 cases) and inflammation (60 cases). Texture were extracted with Gray Level Run Length (GLRL) and Gray Level Co-occurrence Matrix (GRCM) within a region of interest (ROI) placed inside lymph nodes. The obtained characteristics were used to perform the classification through a Machine Learning approach. This method employs the data obtained to distinguish lymph nodes affected by inflammatory from tumoral processes. The characteristics obtained by GLCM and GLRL were ranked and the best of both techniques were selected to perform the classification.

Results
We obtained area under the curve (AUC) of 71.0%, accuracy of 69.9%, F-score of 69.5%, precision of 69.9% and sensitivity of 69.9%.

Conclusions
The method was efficient in differentiating etiologies (inflammatory versus tumor) in 70% of all exams. Despite its low accuracy and sensitivity (less than 0.7), the AUC greater than 0.7 demonstrated that the model performed well.
Purpose
It is difficult to predict which patients with idiopathic normal pressure hydrocephalus (iNPH) will improve after shunt surgery. This study was done to evaluate the preoperative imaging of patients with iNPH and to identify any associations between patient imaging and long-term patient-reported subjective outcome after shunt placement.

Materials and Methods
A consecutive series of patients diagnosed with iNPH who underwent ventriculoperitoneal shunt surgery at a single institution were reviewed. Long-term patient-reported outcomes were obtained by telephone interview. Preoperative imaging parameters were retrospectively reviewed to determine any associations between imaging and outcome.

Results
Thirty-seven patients were included in the final analysis. The median duration between shunt surgery and interview was 30 months (range 12 - 56). Gait improvement after shunting was present more often in patients without focally dilated sulci (95% vs. 71%, P = .04), but a significant relationship was not found after logistic regression (OR 0.13 [95% CI, 0.01-1.22]; P = .07). Patients with cognitive improvement after shunting had a larger preoperative Evans' index (mean 0.41 vs. 0.36, P < .01), and Evans' index was a predictor of cognitive improvement (OR 1.40 [95% CI, 1.08-1.81], scale of 0.01; P = .01).

Conclusions
In patients with iNPH, a larger Evans' index is a predictor of long-term cognitive improvement. No imaging feature was found to be predictive of long-term gait or urinary improvement. Addition of the Evans' index to clinical assessment and large volume cerebrospinal fluid removal may assist in the selection of patients for shunt surgery.

Table 1. Comparison of patient imaging features and cognitive outcome (n=28)

<table>
<thead>
<tr>
<th>Imaging Feature</th>
<th>Cognitive Improvement</th>
<th>No Cognitive Improvement</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evans' index</td>
<td>0.41</td>
<td>0.36</td>
<td>.002*</td>
</tr>
<tr>
<td>Temporal horn width (mm)</td>
<td>7.4</td>
<td>7.1</td>
<td>.65</td>
</tr>
<tr>
<td>Diameter of the third ventricle (mm)</td>
<td>11.3</td>
<td>9.5</td>
<td>.05</td>
</tr>
<tr>
<td>Height of corpus callosum (mm)</td>
<td>40</td>
<td>36 (n=15)</td>
<td>.06</td>
</tr>
<tr>
<td>Thickness of corpus callosum (mm)</td>
<td>4.4</td>
<td>4.5 (n=15)</td>
<td>.79</td>
</tr>
<tr>
<td>Angle of corpus callosum (degrees)</td>
<td>63</td>
<td>71 (n=15)</td>
<td>.26</td>
</tr>
<tr>
<td>Dilation of the Sylvian fissures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narrow or normal</td>
<td>2 (40%)</td>
<td>3 (60%)</td>
<td>.07</td>
</tr>
<tr>
<td>Mild dilation</td>
<td>5 (29%)</td>
<td>12 (71%)</td>
<td></td>
</tr>
<tr>
<td>Severe dilation</td>
<td>5 (83%)</td>
<td>1 (17%)</td>
<td></td>
</tr>
<tr>
<td>Compression of the medial high convexity</td>
<td></td>
<td></td>
<td>.62</td>
</tr>
<tr>
<td>Grade 0</td>
<td>1 (33%)</td>
<td>2 (67%)</td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>0 (0%)</td>
<td>1 (100%)</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>11 (46%)</td>
<td>13 (54%)</td>
<td></td>
</tr>
<tr>
<td>Compression of the peripheral high sulci</td>
<td></td>
<td></td>
<td>.54</td>
</tr>
<tr>
<td>Grade 0</td>
<td>1 (25%)</td>
<td>3 (75%)</td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>5 (38%)</td>
<td>8 (62%)</td>
<td></td>
</tr>
<tr>
<td>Grade 2</td>
<td>6 (55%)</td>
<td>5 (45%)</td>
<td></td>
</tr>
<tr>
<td>Disproportionately enlarged subarachnoid space</td>
<td></td>
<td></td>
<td>.59</td>
</tr>
<tr>
<td>Present</td>
<td>10 (45%)</td>
<td>12 (55%)</td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>2 (33%)</td>
<td>4 (67%)</td>
<td></td>
</tr>
</tbody>
</table>

* P < .05

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1269

Thinking on your feet in the ED: An on-the-fly Adjustment to Improve a Common DWI Artifact
K Riley¹, R WIGGINS², Y ANZAI³
¹The University of Utah, Salt Lake City, UT, ²UNIVERSITY OF UTAH, SALT LAKE CITY, UT, ³UNIVERSITY OF UTAH SCHOOL OF MEDICINE, SALT LAKE CITY, UT

Purpose
Isolated cranial nerve palsies are occasionally observed with leptomeningeal involvement of systemic lymphoma. MRI is the mainstay of imaging in these scenarios, however, it is often fraught with artifacts. We present an unusual case of an isolated sixth cranial nerve palsy in a patient presenting to the ED and discuss and how its diagnosis was aided by an on-the-fly adjustment to the DWI sequence to address a common artifact.

Materials and Methods
A man in his thirties presented to the ED with a growing right axillary mass over one month as well as a left sixth cranial nerve palsy over the same time. MRI of the brain and skull base revealed a mass within the left cavernous sinus with involvement of the adjacent sixth cranial nerve. Initially the mass was obscured on DWI/ADC due to susceptibility artifact from dental hardware and air within the paranasal sinuses, however, a quick adjustment to the phase and frequency encoding directions of the sequence while the patient was still on the table allowed for better visualization and more confidence in the favored imaging diagnosis of lymphoma. The patient was admitted and subsequently diagnosed with HIV. Biopsy of the right axillary mass yielded a diagnosis of Burkitt Lymphoma.

Results
MRI showed a mildly enhancing mass within the left cavernous sinus (Panel A) with extension of tumor along the left sixth cranial nerve as demonstrated on the axial T2 space sequence (Panel B). Initial DWI/ADC contained significant susceptibility artifact related to dental hardware (Panel C), obscuring the mass. Repeat DWI/ADC after changing the phase and frequency encoding directions of the sequence contained persistent artifact, however, the distribution changed such that the mass was now visualized and showed markedly low signal on the ADC map (Panel D) with an ADC value of 206 mm²/sec, highly supportive of a diagnosis of a hypercellular tumor such as lymphoma.

Conclusions
Susceptibility artifact on brain MRI due to dental hardware is commonly encountered in clinical practice and can obscure significant portions of the brain and skull base, particularly on DWI/ADC. Changing the phase and frequency encoding directions on DWI is a quick troubleshooting method that alters the distribution of the susceptibility artifact and may allow visualization of a previously obscured region and significantly increase confidence in diagnosis, as shown in this case of a patient presenting with isolated sixth nerve palsy due to cavernous sinus involvement of lymphoma.
Thoracic Spine Ligamentum Flavum Laxity: A Hirayama-Like Disease and Its Confounders

M BRAILEANU¹, M Hoch², B WEINBERG¹
¹Emory University School of Medicine, Atlanta, GA, ²University of Pennsylvania School of Medicine, Philadelphia, PA

Purpose
To present cases of thoracic spine ligamentum flavum laxity using MRI and MRA. To compare and contrast imaging findings and clinical presentation of thoracic ligamentous laxity to Hirayama disease. To examine imaging mimics and differentiate thoracic spinal ligamentous laxity from extradural fistulas.

Materials and Methods
We present 3 cases of thoracic spine ligamentous laxity on both MRI and MRA. The first patient is a 33-year-old male with a history of remote trauma 5 years ago presenting with thoracic sensitivity and pain (figure 1). The second patient is a 58-year-old male
presenting with thoracic back pain radiating to the lower extremities. The third patient is a 26-year-old male with neck and right arm "tugging" sensations, paraesthesias, and pain. All patients were managed conservatively.

Results
On MRI, all patients demonstrated prominent dorsal epidural fat with dilated veins at the level of the superior thoracic spine (Figure 1A). The first patient also has flexion sequences demonstrating the forward migration of the posterior wall of the dura mater with accentuation of the dorsal epidural venous flow voids at the level of T2 to T7 (Figure 1B). The second patient demonstrated short segment abnormal T2 hyperintense signal in the upper thoracic spine. On MRA, there was no evidence of a dural arteriovenous fistula or other vascular abnormality for all patients (Figure 1C).

Conclusions
We present 3 cases of thoracic spine ligamentous laxity. All patients demonstrated prominent dorsal epidural fat with dilated veins at the level of the thoracic spine. Imaging findings are similar to Hirayama disease, a condition of dorsal ligamentous laxity in the cervical spine presenting with cervical flexion myelopathy. Our patients had similar imaging findings to Hirayama disease but presented with atypical symptoms, likely correlating to the spinal level of the imaging abnormality. Patients had resulting epidural venous plexus dilation in the thoracic spine which could mimic a spinal vascular malformation. However, all patients had negative MRAs. Flexion and angiographic imaging sequences, as well as clinical history, may help differentiate thoracic ligamentous laxity from Hirayama disease and thoracic spinal vascular abnormalities.

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1262

Thyroid Eye Disease after Treatment for Papillary Thyroid Carcinoma

O Kohannim1, K McCowen1, J Bykowski1

1UC San Diego, San Diego, CA

Purpose
To present a case of atypical thyroid-related orbitopathy in a patient with a history of papillary thyroid cancer without history of Graves disease

Materials and Methods
A 54 year old female presented in 2019 with hypertropia of the right eye. In 2015, the patient was diagnosed with papillary thyroid cancer and left level II-IV nodal metastatic disease. She was treated with total thyroidectomy and left modified radical neck dissection. In 2016, the patient received 159 mCi of Iodine-131 therapy. In 2017, she developed recurrence and underwent revision left modified radical neck dissection. No distant metastatic disease was identified. She was continued on thyroid treatment for iatrogenic hypothyroidism.
Results
CT neck at the time of treatment for papillary thyroid cancer recurrence showed normal appearance of the extraocular muscles bilaterally (Figure). MRI of the orbits performed 2 years later in the setting of clinical symptoms confirmed enlargement and enhancement of the right superior rectus and bilateral inferior rectus muscles with sparing of the myotendinous junctions, consistent with thyroid-related orbitopathy (Figure). The extraocular muscle involvement differed from the classic distribution, sparing of the medial rectus, despite inferior and superior rectus involvement.

Conclusions
Antibody testing confirmed elevated thyroid stimulating hormone (TSH) receptor antibody level of 11.9. Although Graves disease is the most common cause of thyroid-related orbitopathy, patients with other thyroid disorders can also develop eye disease. Few have reported orbitopathy in the setting of papillary thyroid carcinoma1,2,3. It has been hypothesized that this may be secondary to antigen from undetectable thyroid tissue. Imaging characteristics and mechanism of this rare presentation of thyroid eye disease are not, however, well described in the literature and the atypical extraocular muscle involvement pattern may be related to differences in underlying etiology.

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Topographic Correlation Between Sella Turcica MRI and Endoscopic Endonasal Surgery Classification for Craniopharyngioma

P Sepúlveda Massone¹, F Sepúlveda¹
¹Instituto Neurocirugía Dr. Asenjo, Santiago, Santiago

Purpose
Correlate endoscopic classification for craniopharyngioma with MRI of the sella turcica in patients who underwent endoscopic endonasal surgery (CEE) at the Instituto de Neurocirugía Asenjo between November 2011 and May 2019.

Materials and Methods
A biased neuroradiologist evaluated preoperative MRI of patients included in this study. The location of the tumor in relation to the pituitary stalk and its suprasellar extension were considered. Kassam’s et al endoscopic classification (Type I is preinfundibular; Type II is transinfundibular (extending into the stalk); Type III is retroinfundibular, extending behind the gland and stalk, and has 2 subdivisions (IIIA, extending into the third ventricle; and IIIB, extending into the interpeduncular cistern); and Type IV is isolated to the third ventricle and/or optic recess and is not accessible via endonasal approach) was taken as a point of comparison recorded in the operative protocols or in videos of surgeries.

Results
Thirteen patients between 6-69 yo (34 yo average) at the time of EES were included. 7 were women and 6 men. 5 patients underwent reoperation and 8 to CEE for the first time. 54% of the lesions were cystic and 46% were solid-cystic on MRI. 92% (1/13) were found to be adamantinomatous craniopharyngiomas. In the group of patients who received EES for the first time, MRI showed that the relationship between the tumor and the infundibulum was preinfundibular (2), transinfundibular (4), retroinfundibular (2) and that, according to Kassam’s classification, would correspond to types I, II and IIIb, respectively (Table 1). There were no patients in which types IIa or IV were described in this series. On the other hand, for patients who were reoperated, only 2 showed retroinfundibular craniopharyngioma in preoperative MRI, compatible with was registered in the operative protocols (Kassam IIIb). The rest was not concordant (Table 2).

Conclusions
Application of endoscopic endonasal technique requires knowledge of regional anatomy. Kassam's classification has been fundamental to understand the relationship between the tumor and stalk, and thus, the approach to it. MRI in patients undergoing EES for the first time is a useful tool for preoperative assessment to establish the tumor situation in relation to the pituitary stalk. In addition, it would have an excellent correlation to Kassam's classification. In the reoperated group, this relationship (Stalk-tumor) was not adequate. A larger series is required to obtain statistically significant results.
Training and Validation of DeepMedic Machine Learning Tool for Automated Intracerebral Hemorrhage Segmentation and Volume Analysis on CT Using Multicenter Data

T Huynh¹, A Guida², S Nurmsoo³, A Wong⁴, J Patel⁵, D Rao⁶, D Dowlatshahi⁷, R AVIV⁸
¹University of Florida Health Jacksonville, Jacksonville, FL, ²IWK Health Centre, Halifax, Nova Scotia, ³Dalhousie University, Halifax, Nova Scotia, ⁴Dalhousie University, Halifax, NS, ⁵University of Florida College of Medicine - Jacksonville, Jacksonville, FL, ⁶University of Florida College of Medicine Jacksonville, Jacksonville, FL, ⁷University of Ottawa, Ottawa, AK, ⁸SUNNYBROOK HEATH SCIENCES CENTER, TORONTO, ON

Purpose
We sought to train and validate an automated machine learning algorithm for intracerebral hemorrhage (ICH) segmentation and volume calculation using multicenter data.

Materials and Methods
An open-source 3D deep machine learning algorithm "DeepMedic" was trained using manually segmented ICH from 208 CT scans (129 patients) from the multicenter PREDICT study. The algorithm was then validated with 151 manually segmented CT scans (62 patients) from the SPOTLIGHT and STOP-IT studies. Manual segmentation was performed with Quantomo semi-automated software. ABC/2 was measured for all studies by two neuroradiologists. Accuracy of DeepMedic segmentation was assessed using the Dice similarity coefficient. Analysis was stratified by presence of IVH. Intraclass correlation (ICC) with 95% confidence intervals (CI) assessed agreement between manual vs. DeepMedic segmentation volume; and manual segmentation and ABC/2 volume. Bland-Altman charts were analyzed for ABC/2 and DeepMedic vs. manual segmentation volumes.

Results
DeepMedic demonstrated high segmentation accuracy in the training cohort (median Dice 0.96; IQR 0.95 - 0.97) and in the validation cohort (median Dice 0.91; IQR 0.86 - 0.94). Dice coefficients were not significantly different between patients with IVH in the training cohort; however was significantly worse in the validation cohort in patients with IVH (Wilcoxon p<0.001). Agreement was significantly better between DeepMedic and manual segmentation (PREDICT: ICC 0.99 [95%CI 0.99 -1.00]; SPOTLIGHT: ICC 0.98 [95%CI 0.97 - 0.99]) than between ABC/2 and manual segmentation (PREDICT: ICC 0.92 [95%CI 0.89 - 0.95]; SPOTLIGHT: ICC 0.95 [95%CI 0.93-0.97]). Improved accuracy of DeepMedic was demonstrated in Bland-Altman charts (Fig 1).

Conclusions
ICH machine learning segmentation with DeepMedic is feasible, accurate, and demonstrates greater agreement with manual segmentation compared to ABC/2 volumes. Accuracy of the machine learning algorithm however is limited in patients with IVH.
transcarotid access is sometimes required (1). We describe a case series of transcarotid MT to assess its technical and clinical efficacy. Additionally, we compared these transcarotid MT against successful transfemoral access age matched controls.

Materials and Methods
We retrospectively studied 8 patients that underwent MT for anterior circulation acute ischemic stroke requiring transcarotid access. Using age matched controls (> 80 years), we compared demographics, NIHSS, complications, technical and clinical efficacy. All 8 cases of carotid access and 8 age matched controls were also analyzed for aortic arch anatomy type and number of cervical vascular tortuosity >90°. Using 3D CTA, angular path changes were summated from the aortic arch to the carotid bifurcation and analyzed as a sum of angular tortuosity from the horizontal baseline of the aortic arch. Chi-square, Mann-Whitney U and student t tests were used for variables univariate analysis as appropriate.

Results
Both transcarotid group and control group were matching in age (89.8 and 89.6 years respectively), both groups were comparable.
regarding their NIHSS (16 vs 20, p=0.26). There was no significant difference between both groups regarding history of hypertension, DM, Hyperlipidemia, Smoking, CHF or AF (p=0.52, 1, 0.13, 1, 0.32, 0.36 respectively), however the transcarotid group was associated with a significantly higher history of previous stroke/TIA (62.5% vs 12.5%, p=0.04). The mean number of curve>90° was higher and was trending to be significant (1.2±0.8 vs 0.3± 0.75, p= 0.055), the sum of angle tortuosity was trending to be higher in the transcarotid group (371±165 vs 214 ± 86, p=0.14), also those who failed femoral access were trending to be more associated with type 3 arch (62.5% vs 25%, p=0.13). There was no difference between both groups regarding the 90-days mRS outcome (p=0.95). Only one patients in transcarotid group had an iatrogenic cervical ICA dissection.

Conclusions

Transcarotid approach is a relatively safe alternative to transfemoral approach in MT, and may be considered in patients with type 3 arch, more than 1 cervical curve>90°. These patients were more likely to be older and have history of previous stroke/TIA.

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**Turning Up the Volume: A Case Report of Cerebral Hyperperfusion Syndrome After Carotid Endarterectomy**

V Kuttappan1, B Peiffer1, H Mazin1, P Shah1

1Advocate Illinois Masonic Medical Center, Chicago, IL

Purpose

Cerebral hyperperfusion syndrome, a rare postprocedural entity, shares a number of imaging features with acute hypertensive encephalopathy and status epilepticus, however with the potential for markedly different outcomes. Due to these neuroimaging features, clinical manifestations can be similar further complicating distinction. We present a case which classically demonstrates this rare syndrome after carotid endarterectomy.

Materials and Methods

We present a 70-year-old male with a past medical history of hypertension, Factor V Leiden mutation receiving lifelong anticoagulation and recent history of elective right carotid endarterectomy. Three days after the procedure, patient presented to the emergency department with headaches, left upper extremity weakness and cramping and generalized seizures. Emergent noncontrast CT head demonstrated right frontal subarachnoid hemorrhage. CT angiogram and CT perfusion revealed asymmetric enlargement of the right MCA and PCA branches and increased cerebral blood volume and flow to the right cerebral hemisphere respectively. Following MRI brain demonstrated multiple areas of FLAIR hyperintensity in the cortex and subcortical white matter of the right cerebral hemisphere, centrum semiovale and thalamus without associated restricted diffusion. Patient's anticoagulation was immediately stopped and his condition improved during his admission course prompting discharge four days later. Follow-up MRI six weeks later demonstrated complete resolution of the previously visualized aberrant FLAIR signal.

Results

A) CT Perfusion illustrating a slight asymmetric increase in rCBF to the right cerebral hemisphere. B) Maximum Intensity Projection image demonstrating the asymmetrically increased size and conspicuity of right MCA and PCA branches. C) Initial MRI showing scattered areas of high FLAIR signal in the right cerebral hemisphere. D) Follow-up MRI six weeks later showing complete resolution of the aberrant FLAIR signal.

Conclusions

A rare complication of carotid endarterectomy, this case demonstrates a classic constellation of findings representative of cerebral hyperperfusion syndrome (CHS). Considered a neurological emergency with the potential for significant morbidity and mortality, we review these imaging characteristics that share similarities with acute hypertensive encephalopathy (PRES) and status epilepticus with a goal of improving diagnostic and therapeutic accuracy.

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**Two Rare Cases of Intracranial Granulocytic Sarcoma**

M Mitsunaga1, O Raslan1, A Ozturk1, N Pham1, R Assadsangabi1, V Ivanovic1, M Bobinski1, J Chang1

1UC Davis Medical Center, Sacramento, CA
Purpose
To present two pathologically proven cases of granulocytic sarcoma in patients with acute myelogenous leukemia (AML).

Materials and Methods
Patient 1 was a 43 year-old woman presenting with gum swelling and petechiae, found to have an elevated WBC count. Bone marrow biopsy showed AML. She was treated with chemotherapy and stem cell transplant, remaining in remission for over 10 years. She then developed progressive vision loss. MRI brain with contrast showed a large left mesial temporal intra-axial mass. Partial resection and pathology was consistent with myeloid sarcoma. She was treated with chemoradiation with continued decrease in size of the mass over serial MRIs. Patient 2 was a 52 year-old gentleman with a history of AML treated with chemotherapy. One year later, platelet counts decreased and bone biopsy was consistent with relapsed AML. He was treated with chemotherapy and underwent stem cell transplant. Two years later he presented with left upper and lower extremity weakness and numbness. MRI brain with contrast showed an enhancing left posterior frontal parasagittal enhancing extra-axial mass with parenchymal invasion and leptomeningeal enhancement. Biopsy was consistent with myeloid sarcoma. CSF studies showed blasts. He was started on intrathecal chemotherapy and received radiation treatment. The mass decreased in size on serial MRIs. Four months later, he developed systemic recurrence and he then decided on transitioning to hospice.

Results
Patient 1’s (top row) brain MRI with contrast shows a homogenously enhancing intra-axial mass involving the left basal ganglia, midbrain, and temporal lobe with mass effect on the left optic tract. Patient 2’s (bottom row) brain MRI with contrast shows an enhancing left posterior frontal parasagittal extra-axial mass with parenchymal invasion and leptomeningeal carcinomatosis.

Conclusions
Granulocytic sarcoma or chloroma is a solid extra-medullary neoplasm comprised of immature myeloid cells and has been reported in less than 9% of patients with AML. Lesions usually occur in the osseous structures and soft tissues. It is rare in the CNS. Typical intracranial findings are extra-axial masses that are hyperdense on CT, variable on T1 and T2-weighted images, and enhance homogenously. The differential includes meningioma, lymphoma, and metastases. Treatment typically includes resection, radiation, and systemic chemotherapy.

Usefulness of Ultrashort TE 4D MR Angiography after Stent-Assisted Coil Embolization for Posterior Circulation Aneurysms
Purpose
Blood flow in an intracranial stent is difficult to evaluate with 3D time-of-flight (TOF) MR angiography (MRA) owing to severe susceptibility artifacts. To overcome this issue, 3D MRA by using an ultrashort TE (UTE) combined with an arterial spin-labeling (ASL) technique has been developed. Furthermore, continuous data acquisition (4D) in UTE MRA enables us to evaluate hemodynamic flow information in the stent. The purpose of this study was to evaluate the usefulness of the UTE 4D MRA for hemodynamic flow information of the intracranial stent placed arteries in the posterior circulation.

Materials and Methods
This study included ten patients treated with stent-assisted coil embolization for the posterior circulation aneurysm. All patients underwent 3T MRI including 3D TOF MRA and UTE 4D MRA after embolization. Two neuroradiologists independently assessed the TOF and UTE 4D MRA images and scored the flow visualization in the stent using a 4-points grading system as 1 (not visible) to 4 (excellent). The latest x-ray digital subtraction angiography images were used as a reference standard. The flow direction in the stent was also evaluated in comparison with DSA. The scores of two readers were averaged, and the Wilcoxon test was performed in the statistical analysis of the subjective scores for flow in a stent. The level of interobserver agreement in the evaluation was analyzed by weighted κ statistics.

Results
On the UTE 4D MRA, the major intracranial arteries were demonstrated at a temporal resolution of 200 milliseconds. In both readers, the score of UTE 4D MRA was higher than that of TOF MRA in all cases. The mean score for UTE 4D MRA was 3.25±0.59, and for TOF MRA, it was 1.3±0.48 (P =.0048). Interobserver agreement was good (κ = 0.76). All patients show antegrade blood flow in the stent in UTE 4D MRA, and flow direction observed on UTE 4D MRA was consistent to that on DSA.

Conclusions
UTE 4D MRA was superior to 3D TOF MRA for flow visualization and hemodynamic information in the intracranial stent placed arteries in the posterior circulation.

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Using Apparent Diffusion Coefficient to Predict Facial Nerve Outcomes After Vestibular Schwannoma Resection: Data From a Retrospective Clinical study

D Raban1, A Thaker2
1University of Colorado School of Medicine, Aurora, CO, 2University of Colorado, Aurora, CO

Purpose
Correlation of preoperative Apparent Diffusion Coefficient (ADC) for vestibular schwannoma with intraoperative tumor characteristics, and with post-operative clinical outcomes, as measured by the House-Brackmann score (HB).

Materials and Methods
This was a retrospective review of 72 patients who underwent vestibular schwannoma resection from 2008 – 2018, for whom preoperative MRI and follow up clinical records were available. Clinical outcomes as quantitated by House-Brackmann score (HB), a physical examination grading system that measures motor function of the facial nerve, were recorded at an immediate postoperative evaluation, and at final follow-up. Intraoperative findings of tumor consistency and adherence, as described in the operative note, were recorded. Multiple imaging parameters were recorded independently by two radiology residents, and then reconciled by a neuroradiologist, all of whom were blinded to operative data and clinical outcome. Measurements included mean ADC values (mm2/s). Logistic and linear modeling was performed to correlate ADC with immediate and final HB scores. Regression tree analysis was also performed to identify distinct ADC categories with statistically different facial nerve outcomes.

Results
Regression tree analysis identified 3 ADC categories with statistically different facial nerve outcomes, for which the intermediate ADC category (ADC 1006.04 – 1563.93 x 10 -6 mm2/s) was associated with higher rates of facial nerve dysfunction postoperatively. ADC did not significantly predict intraoperative tumor characteristics. A significant predictor of a poor clinical outcome of facial nerve function as measured by a high HB score was intraoperative adherence as described in the operative note, for which ADC did not correlate on subgroup analysis, either as a continuous variable (p = 0.55), or when sorted into ADC groups (p = 0.68).

Conclusions
A subset of vestibular schwannomas with intermediate ADC values were associated with worse facial nerve outcomes. Diffusion weighted imaging may be a useful sequence to obtain in preoperative planning studies, to further stratify the risk of facial nerve dysfunction following gross- or near-total resection.

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Utility of MRI in the Subaxial Cervical Spine Injury Classification: Justification for extra Imaging cost with low grade injury

R Rehmani¹, O Cisneros², R Rahme²
¹Saint Barnabas Health Care System, NEW YORK, NY, ²Saint Barnabas Hospital, BRONX, NY

Purpose
The purpose of this study was to assess the added value of MRI STIR imaging in predicting failure of conservative management and thus identifying those patients who may benefit from early surgical stabilization in traumatic subaxial cervical spine injuries. CT forms the main workhorse for the initial evaluation of subaxial cervical spine injuries (C3-C7). However, magnetic resonance imaging (MRI), particularly the short tau inversion recovery (STIR) sequence provides superior soft tissue evaluation. However, not uncommonly, MRI STIR imaging may uncover soft tissue and ligamentous injuries, contrasting with an otherwise normal or nonconsequential CT study. It is unclear whether early surgical fusion of the cervical spine is warranted on the basis of such MRI findings. Yet, in practice, many such patients undergo surgical spinal stabilization based on MRI soft tissue findings.

Materials and Methods
We reviewed consecutive adult trauma patients over 3 year period at our institution who sustained a traumatic subaxial cervical spine injury (C3-C7) and underwent CT and MRI. Exclusion criteria were pathologic fractures, non-traumatic spine injury, rheumatologic spine disorders and non subaxial location. Patients managed conservatively were retained. Randomized double blinded retrospective review of the MRI was performed by three independent readers and injuries were classified according to the Subaxial Cervical Spine Injury Classification (SLIC) system.

Results
Our trauma database search identified only 47 patients with set criteria who underwent both MRI and CT of the cervical spine. SLIC neurologic score was assessed for each independently. All 47 patients had a SLIC score of less than 4 and were managed conservatively with C-Collar. Approximately 20% patients failed to follow up. With SLIC score less than 4, conservative management was favored overall, and neurosurgical intervention was not recommended.

Conclusions
MRI STIR is superior to CT in the evaluation of subtle soft tissue injuries in cervical spine trauma. However, ultimately with low grade injuries with SLIC score of 4, conservative management is preferred. Hence, we believe that the utility of MRI is limited in such cases with otherwise normal initial CT and adds an extra burden to the healthcare cost without contributing significantly to the overall care of the patients.
Utilizing Brain Hemispheric Asymmetries on MRI to Assess Neurologic Dysfunction

N Joshi1, M Caulfield2, A Barrett3
1Rowan University School of Osteopathic Medicine, Stratford, NJ, 2Villanova University, Villanova, PA, 3Kessler Foundation, West Orange, NJ

Purpose
Abnormal structural asymmetries are a robust measure that can be derived from brain MRI and are present in numerous disease processes such as aphasia, apraxia, stuttering, dyslexia, and neurodegenerative disorders. This study established a standardized method of measuring hemispheric asymmetries from axial MRI slices and demonstrated its efficacy to predict behavioral differences following neurological damage on a sample of stroke patients with spatial neglect.

Materials and Methods
T1 and T2-weighted brain MRI were measured using ImageJ processing software via a freehand tracing method that involved outlining the gyri and sulci of the left and right prefrontal and parieto-occipital regions. For each participant, slice positions (SP) and slice lengths (SL) were used to calculate slice gap (mm), slice volume (mm3), and slice gap volume. The volumes for each slice and gap were summed together for each respective subject and brain area to obtain a total volume for each brain region. Behavioral measures of spatial neglect included the Behavioral Inattention Test-Conventional and the Catherine Bergego Scale (CBS). The Barthel Index was used as a measure of functional dependence in everyday activities.

Results
We applied brain structural asymmetry measurement to study spatial neglect severity in 30 patients and found that for between-group comparisons of mild and moderate/severe neglect, the mild neglect group indicated an atypical (left<right) parieto-occipital asymmetry, whereas the moderate/severe group had a more typical asymmetry (p = .041), not accounted for by lesion volume.

Conclusions
These results support this method as an effective means of measuring abnormal brain hemispheric asymmetry from clinical MRI scans. Here, groups created using neglect severity demonstrated significantly different hemispheric asymmetries, suggesting that those with a greater abnormal asymmetry may better able compensate for their dysfunction. This method provides a possible structural biomarker for clinical correlation in predicting neurological recovery after stroke.

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Utilizing Cervical Level Muscle Mass on Computed Tomography to Screen for Sarcopenia.

K Bohn1, A Alleman2
1University of Oklahoma, OK, OK, 2N/A, N/A

Purpose
Sarcopenia (depleted muscle mass) has been recognized as an independently prognostic component of cancer cachexia. Observed comorbidities have included dysphagia,odynophagia, anhedonia, post-treatment complications and other symptoms hindering cancer treatment. Abdominal imaging has been used to identify sarcopenia based on muscle measurements at the lumbar level, but body imaging is not routine in patients with head and neck cancer (HNC). HNC is evaluated by Neck CT, and C3 muscle index has been measured by CT to predict L3 muscle index. An institutional pilot study utilizing concurrent abdominal and neck imaging to establish a C3-muscle index cutoff for sarcopenia in patients with HNC was underpowered.

Materials and Methods
In order to accrue more patients, unique sequential PET/CT studies of this single-institute tertiary care center were retrospectively evaluated. Exclusion criteria included repeat exams, uninterpretable images, and incomplete clinical data. At the level of L3, the cross-sectional area (CSA; cm2) of all skeletal muscle was summed. At the level of C3, the CSA of the paraspinous and sternocleidomastoid muscles was summed. Height-adjust CSA at L3 (aLCSA) was used to categorize all patients as sarcopenic or non-sarcopenic according to established cutoffs (52.4 cm2/m2 for males and 38.5 cm2/m2 for females). Ranges of height adjusted C3 CSA (aCCSA) criteria predicting sarcopenia were plotted into receiver operating characteristic (ROC) curves in males and females. C3 CSA was separately used to predict aLCSA according a height adjusted Swartz formula.

Results
Sarcopenic patients have significantly lower aCCSA than non-sarcopenic patients (P<.001 in males and in females). For predicting L3-designated sarcopenia in males, an aCCSA cutoff of 14 cm2/m2 gave the most accuracy (sn=0.85, sp=0.58, ac=0.75; ROC AUC=0.81). More accurate thresholds in females were less sensitive, however a cutoff of 10.7 cm2/m2 gave similar sensitivity without sacrificing specificity (sn=0.84, sp=0.68, ac=0.73; ROC AUC=0.84). The height adjusted Swartz formula improved accuracy in men (sn= 0.96, sp=0.47, ac=0.78) and sensitivity in women (sn= 0.90, sp=0.62, ac=0.71).

Conclusions
Muscle measurement at C3 is sufficiently sensitive for detection of sarcopenia compared to established methods in abdominal imaging. Given sensitivity is the preferred metric for screening exams, this increases the pool of prospective patients for studies into sarcopenia as it relates to treatment response and tolerance.

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Utilizing Hybrid PET/MR Imaging to Understand Acute Sports Concussion

K Naser-Tavakolian¹, M Clifton², M Salerno¹, A Franceschi³, G Cruciata², D Ouellette¹, D Komatsu⁴, K Wengler⁵, B Cruickshank⁴, D Franceschi³, L Bangiyev⁶, C Huang⁷, E Thomas¹, J Oseni⁴, K Dams-O’connor⁴, M Schweitzer¹, J Penna⁴, X He⁴, P Vaska¹

¹STONY BROOK UNIVERSITY HOSPITAL, Stony Brook, NY, ²Stony Brook University Hospital, Brooklyn, NY, ³Northwell, New York, NY, ⁴Stony Brook University Hospital, Stony Brook, NY, ⁵Stony Brook University Hospital, Stony Brook, NY, ⁶Stony Brook University Medicine, Stony Brook, NY

Purpose
The neuropathological cascade following concussion has been studied in animal models and consists of large and short-lived disruptions in glucose metabolism and homeostasis in the acute phase. Our goal is to establish the existence, magnitude, and regional distribution of fluctuations in glucose metabolism and related hemodynamic effects in humans.

Materials and Methods
Athletes (male age 18-22) from a single NCAA Division I university consented to undergo PET/MRI brain imaging in the event of concussion, using a within-subjects design in which subjects are imaged as soon as possible after injury and again after symptoms have resolved (>3 months later). PET/MRI was performed 40 min after I.V. injection of 3-5 mCi of FDG. MRI included standard structural scans and quantitative measures of cerebral blood flow (CBF) and cerebral metabolic rate of oxygen (CMRO2). PET images were analyzed in clinical MIM software and independently, registered to the Hammers brain atlas for quantitative ROI analysis in PMOD software.

Results
7 subjects were scanned between 31 and 94 hrs post injury, 4 of which had a follow-up scan. No structural or functional abnormalities were noted. Relative to follow-up, whole-brain SUV was lower by 26% although not statistically significant unless the latest scan is excluded (at 94 hrs, p = 0.02). Paired analysis (n=4) of individual regions indicated acute hypometabolism (<10%) relative to the follow-up scan primarily in the temporal lobe (p=0.03), but also hypermetabolism in left hippocampus (p = 0.02). Cortical surface maps read by a neuroradiologist and nuclear medicine physician also suggested mild medial temporal hypometabolism (primarily left side) in acute condition. The ratio of acute SUV to follow-up SUV (in both gray matter GM and white matter WM) decreased with delay from injury to scan time until ~48 hours post-injury (n=3, R² > 0.99) and then rebounded by 94 hours.

Conclusions
Observed trends suggest that acute phase after injury is hypometabolic across the whole brain when assessed between 1 and 2 days after injury, after which metabolism normalizes by day 4. With improved understanding of the acute metabolic changes in the brain after a concussion this can open additional pathways for diagnosis and treatment.

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Validation and Calibration of Fully-Automated CT Perfusion Deconvolution Software

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Purpose
To validate and calibrate newly developed in-house CTP deconvolution software, automated segmented brain volumes with specified Tmax, CBF and CBV deficits determined with in-house CTP deconvolution software were compared to those provided by Rapid iSchemaView (1).

Materials and Methods
Standard clinical raw CT data (10mm slice thickness with 4mm slice interval) obtained in patients at a single institution with acute ischemic stroke were reconstructed using fully-automated deconvolution software developed in-house using Matlab in an IRB-approved study in 43 patients from the GENESIS cohort. The volumes of brain with delayed perfusion were assessed at four thresholds (Tmax > 4, 6, 8 and 10s), as was ischemic core volume (brain with CBF < 30% normal; normal brain defined as tissue with Tmax < 4s) as well as volume of brain with CBV < 0.38% of normal. The hypoperfusion intensity ratio (HIR) (vol brain Tmax >10s/vol Tmax >6s) (2) as well as bolus arrival time (BAT) were assessed. Coefficients of the linear fits to the values provided by iSchemaView, as well as the coefficient of multiple determination (R2) and correlation coefficient were compared.

Results
The coefficients of the linear fits of the calculated values (Y) compared to those provided by iSchemaView (x) are provided in the table. The arrival time of the bolus (BAT) was well-determined, to within 1s. R2 values ranged from 0.45 to 0.91 for all fits. R2 was higher at more profound ischemia (0.91 for Tmax>10s) and was better for CBF (0.89) compared to CBV (0.54). The slope of the fit for all volume correlations was 0.57-0.66, indicating a consistent ~40% under-estimation of brain volume compared to iSchemaView. Previous studies of volumetric analysis by CT have shown 39% underestimation when using 5mm slices (3). Alternative explanations may include a calibration performed by iSchemaView or less likely differences in the venous outflow height determination (4).

Conclusions
In-house fully-automated CTP deconvolution software provides volumes highly correlated to those determined by iSchemaView; however, with a 40% underestimation in volume. This factor can be used to calibrate the volumes to those provided by iSchemaView, although further study is warranted.

<table>
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<th>Fit</th>
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<th>Correlation Coef</th>
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(Filename: TCT_2788_figure2.jpg)
Validity of SyMRI for the Assessment of the Neonatal Brain

V Schmidbauer¹, G Geisl¹, M Diogo¹, D Prayer², G Kasprian³
¹Medical University of Vienna, Vienna, Austria, ²N/A, N/A, ³MEDICAL UNIVERSITY OF VIENNA, VIENNA, Austria

Purpose
The purpose of this study was to assess the diagnostic accuracy of T1- and T2-weighted contrasts generated by the MR data post-processing software "SyMRI" for neonatal brain imaging.

Materials and Methods
We retrospectively collected 36 cases of neonatal MRI, which included T1- and T2-weighted sequences as well as multi-dynamic multi-echo (MDME) sequences. There were 32/36 neonates included in this study. Four neuroradiologists independently assessed neonatal brain examinations on the basis of conventional and "SyMRI"-generated T1- and T2-weighted contrasts, in order to determine the presence or absence of lesions. The sensitivity and specificity of both methods were calculated and compared.

Results
Compared to conventionally acquired T1- and T2-weighted images, "SyMRI"-generated contrasts showed a lower sensitivity but a higher specificity ["SyMRI": sensitivity: 0.88, confidence interval (CI): 0.72 – 0.95; specificity: 1, CI: 0.89 – 1 / Conventional MRI: sensitivity: 0.94, CI: 0.80 – 0.98; specificity: 0.94, CI: 0.80 – 0.98].

Conclusions
T1- and T2-weighted images, generated by "SyMRI" showed a diagnostic accuracy comparable to that of conventionally acquired contrasts. In addition to semi-quantitative imaging data, "SyMRI" provides diagnostic images and leads to a more efficient use of available imaging time in neonatal brain MRI.
Value of Black-blood MR Angiography Generated from Vessel Wall Imaging in the Assessment of Stented Intracranial Arteries

K Tsuchiya¹, M Gomyo¹, M Shojima¹, K Yokoyama²
¹Saitama Medical Center, Saitama Medical University, Kawagoe, Japan, ²Kyorin University, Mitaka, Japan

Purpose
For the assessment of stented intracranial arteries, DSA, 3D-TOF MRA, and CTA have been employed. However, they are complicated by invasiveness, susceptibility artifacts, and beam-hardening artifacts, respectively. We evaluated the value of an alternative method, black-blood MRA (BB-MRA) generated by minimal intensity projection (minIP) of data of vessel wall MR imaging (VWI), which we recently developed.

Materials and Methods
Our study group compromised 16 patients (4 men and 12 women; 56-77 years) after stent-assisted treatment. They included 15 after stent-assisted coil embolization of a cerebral aneurysm and 1 after angioplasty and stenting for MCA stenosis. All patients underwent 3D-TOF MRA and VWI on a 3-T MR scanner. BB-MRA was generated in the axial and coronal planes by minIP (30-mm thickness and 2-mm interval) of data of whole brain VWI obtained using a 3D T1-weighted SPACE sequence. First, we compared the contrast ratio (CR) of the stented artery with that of the normal artery proximal to the stent on both 3D-TOF MRA and BB-MRA. Second, we calculated the relative diameter index (DI) dividing the diameter of the stented artery by that of the normal artery proximal to the stent. Third, we visually evaluated the depiction of the stented artery using the four-grade assessment score (0 = complete signal loss to 3 = continuous and homogeneous flow signal).

Results
On 3D-TOF MRA, the CR in the stented artery was significantly lower than normal artery (0.36 vs. 0.67), but there was no significant difference on BB-MRA. The DI was significantly smaller on 3D-TOF than BB-MRA (0.56 vs. 0.94). The visual assessment score was significantly higher on BB-MRA than 3D-TOF MRA (3.0 vs. 1.0).

Conclusions
BB-MRA generated from VWI could be a useful method for the follow-up study of stent-assisted treatment of intracranial arterial diseases.

Vertebral Augmentation for Vertebral Compression Fractures: a Retrospective Comparative Study of Clinical Outcomes on Four Different Techniques

G Galassi¹, E Piras¹, S Marcia¹, R Pantaleoni², M Bellini³
¹U.O.C. Radiologia, P.O. Santissima Trinità, ASSL Cagliari, Cagliari, Italy, ²Dipartimento Neuroradiologia, Ospedale Santa Maria della Misericordia, A.O.U. Perugia, Perugia, Italy, ³UOC Neuroimmagini, Dipartimento di Neuroscienze, Azienda Ospedaliera Universitaria Senese, Siena, Italy
Vestibular aqueduct size is dynamic with age.

H Bagce1, A Ramaswamy1, A Lalwani1, G MOONIS2
1Columbia University Medical Center, New York, NY, 2CUIMC, SOUTH ORANGE, NJ

Purpose
Changes in vestibular aqueduct (VA) size with patient age has not been described in the literature. Prior studies have demonstrated normal distribution of VA size in the pediatric population (Juliano AF 2016, Vijayasekaran et al 2007) and in a general population (Ozgen et al. 2008); however, the latter study had inadequate sample size to parse data by age. In the current study, we retrospectively investigate vestibular aqueduct size across ages.

Materials and Methods
CT temporal bone images were acquired using 64-channel multidetector CT in the axial plane. Images were obtained with 0.625-mm thickness, 130 mAs,120 kVp (pediatric 70 mAs). CT data was processed in a similar method as described by Juliano et al 2016. In brief, CT data was manipulated to display the entire length of the VA in the 45° oblique (Pöschl) plane utilizing a bone algorithm with 0.3 mm section thickness, data was transferred to an independent workstation and exported to ImageJ Software for post-processing. A line perpendicular to the midpoint between the external aperture and crus commune of the VA was drawn in the Pöschl plane, and Hounsfield data along this line was exported to Excel. An automated macro interpolated datapoints along the midpoint and calculated VA width at a cutoff of 30% maximum, as outlined by Juliano et al. Clinical and radiological data were compared between patient subsets utilizing two-tailed independent-sample t-tests.

Results
CT temporal bone of 58 patients without sensorineural hearing loss or other congenital ear abnormality were studied. Patients ranged in age from 1 to 77 years old (Mean ± SD age: 31.2 ± 21.2 yo). Overall average VA width across all ages measured 0.647 mm (SD ± 0.088 mm). There is an apparent peak in VA width at a cutoff of 30% maximum, as outlined by Juliano et al. Clinical and radiological data were compared between patient subsets utilizing two-tailed independent-sample t-tests.

Conclusions
We demonstrate that VA is larger in 21-40yo compared to younger and older groups suggesting that its size is dynamic with age. This variation in size with age has implications for determination of normal versus enlarged VA. Variation in VA size may be explained by bone remodeling due to age dependent fluctuation in intraluminal pressure within endolymph.
VISUALIZATION OF NORMAL PITUITARY GLAND ON 3D ARTERIAL SPIN LABELING

M Bohara1, M Nakajo1, K Kamimura1, T Yoneyama1, T Ayukawa1, T Yoshiura1
1Department of Radiology, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan

Purpose
To evaluate the visualization of the normal pituitary gland on 3D pseudo-continuous arterial spin labeling (PCASL) imaging and its relation with age, sex and volume of the pituitary gland.

Materials and Methods
In this retrospective study, we included 64 patients (age: 53.18±22.49 years; 38 males and 26 females) who underwent 3D PCASL (labeling duration=1.8 s, postlabeling delay=2.0 s) for central nervous system diseases not involving the pituitary area. The visualization of the pituitary gland on PCASL was assessed independently by two observers, and based on the visual evaluation, was divided into 4 grades: grade 0 with cerebral blood flow (CBF) equivalent to image-background; grade 1 with CBF higher than the background and equivalent to or lower than that of white matter, grade 2 with CBF higher than that of white matter and equivalent to or less than that of gray matter, and grade 3 with CBF higher than that of gray matter. The interobserver agreement was determined with the kappa statistic (κ) and the consensus readings were used for further analysis. The association of the visual grades with age, sex and pituitary gland volume was assessed by multivariate logistic regression. For each case, the volume of pituitary gland was measured by other two independent observers. Intraclass correlation coefficient (ICC) was used to evaluate the interobserver agreement and then, the average values from two readers were used.

Results
The interobserver agreement was excellent both for visual rating (κ=0.831; 95% confidence interval [CI]: 0.721, 0.941) and volume measurement (ICC=0.833; 95% CI: 0.652, 0.912). Out of the 64 cases, grade 0 included 12 cases (18.8%), grade 1 included 1 case (1.6%), grade 2 included 27 cases (42.2%) and grade 3 included 24 cases (37.5%). The logistic regression analysis revealed that the volume of pituitary gland was significantly associated with the visual grading of the pituitary gland on ASL (P= 0.0023; odds ratio [OR] = 862.530; 95% CI: 11.178, 66554.425). However, there was no significant association between visual grades of pituitary gland, and age and sex (P= 0.8976 and P= 0.7757, respectively).

Conclusions
The normal pituitary gland is often visualized with higher CBF than the cortical gray matter on PCASL perfusion imaging, especially in individuals with larger pituitary volume.
Voice-Activated Labeling of 3D Printed Anatomic Models with Color Light Emitting Diode Lights and Strips

R Javan¹, N Mostaghni², A Drozdov¹, I Elsayed³, C Fleming⁴, D Hamdan⁵
¹George Washington University Hospital, Washington, DC, ²University of California, Irvine, Irvine, CA, ³University of California Irvine, Irvine, CA, ⁴George Washington University School of Medicine, Washington, DC, ⁵George Washington University, Washington, DC

Purpose
The aim of this project was to demonstrate the feasibility of using Light Emitting Diode (LED) light sources as a potential method for labeling and identifying subcomponents of a three-dimensionally (3D) printed model for teaching purposes in training models and for communication purposes in clinical cases. As an example, we applied this system to a hollow 3D printed ventricular and cisternal system based on a normal MRI brain, due to its complexity of negative space anatomy and interconnections.

Materials and Methods
We incorporated LEDs in particular landmarks on the 3D printed model and wired them to an Arduino Uno, a microcontroller board. We also installed a Bluetooth transceiver on the board, allowing us to communicate between an Android phone and the board. The user then would be able to verbalize an anatomic structure into the free speech-to-text phone application, sending it as a command to the Bluetooth transceiver. We used the freeware Arduino Integrated Development Environment (IDE) which is the programming application for Arduino Uno. In the code, the LEDs correspond to pin numbers on the Arduino board. Up to 12 different structures/choices were made available corresponding to the 12 different LED colors that were available. The ventricular and cisternal system was segmented using Materialise InPrint 3.0 by an experienced neuroradiologist, after which an arbitrary wall thickness of 1 mm was chosen for outward hollowing of the 3D model. Dedicated holes were incorporated for placement of wired LEDs.

Results
When the user verbalizes any of the structures, command is sent from the Bluetooth transceiver to the Arduino, the code would look for the "trigger word" i.e. the anatomical term, which would illuminate the corresponding LED. Saying the phrase again will turn off the LED. This package can be used for labeling any other 3D model for up to 12 terms, as long as those terms are appropriately designated in the code and as long as they are recognizable by the voice recognition system, which does require Wifi or cellular data collection for communication with Google server.
Conclusions
Labeling of complex 3D printed models is difficult and introduces a limitation in seamless independent use of the models both in the educational settings and for clinical interdisciplinary communication. Incorporation of LEDs may provide a route to circumvent this issue. In the future, if 3D printers are made where the wiring can be simultaneously printed, it can simplify application of colored LEDs into models.

(Filename: TCT_2336_LEDVentricle.jpg)

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What the Neuropththalmologist Wants to Know From the Neuroradiologist.

D LOPEZ GARCIA¹, C Koegel², L Linscott³
¹Primary Childrens Hospital. University of Utah, Salt Lake City,, UT, ²Primary Childrens Hospital. University of Utah, Salt Lake City, UT, ³Primary Childrens Hospital, Salt Lake City, UT

Purpose
To review the optic pathway anatomy with an emphasis on brainstem and cranial nerve function. To review clinical and imaging findings, as well as the surgical implications of various congenital and acquired conditions of the eye, orbit, and visual pathway system in the pediatric population.

Materials and Methods
A retrospective review of Pediatric neuroophthalmologic pathologies was performed in a children's hospital. A series of cases in children 0 to 20 years of age were collected.

Results
Presentation of the CT and MR imaging findings of pediatric neuroophthalmologic pathologies. A short discussion will be included after each case. The cases include: - Pediatric idiopathic intracranial hypertension - Horner Syndrome - Optic nerve hypoplasia - Optic neuritis - Optic pathway gliomas - Congenital absence of abducens nerve - Congenital fibrosis of the extra-ocular muscles - Brainstem tumors causing cranial nerve dysfunction

Conclusions
Knowing what the neuroophthalmologist is looking for with a given indication (e.g. esotropia) is critical for the neuroradiologist to provide the most useful consultation. An understanding of the visual pathway anatomy and function will guide the neuroradiologist's search pattern and improve the detection of subtle imaging abnormalities.
White Matter Hyperintensities on Magnetic Resonance Imaging and Aging: Comparison of Three Visual Rating Scales Using Convolutional Neural Networks

J Puig¹, A Jimenez-Pastor², E Camacho-Ramos³, C Biarnes³, J Garre-Olmo⁴, R Ramos-Blanes⁵, J Vilanova³, R Pamplona⁶, M Essig⁷, S Pedraza¹, A Alberich-Bayarri²

¹IDI-IDIBGI, Girona, Spain, ²QUIBIM, Valencia, Valencia, ³IDI-IDIBGI, Girona, Girona, ⁴IDIBGI-IAS, Girona, Girona, ⁵IDIBGI, Girona, Girona, ⁶University of Lleida-IRBLleida, Lleida, Lleida, ⁷University of Manitoba, Winnipeg, Manitoba

Purpose
White matter hyperintensities (WMH) on magnetic resonance imaging (MRI) increase with age and are associated with stroke, cognitive decline, and dementia. Although consistent assessment of WMH burden is crucial for epidemiological and clinical studies, little evidence is available about the performance of proposed visual rating scales. We used deep-learning-based models to compare three visual WMH rating scales.

Materials and Methods
We studied 418 healthy participants (mean, 66.67+/−7.96 years [range, 50-96 years]) consecutively recruited in a population-based aging study. All imaging studies were obtained on a 1.5 T MRI system (Vantage Elan, Canon Medical Systems, Japan). WMHs were rated according to Fazekas’ scale (FZ), Age-Related White Matter Change (ARWMC) scale, and van Swieten’s (VS) scale. For each scale, WMH burden was categorized as none or slight, moderate, or severe. Artifacts, lacunae, and chronic territorial infarcts were excluded. We used convolutional neural networks to assess WMH metrics, including volume, dissemination, number of lesions, and mean entropy. We used t-tests to compare group means.

Results
The different scales classified WMH burden as none or slight (FZ=331 subjects [mean WMH volume 0.487±0.639 mL]; ARWMC=327 subjects [0.477±0.625 mL]; VS=186 subjects [0.231±0.361 mL]), moderate (FZ=69 subjects [3.529±2.652 mL], ARWMC=70 subjects [3.404±2.604 mL], VS=177 [1.192±1.561 mL]), and severe (FZ=18 subjects [9.568±4.795 mL], ARWMC=21 subjects [8.707±5.068 mL], VS=57 subjects [5.675±4.326 mL]). On FZ and ARWMC, WMH volumes in each category were similar. However, on SV, WMH volumes in all categories were smaller than on FZ and ARWMC (P<0.001). Additionally, on FZ and ARWMC, WMH dissemination, number of lesions and mean entropy in moderate and severe category were similar.

Conclusions
Our results indicate that FZ and ARWMC ratings of WMH CNN-based quantification are similar; SV tends to underrate WMH burden. Therefore, FZ and ARWMC could be applied equally to assess WMH characterization.
Late Breaking Oral Presentations

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7T MRI in drug-resistant epileptic patients

M Vargas¹, P Reymond¹, J Jorge², L Xin³, S Vulliemoz¹
¹Hôpitaux Universitaires de Genève, Geneva, Switzerland, ²EPFL, Lausanne, Switzerland, ³CIBM/EPFL, Lausanne, Switzerland

Purpose

7T MRI was recently approved by FDA and CE for clinical use. It allows an exquisite differentiation between white and grey matter and its clinical use presents new and exciting challenges for neuroradiologists. The aim of this study is to illustrate principal advantages and disadvantages of this type of imaging in drug-resistant epileptic patients.

Materials and Methods

7T MRI studies were conducted from July 2014 until January 2020 on a research 7T head-only scanner (Siemens Magnetom, Erlangen, Germany), equipped with a 32-channel head coil (Nova Medical, MA). MRIs with the following sequences (MP2RAGE, SWI, FLAIR, DTI) were performed on 39 patients (62% males) known for epilepsy with a mean age of 30 years, ranging from 14 to 60 yo. Inclusion criteria were: drug resistant epilepsy with focal seizure, no clearly visible lesion on the clinical 3T MRI study. Exclusion criteria were the same contraindications as for a 3T MRI study.

Results

Morphological MRI detected pathological findings in 14 patients, among whom 8 patients underwent neurosurgical interventions following the 7T MRI. Histopathological results reported dysplasia FCD (n=4), ganglioglioma (n=2), ectopic neurons with cortico-subcortical fragments (n=1) and ectopic neurons with no true underlying lesion(n=1). All patients are reported free of epileptic seizures since their neurosurgical intervention. The 6 patients who were not operated presented the following MRI pathological findings: Rasmussen's encephalitis (N=1), polymicrogyria (N=1), tuberous sclerosis complex (N=1) findings suggestive of dysplastic area (N=2) and strong suspicion of FCD (N=1). The last patient did not want to be treated. Epilepsy localization whenever available, was identified in the frontal lobe (41%), temporal lobe (28%), temporal-occipital lobe (10%), insula (7%), parietal lobe (7%) and amygdala (7%). Left and right distributions of lesions were similar in frontal and temporal lobes. Temporal-occipital and insula lesions were on the left side, and parietal lesions on the right side.

Conclusions

Ultra-high field MRI is a very useful tool to detect and characterize cortical and potentially epileptogenic malformations. It should be noted that, however, it presents challenges due to new emergent findings and artefacts which we should take into account.

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A Fully Automated Pipeline for Differential Diagnosis on Brain MRI

D Weiss¹, A Rauschecker², R BRYAN³, A Pradhan³, J Wang¹, J Rudie²
¹University of Pennsylvania, Philadelphia, PA, ²UCSF Radiology, San Francisco, CA, ³University of Texas, Austin, Austin, TX
Purpose
Artificial intelligence tools in radiology are typically focused on narrow tasks, which significantly limits their potential clinical utility. In order to increase radiologists' accuracy and throughput, we sought to develop a more broadly applicable, transparent AI system that detects and characterizes imaging findings on multimodal clinical brain MRI and then integrates these features into a differential diagnosis covering a wide array of diagnostic entities.

Materials and Methods
T1, T2, T2-FLAIR, T1Post, GRE, DWI, and ADC images were extracted from 388 studies of patients with 50 different diseases. 3D U-Nets were trained to skull-strip, segment tissue types on T1 (Fig. 1A), and recognize abnormal signal on each sequence type (Fig. 1B-E). Anatomical structure and spatial feature states were determined by direct quantitative analysis of the segmentation maps. To determine a reference standard, an academic neuroradiologist rated signal, anatomical, and spatial key feature states. Automated feature extraction methodologies and thresholds were chosen to maximize feature accuracy when compared to the reference standard. An expert-trained naïve Bayes network (Fig. 2) was developed to integrate signal, anatomical and spatial imaging features into a probabilistic differential diagnosis, similar to the one described by Rauschecker et al. (in press), that encompassed the 50 different diseases. Conditional probabilities were determined by expert consensus between two neuroradiology fellows. Bayesian inference was performed on the feature state outputs of the image analysis pipeline.

Results
Our pipeline automatically recognizes validation set sequence types with an accuracy of 0.98. Testing accuracy, sensitivity, and specificity for feature states were 0.72, 0.68, and 0.75, respectively, when compared to the attending's ratings. The pipeline output the true diagnosis in the top 3 of the differential diagnosis 39.7% of the time in the held out test set.

Conclusions
This study describes an end-to-end automated diagnostic tool for brain MR studies that recognizes 50 disease entities with no human input. In contrast to most black box AI systems, by providing both differential diagnoses and the key features used to determine these diagnoses, the algorithm can be easily interrogated and errors can be investigated. We anticipate that this tool can be integrated into clinical workflows as a clinical decision support tool because of its ease of use, broad applicability, and human-interpretable outputs.
A fully-automated convolutional neural network with deep supervision approach for haemorrhage segmentation and volume quantification in CT scans

A Arab¹, B Chinda¹, W Siu², T Gu³, H Guo⁴, G Hamarneh¹, X Song⁵
¹Simon Fraser University, Burnaby, British Columbia, ²Royal Columbian Hospital, New Westminster, British Columbia, ³Beijing Hospital, Dongcheng, Beijing, ⁴Tianjin Medical University General Hospital, Tianjin, Heping, ⁵Fraser Health Authority, Surrey, British Columbia

Purpose
To aid more effective management of haemorrhagic stroke [1,2], we developed a fully automated method applying convoluted neural network with deep supervision (CNN-DS) [3,4] for improved haematoma segmentation and volume quantification in computed tomography (CT) images. The main objectives are to generate the CNN-DS method and to evaluate its performance while making comparisons to previously established machine learning (ML) methods.

Materials and Methods
Non-contrast whole-brain CT scans of 55 patients with haemorrhagic stroke were retrieved from clinical database from three hospitals in Fraser Health, British Columbia, Canada. The CT scan of each patient was standardized to 64 slices of 128 x 128 pixels, and annotated independently by experienced raters, to generate a binary classification of hematoma vs. normal brain tissue. For each voxel, the class label with majority-voting was used as the reference standard. The dataset was split into training (n=45) and testing (n=10) subsets. Applying the training set, the CNN-DS method was built based on U-Net architecture with deep supervision. The accuracy and efficiency of the CNN-DS method were examined using the testing set and compared with the random forests based PItcHPERFeCT [5] and patch-wise U-Net deep neural networks methods.

Results
The CNN-DS method for hematoma quantification in the training set had a Dice coefficient score of 0.82±0.06 at an average running time of 0.59±0.02 seconds (s). The testing set revealed a Dice coefficient of 0.83±0.07 and precision of 0.84±0.09, superior to the other methods. The recall of 0.82±0.08 recall rate with CNN-DS method was greater than patch-wise U-Net (0.76), while PItcHPERFeCT showed a higher recall (0.98) at a high cost of processing time, considerably slower than CNN-DS (1412±150s vs 0.74±0.07s). Kappa coefficients for interrater agreement rate did not differ statistically between the "human-human" and "method-human" pairs.

Conclusions
The CNN-DS method developed in this study demonstrated human-level performance in segmenting and quantifying hematoma, signifying substantial improvements over the previously established methods. The result warrants further research in realizing the potential of the CNN-DS method for more effective stroke assessment and management.
Table 1: Segmentation Quantitative Performance

<table>
<thead>
<tr>
<th>Method</th>
<th>Dice Score</th>
<th>Precision</th>
<th>Recall</th>
<th>Processing Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original U-Net</td>
<td>0.74±0.09</td>
<td>0.73±0.17</td>
<td>0.76±0.09</td>
<td>9.4±0.2</td>
</tr>
<tr>
<td>PItcHPERFeCT</td>
<td>0.76±0.11</td>
<td>0.63±0.15</td>
<td>0.98±0.01</td>
<td>1412.34±20.05</td>
</tr>
<tr>
<td>CNN-DS</td>
<td>0.84±0.06</td>
<td>0.85±0.07</td>
<td>0.83±0.07</td>
<td>0.74±0.07</td>
</tr>
</tbody>
</table>

Figure 1: Segmentation of a simple regular hematoma case

An example of a simple and regular hematoma segmentation. From left to right, the images represents the original CT slice, the ground truth, and the predicted segmentation, respectively.

Figure 2: Segmentation of a complex irregular hematoma case

An example of a more complex and irregular hematoma segmentation. From left to right, the images represents the original CT slice, the ground truth, and the predicted segmentation, respectively.
A prospective, randomized, multicenter study of intraosseous basivertebral nerve ablation for the treatment of chronic low back pain: 12-month results

J Hirsch1, M Smuck2, J Khalil3, K Barrette4, D Nguyen5, D Beall6, S Garfin7

1Massachusetts General Hospital, Boston, MA, 2Stanford University, Redwood City, CA, 3William Beaumont Hospital, Royal Oak, MI, 4Stanford, Redwood City, CA, 5Neuroradiology & Pain Solutions of Oklahoma, Oklahoma City, OK, 6Summit Medical Center, Edmond, OK, 7UC San Diego, San Diego, CA

Purpose
Vertebral endplates, innervated by the basivertebral nerve (BVN), are a source of chronic low back pain (CLBP). In a published sham-controlled trial, intraosseous radiofrequency ablation (RFA) of the BVN demonstrated efficacy and durability in patients with CLBP and endplate changes on MRI (Modic Type I or II). This trial compared BVN ablation to standard care (SC). A pre-planned interim analysis at 60% of the primary endpoints was conducted by a data management committee (DMC). Due to statistical superiority of BVN ablation in all endpoints, randomization was halted and early cross-over of the SC arm was initiated. We report results of the full randomized cohort including 6-mo between arm comparisons, 12-mo treatment arm results, and 6-mo outcomes of the cross-over group.

Materials and Methods
Prospective, open label, 1:1 randomized controlled trial in 20 sites comparing BVN ablation to SC. Per DMC recommendation, randomization was halted, SC patients were re-baselined, and offered early cross-over at next study visit. BVN ablation arm was followed at 6 wks and 3, 6, 9, and 12 mos. SC cross-over patients were followed at 3 and 6-mos post BVN ablation. Primary endpoint was the difference between arms of mean change in Oswestry Disability Index (ODI) at 3 mos. Secondary endpoints were Visual Analog Scale (VAS), SF-36, EQ-5D-5L, and responder rates.

Results
140 randomized (66 BVN ablation, 74 SC). At cross-over, 8 SC patients had withdrawn, 5 declined cross, and 61(92%) underwent BVN ablation. At 12 mos, BVN ablation patients demonstrated significant improvements in function and pain with a mean ODI reduction of 25.7 from 44.7 at baseline (p<0.001), and a mean VAS reduction of 3.79 from 6.73 (p<0.001). ODI was reduced by ≥20-points in 61% of treatment arm patients. VAS reduced by ≥50% in 64%, ≥75% in 44%, and 29% had 100% pain relief. Similarly, cross-over patients demonstrated a mean reduction of 25.9 in ODI at 6 mos post treatment from a 46.2 re-baseline (p<0.001), and mean VAS reduction of 3.84 from 6.78 (p<0.001). 64% of cross-over patients had ≥50% VAS reduction, 38% ≥75%, and 22% were pain-free. No serious device-related adverse events were reported through 12 months.

Conclusions
BVN ablation demonstrates significant improvements in pain and function over SC with results sustained through 12 months. Similar outcomes were noted for SC cross-over patients at 6 months post treatment. BVN ablation is an effective, safe treatment for patients with CLBP of vertebrogenic origin.

Figure 1 – Depicts mean ODI over 12 months for the randomized arms. Standard care (SC) control patients were re-baselined at cross-over and followed at 3 and 6-months post BVN ablation.
Deep learning of MRI data predicts neurodevelopmental outcome of preterm neonates

M Wagner1, D So2, T Guo2, M Shroff3, B Ertl-Wagner4, R Grunau3, V Chau2, L Erdman2, S Miller2
1THE HOSPITAL FOR SICK CHILDREN, TORONTO, CANADA, TORONTO, ON, 2The Hospital for Sick Children, Toronto, Ontario, 3Hospital for Sick Children, Toronto, ON, 4The Hospital for Sick Children, University of Toronto, Toronto, Ontario, 5BC Children's Hospital, Vancouver, British Columbia

Purpose
To predict adverse and favorable neurodevelopmental outcomes in very preterm neonates using a convolutional neural network (CNN) on MRI data.

Materials and Methods
A 3D-CNN architecture based on MRNet was trained with MRI data of 173 preterm neonates (median gestational age 28.1 weeks) whose motor, cognitive, and language outcomes were assessed at 18 and 36 months corrected age using the Bayley-III scales. Neonates were scanned at a mean age of 32.2 postmenstrual weeks (median: 32.1 weeks, range: 27.3 to 40 weeks) and 68 (31.5%) had white matter injury. Imaging data fed to the CNN consisted of 3D T1w sequences only. The cognitive outcome at 18 months was chosen as the predicted outcome since it had the most available data (mean Bayley-III: 93.5, range: 55 to 135). The MRNet architecture was reformulated for a regression task and each image was fed into a pre-trained AlexNet model for fine-tuning. Input volumes were pooled into a shape of s x 256 and then fully connected to a single output node, corresponding to the continuous outcome. Mean Squared Error (MSE) loss was used to estimate the average of the squares of the errors. The CNN was trained for 100 epochs and converged.

Results
Ten randomly selected participants (6%) excluded from the training phase were used as the validation cohort. The weights of the best model (36th epoch) corresponded to a lowest validation MSE of 99.6. Statistically significant correlation was found between the actual and the CNN predicted neurodevelopmental outcome at 18 months (spearman rank correlation, r = 0.743, p-value = 0.0137).

Conclusions
Transfer learning of MRI data of preterm neonates predicts cognitive neurodevelopmental outcome at 18 months with strong correlation. Additional analysis will be conducted to assess the models in predicting categorical neurodevelopmental outcomes at 18 months, 36 months and 4.5 years of age.

ENDOVASCULAR TREATMENT IN CAROTID TIP OCCLUSION: A RETROSPECTIVE STUDY

M Muto1, G Leone2, G Ambrosanio3, G Guarnieri2, D Romano3, G Frauenfelder3, P Candelaresi2, G Servillo2, V Manzo2, R Saponiero3, m muto2
1University Federico II, AORN Cardarelli Hospital, Naples, Italy, 2AORN Cardarelli Hospital, Naples, Italy, 3AOU San Giovanni e Ruggi, Salerno, Italy

Purpose
Endovascular treatment (EVT) is nowadays the standard of care in acute ischemic stroke (AIS). Nevertheless, acute occlusions of terminal internal carotid artery (ICA) are still frequently associated to bad neurological outcomes and high mortality, mostly because of the large amount of thrombus and thus low recanalization rates. The aim of the study is to retrospectively evaluate clinical effectiveness of endovascular treatment (EVT) and the recanalization rates after terminal ICA occlusions.

Materials and Methods
All patients with AIS due to terminal ICA occlusion who underwent EVT in two major Comprehensive Stroke Centers (CSC) were retrospectively assessed from our prospective registry between December 2018 and December 2019. Clinical and imaging criteria (including CT-ASPECTS, multiple-phase CTA and CT-Perfusion) were used to enroll patients for EVT. Age, sex, preoperative National Institutes of Health Stroke Scale (NIHSS), modified Rankin Score (mRS), cerebral infarction subtypes and medical history were investigated. Primary outcomes included modified Rankin Score (mRS) at 90 days, recanalization rates according to modified Treatment in Cerebral Infarction Score (mTICI) and hemorrhagic transformations evaluated according to ECASS I.

Results
Among both CSCs, a total of fifty-eight patients were admitted with a median onset-to-door time of 98 minutes and a median ASPECTS of 9. A cohort of 39 male and 32 females was enrolled with a median age of 65.4 year (33-87). At admission median NIHSS was 17.2 (6-26). All patients underwent to EVT with mechanical thrombectomy. A majority (56.9%) also received intravenous thrombolysis (iVT) with alteplase. PH1 and PH2 occurred in 18 out of 58 (31%), while H1 and H2 occurred in 9 out of 58 (15%); in 54% of patients no hemorrhagic transformation occurred (31 out of 58). Successful recanalization (≥TICI 2b) was achieved in 76% of
At 90 days, 29 out of 58 (50%) were functionally independent (mRS score of 0-2); 15 patients (26%) presented neurological disabilities (mRS score of 3-5); 11 patients (19%) died (mRS of 6) within 90 days.

Conclusions
Endovascular treatment of terminal ICA occlusion is safe and effective. Hemorrhagic transformation rate is not negligible, while the percentage of patients with functionally independence (mRS score of 0-2) is similar to those patient harboring M1 MCA occlusion.

Evidence-Based Imaging for Medulloblastoma Clinical Trials: Lessons from SJMB12 (You don’t know what you’re missing)

J Harreld\(^1\), A Khan\(^1\), Y Guo\(^1\), Y Li\(^1\), G Robinson\(^1\), A Gajjar\(^1\)
\(^1\)St. Jude Children's Research Hospital, Memphis, TN

Purpose
Recently published consensus recommendations for standardized imaging of parenchymal brain metastases in clinical trials\([1]\) are insufficient for leptomeningeal metastasis detection in medulloblastoma. Evidence-based recommendations are sparse. We therefore investigated the association between key technical MRI parameters and detection of leptomeningeal metastases in the context of an ongoing phase 2 medulloblastoma clinical trial.

Materials and Methods
Initial brain and spine MRIs and repeat imaging with trial-recommended parameters for 179 patients (10.6±5.1 years, 38% female) with newly-diagnosed medulloblastoma between 6/2013-1/2020 were assessed for slice thickness, gap and T1+Gd sequence type; use of T2 FLAIR+Gd and plane of 3DT1+Gd (brain). Differences in rates of metastasis detection were compared for categorical (Fisher's Exact) and continuous technical variables (Wilcoxon signed rank). Association between continuous variables and metastasis detection were assessed by logistic regression.

Results
81/179(45.3%) had metastases on presentation to our institution, 67(37.4%) brain, 47 (26.3%) spine, and 6 (3.4%) CSF only. Of these, 34/67 (50.7%) brain and 19/47(40.4%) of outside spine MRIs were misinterpreted as negative at outside facilities. CSF was positive in 25/81(30.8%). Repeat imaging changed M stage in 40 (22.3%) patients – increased in 35, decreased in 5. Metastasis detection was greater with T2 FLAIR+Gd, sagittal 3DT1+Gd and axial GRE in brain (P<.0001 for all); axial VIBE/FAME/LAVA T1+Gd (P=0.0013), sagittal T1 FLAIR+Gd (P=0.0002) in spine. Logistic regression showed increased odds of false negative (FN) for each 1mm increase in axial slice thickness in brain (OR 3.77, 95%CI1.67,8.75; TP 4.16±0.37 vs. FN 4.47±0.71; P=0.0016, <.0001) and spine (OR 1.93,95%CI1.19,3.27; TP 3.43±0.84 vs. FN 4.18±1.33, P=0.0093;<.0001), axial gap in brain (OR 8.69, 95%CI4.05,20.8; TP 0.27±0.49 vs. 1.00±0.59, P<.0001 both) and spine (OR 2.03, 95%CI1.19,3.67; TP 0.46±0.80 vs. FN 1.13±1.04, P=0.012; 0.0098), and larger sagittal gap in spine (OR 6.97, 95%CI 1.70,30.25; TP 0.22±0.34 vs. FN 0.48±0.29, P=0.0072).

Conclusions
Specific techniques, including use of thin slices with 0 gap; post-contrast T2FLAIR and sagittal 3DT1+Gd in brain; and avoidance of axial TSE/FSE sequences, are associated with improved leptomeningeal metastasis detection in children with medulloblastoma.
Examining the association between sluggish cognitive tempo and functional connectivity in children with ADHD: A pilot study

A Braimah\textsuperscript{1}, J Dudley\textsuperscript{1}, S Becker\textsuperscript{2}
\textsuperscript{1}Imaging Research Center; Cincinnati Children's Hospital Medical Center, Cincinnati, OH, \textsuperscript{2}Behavioral Medicine and Clinical Psychology; Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Purpose
There is growing evidence that children's attention problems are heterogeneous, with increasing interest in a sluggish cognitive tempo (SCT) phenotype characterized by excessive daydreaming, mental confusion, and slowed behavior/thinking. Approximately 40% of children with attention-deficit/hyperactivity disorder (ADHD) also experience symptoms of sluggish cognitive tempo (SCT). SCT refers to excessive daydreaming, mental confusion, and slowed behavior/thinking. Despite the prevalence of SCT and links to functional impairment, neural correlates remain unexamined. The present study examined functional connectivity in children with ADHD with and without co-occurring SCT, in addition to typically developing (TD) children with neither ADHD nor SCT.

Materials and Methods
Subjects (TD=20, ADHD-SCT=22, ADHD+SCT=20, age=10.27+/1.54 yrs) underwent both T1w structural and functional scan acquisitions with a Philips 3T Achieva (Best, The Netherlands). Structural images were preprocessed with FreeSurfer and functional images were preprocessed with FSL's FEAT, followed by independent component analysis (ICA) based cleanup. A 40-component group-ICA was performed to identify within-cohort pediatric resting-state networks. Group differences between identified resting-state networks were then assessed via permutation testing.

Results
Identified resting-state networks included the: default mode network (Fig. 1C), primary visual network (Fig. 1A and 1B), ventral visual network, and executive function network. ADHD-SCT children had greater functional connectivity between their default mode network and the anterior portion of their right supramarginal gyrus compared to TD children (Fig. 1D; green). Children in the ADHD+SCT group had increased functional connectivity between their primary visual network and their left pre- and postcentral gyri compared to TD children (Fig. 1D; light blue). ADHD+SCT children also exhibited increased connectivity in their left superior frontal and superiorparietal gyri, in addition to the left pre- and postcentral gyri when compared to ADHD-SCT children (Fig. 1D; red-yellow).

Conclusions
This study presents the first neuroimaging examination of functional connectivity between children with ADHD+SCT, ADHD-SCT, and typically developing controls. These differential patterns of connectivity between ADHD+SCT and ADHD-SCT may suggest SCT is an etiologically distinct subtype of ADHD. Further research into the neural correlates of SCT is needed, given the implication to diagnosis and treatment.
Monitoring of changes in cognitive function and carotid blood flow post carotid angioplasty and stenting using functional and quantitative flow MRI: Preliminary results

B Chinda1, W Siu2, S Liang3, X Song4

1Simon Fraser University, Burnaby, British Columbia, 2Royal Columbian Hospital, New Westminster, British Columbia, 3University of British Columbia, Vancouver, British Columbia, 4Fraser Health Authority, Surrey, British Columbia

Purpose
Current evaluation of treatment success in patients receiving carotid angioplasty and stenting (CAS) relies on carotid ultrasound and angiogram of stent placement and perioperative complications assessment [1,2]. We conducted this study using task-phase functional and quantitative flow MRI (i.e fMRI & Qflow) [3,4], to provide more direct evidence of the effect of CAS on cognition and carotid blood flow over-time.

Materials and Methods
In this preliminary study, patients with severe carotid stenosis (n=3; Age=65-85 years; 2 males) were enrolled and had an MRI, followed by CAS in 2-14 days, and another MRI two months post CAS. MRI scans were conducted using Philips 3.0T Ingenia CX system equipped with 32-channel dStream head coil. At each MRI scan, patients completed two fMRI sessions while performing a working memory task with two levels of complexity (Fig 1). The fMRI utilized an echo planar imaging (GRE-EPI) sequence (TR/TE=2000/30ms, flip angle=90°, 3x3x3 mm2 voxels covering the whole-brain). A phase-contrast Qflow sequence was also acquired (TR/TE=9/5ms, flip angle=10° slice thickness = 5mm) for flow velocity measurements. High-resolution anatomical T1(for co-registration) and T2 (for viewing pathological changes) images were acquired. Data were analyzed using FMRI Expert Analysis Toolbox and vendor-provided packages. FMRI task response accuracy and reaction time (RT) were examined. Changes in brain function, blood flow, behavioural performance were compared for each individual pre/post CAS.

Results
There were considerable individual differences in behavioural performance and fMRI activation. Pre-CAS, most patients were unable to respond to the fMRI tasks within given time, especially the difficult one (57%-87% missing values out of 30 responses). Task completion rate improved post CAS with 13%-43% missing values. The RT and accuracy were inversely related (Fig. 2). Diverse fMRI activations were detected in each major cortical lobe for the fMRI tasks (Fig 3). Each patient showed variable changes in fMRI activations post CAS, i.e., either decreased or increased. The qflow revealed markedly increased blood supply to the carotid arteries for all patients post CAS (Fig. 4).

Conclusions
Functional MRI showed considerable individual variability. CAS markedly improved blood supply to carotid arteries; related to improved working memory performance. Ongoing effort is geared towards validating the preliminary findings with increased sample and more follow-up sessions, involving a matched control group.
Reliability of Artificial Intelligence Technology as a Screening Tool to Identify Patients for Endovascular Thrombectomy: A Single-Center Analysis

J Ahluwalia1, L Ford2, M Commet3, C Cenzer3, M Aftab4
1Michigan State University, Rochester Hills, MI, 2ATSU-KCOM, Grand Blanc, MI, 3Michigan State University, Holly, MI, 4Ascension Genesys Hospital, Flushing, MI

Purpose
This study analyzes if artificial intelligence (AI) technology is as reliable as neuroradiologist interpretation for identifying patients who are candidates for endovascular thrombectomy (EVT) in the setting of acute ischemic stroke. The AI technology utilized in this study is called RAPID. This study also examines limitations of RAPID and aims to ascertain the degree to which RAPID can be used to triage patients for EVT in the acute setting.

Materials and Methods
This is an IRB approved, retrospective study of 857 patients presenting to our institution from 1/1/2018 to 11/1/2019 with symptoms of acute stroke. Inclusion criteria included patients who entered our institutional stroke protocol and underwent CT, CTA and CTP scans interpreted by both RAPID and radiologists. Hospital records were also obtained to determine which patients were transferred for EVT and their post-transfer outcomes.

Results
A total of 294 patients satisfied the inclusion criteria. Overall, RAPID CTP analysis showed significant sensitivity (90.7%), specificity (92.5%) and negative predictive value (100%) for identifying EVT-eligible patients when using radiologist interpretation as the gold standard. RAPID CTA showed significant specificity (95.9%) and negative predictive value (94.5%) as well. There was also a significant association between RAPID interpretation and neuroradiologist interpretation of CTA and CTP studies.

Conclusions
The high specificity and 100% negative predictive value (NPV) of RAPID suggests that this technology is a reliable screening tool to accurately rule out patients who are not EVT candidates. All patients who had a negative RAPID scan did not require transfer for EVT, and upon review of these cases by a current neuroradiologist, the decision to not transfer those patients was deemed accurate. Correctly identifying patients who are not candidates for EVT is a vital step in the management of patients with stroke and enables providers to more quickly begin the next phases of treatment. If the use of AI technology as a screening tool can be validated, such technology can be incorporated into hospital protocols to potentially expedite patient care. Furthermore, AI technology can be most impactful in the setting of community hospitals, which may lack 24 hour neuroradiologist availability. Overall, this study suggests that RAPID is a reliable screening tool to rule out stroke patients who are not candidates for EVT.

Thrombectomy versus Medical Therapy in Acute Ischemic Stroke: Comparing the Outcomes of Two Independent CT Perfusion Softwares and Therapeutic Decisions
Purpose
To compare the perfusion CT (PCT) outcomes derived from two commercial PCT processing software and evaluate their concordance in terms of eligibility for mechanical thrombectomy (MT) in acute ischemic stroke (AIS), based on DEFUSE III criteria.

Materials and Methods
A total of 118 patients (62 patients in MT group and 56 patients in non-MT group) were included. Volumetric perfusion outputs were compared between Syngo.via (package A) and RAPID (package B). Influence on proceeding or not-proceeding with MT was based on DEFUSE III imaging eligibility criteria.

Results
Median core infarct/ hypoperfusion volumes were 12.3/ 126 ml in MT group and 7.7/ 24.5 ml in the non-MT group with package A and 10.5/138 ml and 1.9/29.3 ml with package B respectively. In the MT group (n=62), concordant perfusion results in terms of patient triage were noted in all but 2 cases. Of these, one patient would not have qualified (low ASPECTS), while the other qualified based on package A results. For the non-MT group (n=56), there was discordance in terms MT eligibility in seven cases. However, none of these patients qualified for MT based on DEFUSE III criteria.

Conclusions
Both perfusion softwares showed high concordance in correctly triaging patients in MT versus non-MT groups (110/118; 93.2%) which further improved when all DEFUSE III imaging criteria were considered (117/118; 99.1%). The core/ hypoperfusion volumes in the non-MT group and core infarct volumes in the MT groups were comparable. The hypoperfusion volumes in the MT group varied slightly but did not affect triage between groups.

### Table: Discordant cases in the MT and NMT group based on perfusion packages. The first two patients belong to the MT group while the remaining patients belong to the NMT group.

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Package A</th>
<th>DEFUSE</th>
<th>Package B</th>
<th>DEFUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT07</td>
<td>50.3/241</td>
<td>V</td>
<td>74/135</td>
<td>N</td>
</tr>
<tr>
<td>MT06</td>
<td>49.9/204</td>
<td>V</td>
<td>73/183</td>
<td>N</td>
</tr>
<tr>
<td>MT08</td>
<td>20.7/142</td>
<td>V</td>
<td>83/144</td>
<td>N</td>
</tr>
<tr>
<td>MT11</td>
<td>6.9/15.2</td>
<td>N</td>
<td>1.2/6.3</td>
<td>N</td>
</tr>
<tr>
<td>MT21</td>
<td>47.9/177</td>
<td>V</td>
<td>74.3/158</td>
<td>N</td>
</tr>
<tr>
<td>MT38</td>
<td>32.8/285</td>
<td>V</td>
<td>57/12.5</td>
<td>N</td>
</tr>
<tr>
<td>MT11</td>
<td>33.4/41.8</td>
<td>V</td>
<td>0/74</td>
<td>N</td>
</tr>
<tr>
<td>MT10</td>
<td>41.6/70.7</td>
<td>V</td>
<td>2/25.5</td>
<td>N</td>
</tr>
<tr>
<td>MT73</td>
<td>31.4/28.6</td>
<td>V</td>
<td>12/29</td>
<td>N</td>
</tr>
</tbody>
</table>

ASPECTS: Alberta stroke program early CT score; C/P: Core volume; LVO: Large vessel occlusion; MCA: Middle cerebral artery; MR: Mismatch ratio; M/M: Mismatch volumes; P: perfusion volume. * Concordance determined after considering all three imaging criteria outlined in DEFUSE III.

2879

**VAST Clinical Results at 12 months: Pain remission through Supplementing Tissue Lost to Degenerative Disc Disease (DDD)**

M Flamm1, M Flamm1, D Beall2

1University of Washington, Seattle, WA, 2Summit Medical Center, Edmond, OK
Purpose
Summary of background data: The function of the intervertebral disc is structural. Loss of tissue alters biomechanics, subsequent disc degeneration, and is attributable to discogenic pain. A viable structural allograft was delivered into degenerate discs to determine whether intervention could safely stabilize anatomy, reduce pain, and improve function. Objectives: A viable tissue matrix product was developed to address the loss of tissue consequent to disc degeneration and to deliver to the nucleus pulposus a scaffold for tissue replacement of lost tissue and subsidize cell loss with progenitor cells to support the new matrix provided.

Materials and Methods
Following IRB approval and patient consent, subjects were randomized to receive allograft or saline at either 1 or 2 levels or continue conservative care. Subjects were randomized to receive supplemental allograft consisting of a cellular nucleus pulposus, placebo, or to continue in conservative care. Patients received intradiscal injections at 1 or 2 levels. Subject distribution included 128 active allograft, 57 placebo, and 102 cross over. Subjects receiving the VIA Disc Matrix achieved improvements that were durable at 12 months. Initial assessments indicate that a 1-level or 2-level treatment offers a reliable intervention that is safe and beneficial.

2890
Viable Allograft as Treatment for Disc Degeneration: Successful 1-level and 2 level Intervention

T Ganey1, c hancock2, D Beall3
1Vivex Biologics, Inc., Tampa, FL, 2University of California Riverside, Palm Desert, CA, 3Summit Medical Center, Edmond, OK

Purpose
Chronic back pain has been linked to genetic, metabolic, and mechanical imbalance, and while physical therapy, dieting, core strengthening, and anti-inflammatory medication have offered symptomatic relief, no remedy for replenishing tissue loss to degeneration exists. This study evaluated safety, and efficacy over a minimum of 12 months following allograft supplementation at 1 or 2 levels.

Materials and Methods
Following IRB approval and patient consent, subjects were randomized to receive allograft or saline a at either 1 or 2 levels. Subject distribution included 128 active allograft, 57 placebo, and 102 cross over. No difference between pain levels existed at baseline between the two groups. Visual Analog Scale (VAS), and Oswestry Disability Index (ODI), as well as adverse events (AEs) were assessed. This trial is registered on www.clinicaltrials.gov (NCT03709901).

Results
ODI demonstrated between the groups with 1-level comparisons of 87.5% of the population reaching MCI in blinded subjects receiving allograft, compared to 57.1% in those subjects blinded and receiving placebo saline. The overall significance was significant at a p-value of 0.020, and a p-value of .0015 comparing allograft and placebo. In crossover patients, 71.4% achieved MCI, but did not achieve significance.

Conclusions
This Level-I study is supported by data demonstrating improved pain and function at 12 months can be attained with a supplemental viable disc matrix. Subjects receiving the VIA Disc Matrix achieved improvements that were durable at 12 months. Initial assessments indicate that a 1-level or 2-level treatment offers a reliable intervention that is safe and beneficial.

2833
Volumetric and Spatial Assessment of Predicted Computed Tomography Perfusion Infarct and Penumbra in Acute Ischemic Stroke Patients: A Multiple-Software Study

K Snyder1, R Rava1, M Mokin2, M Waqas1, X Zhang1, A Podgorsak1, Y Hoi3, A Siddiqui1, J Davies4, E Levy1, C Ionita1
1University at Buffalo, Buffalo, NY, 2University of South Florida, Tampa, FL, 3Canon Medical Systems USA, Inc., Tustin, CA
Purpose
Computed tomography perfusion (CTP) infarct and penumbra estimations are utilized to determine acute ischemic stroke patient eligibility for endovascular intervention procedures. Spatial accuracy of predicted ischemic tissue is of importance as it allows for determination of the occluded vessel and potential estimations of advancement of infarct core [1]. This study aims to determine volumetric and spatial agreement of predicted RAPID, Olea, and Vitrea CTP software infarct and penumbra with final infarct from fluid-attenuation inversion recovery (FLAIR) magnetic resonance imaging (MRI) infarct.

Materials and Methods
Eighty-three emergent large vessel occlusion acute ischemic stroke patients treated at a single comprehensive stroke center were included in this retrospective study. Patients were required to have undergone baseline CTP imaging and follow-up FLAIR MRI. Fifty-five endovascular intervention and 28 non-intervention patients were included to assess predicted infarct and penumbra tissue respectively. For non-intervention patients, it is assumed all estimated penumbra converts to infarct on follow-up MRI imaging. Infarct and penumbra was quantified and segmented within RAPID, Olea and Vitrea CTP software. Volumetric measurements were assessed using mean volume differences. Spatial overlap was assessed using Dice and overlap coefficients.

Results
Mean infarct differences, with 95% confidence intervals, between FLAIR MRI and each CTP software are as follows for endovascular intervention patients: RAPID=10.8±8.0 mL, Olea=4.3±9.7 mL, and Vitrea=4.6±7.5 mL. For non-intervention patients, mean infarct differences are: RAPID=42.0±22.3 mL, Olea=-21.1±20.1 mL, and Vitrea=7.2±9.7 mL. Dice and overlap coefficients [Dice, overlap] for endovascular intervention patients are: RAPID=[0.46, 0.56], Olea=[0.61, 0.68], and Vitrea=[0.64, 0.72]. For non-intervention patients, Dice and overlap coefficients are: RAPID=[0.47, 0.72], Olea=[0.60, 0.75], and Vitrea=[0.68, 0.75].

Conclusions
Olea and Vitrea CTP software provided non-inferior results to commercially available RAPID software regarding volumetric and spatial agreement between final and predicted infarct for endovascular intervention patients. For non-intervention patients, Vitrea CTP software provided the best volumetric estimation and spatial agreement of infarct based on mean volume differences and Dice coefficients.
Figure 1. FLAIR MRI ground truth infarct label with the hyper-intensified regions identifying infarct. RAPID perfusion analysis demonstrates infarct as pink and penumbra as green, while Olea and Vitrea perfusion analysis demonstrates infarct as red and penumbra as yellow. For this intervention case, there is agreement between all 3 software regarding infarct volumetric measurements and their respective spatial locations within FLAIR MRI.

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White Matter Diffusion Changes in the Subacute to Chronic Phase of Adolescent Concussion

J Holcomb¹, G Murugesan², B Shah³, R Fisicaro¹, J DeSimone¹, B Wagner², C Whitlow³, J Maldjian²
¹UT Southwestern Medical Center, Dallas, TX, ²University of Texas Southwestern Medical Center, Dallas, TX, ³N/A, N/A

Purpose
The purpose of this study is to identify brain changes on diffusion imaging between concussed adolescent athletes in the subacute to chronic phase of injury and non-concussed athletes using source-based morphometry (SBM).

Materials and Methods
Diffusion tensor imaging, including fractional anisotropy (FA), linear diffusion (LD), and spherical diffusion (SD) estimations, was performed on 20 adolescent concussed football players (ages 10-18 years old) and 19 non-football controls with no history of concussion (ages 10-18 years old). All concussions occurred between six weeks to one year prior to imaging. SBM was used to identify regions of covariance across all subjects. 20 regions of interest (ROIs) were generated for each diffusion type. Loading coefficients, representing each subject's image contribution to each ROI, were calculated. General linear models with covariates of age and BMI classification were used to compare loading coefficients of concussed subjects and controls. False discovery rate (FDR) correction was used for each diffusion metric. All generated maps were thresholded at a z-score of +/- 3.

Results
While controlling for BMI and age, concussed subjects demonstrate significantly lower FA in the dorsal midbrain, cerebellar peduncle, perithalamic white matter, and ventrolateral thalamic nuclei, and significantly greater FA in the cerebral peduncle than unconcussed controls (p-value: 1.18x10⁻³). Further, concussed subjects demonstrated significantly lower LD in ventrolateral thalamic nuclei, and significantly greater LD in the cerebral peduncle and corticospinal tract (p-value: 7.50x10⁻³). Similarly, concussed subjects demonstrate significantly lower spherical diffusion in the cerebral peduncle, corticospinal tract, and globus pallidus (p-value: 8.62x10⁻³).

Conclusions
This study demonstrates SBM as a novel analysis tool that is sensitive to diffusion changes in the subacute to chronic phase after adolescent concussion. The structural changes associated with concussion that were revealed by SBM may indicate reduced myelination of the dorsal midbrain, cerebellar peduncle, and ventrolateral thalamic nuclei, and cytotoxic edema or gliosis of the cerebral peduncle, corticospinal tract, and globus pallidus.

Figure 1: Differences in loading coefficients and regional changes between concussed and unconcussed subjects by diffusion type. 1a-1c: Differences in loading coefficients between concussed and unconcussed subjects. 1d-1f: Regions of change between groups. All maps are thresholded at a z-score of +/- 3. Blue and red brain regions indicate loci where each diffusion metric is, respectively, greater or lower in concussed subjects than in controls.

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Late Breaking Posters

2881

3D MRI Shows Nerve Roots Descend and may be at Risk of Compromise at a One Level Higher in the Cervical Spine

F Syed¹, C Jeranko², E Liao²
¹VA Ann Arbor Health System / University of Michigan Health System, Ann Arbor, MI, ²University of Michigan, Ann Arbor, MI

Purpose
The purpose of this study is to study the course of the nerve roots on cervical spine 3D MRI studies. Our hypothesis is that there is increased obliquity of the cervical spine nerve roots, more so in the caudal cervical spine, such that two nerve roots can be affected by pathology at one level.

Materials and Methods
The study was approved by the VA Ann Arbor Health System Institutional Review Board. Cervical MRI studies obtained at the VA Ann Arbor Health system were retrospectively reviewed. Patients were included if they had a cervical spine MRI at VAAAHS with a 3D T2 sequence. Patients were excluded if the cervical MRI studies did not have a 3D T2 sequence, had significant artifacts that would hinder accurate evaluation, or had significant spondylosis that would preclude assessment of the cervical nerve root anatomy. 36 patients were reviewed and 20 patients were included in the study. Origins of the C3-C8 ventral and dorsal nerve roots were documented at six levels: 3 (disc, infra-pedicular and pedicular levels) at the level of the exiting cervical nerve and 3 (disc, infra-pedicular, and pedicular levels) above the level of the exiting cervical nerve.

Results
There is caudal progression of obliquity of cervical nerve roots. 92% (200/217) cervical nerve roots originate at or above one disc level higher than their exiting level. This includes 94% (92/98) ventral nerve roots and 97% (96/99) dorsal nerve roots. The obliquity of the cervical nerve roots has an increasing caudal gradient. 90% of C4 nerve roots originate at least one disc level higher while 98% of C8 nerve roots originate at least one disc level higher. No cervical nerve roots originated at or above two disc levels higher than their exiting level.

Conclusions
Cervical nerve roots (C4-C8) have a high probability of originating at least one disc level higher than their exit. Thus, these nerve roots are susceptible to pathology that may occur one disc level higher. Both the ventral and dorsal nerve roots may be at risk. This may explain at least to some extent the apparent overlap of cervical radicular syndromes. This information is not well known in the medical community and may lead to more accurate diagnosis and treatment of cervical radiculopathy.
Comparison of Diffusion and Perfusion Techniques in Differentiating High versus Low Grade Pediatric Brain Tumors

B Gray1, J Parker1, E Diller1, Q Wen1, Y Wu1, G Anthony1, P Territo1, C Ho1
1Indiana University School of Medicine, Indianapolis, IN

Purpose
To compare different perfusion and diffusion techniques such as dynamic contrast enhancement (DCE) and intravoxel incoherent motion (IVIM) with relative cerebral blood volume (rCBV) from dynamic susceptibility contrast (DSC) perfusion and apparent diffusion coefficient (ADC) from diffusion weighted imaging (DWI) in a cohort of pediatric patients with newly diagnosed brain tumors.

Materials and Methods
A retrospective blinded review of pediatric brain tumors with DCE, IVIM, DWI and DSC was performed. Parametric maps were registered to T2 weighted images. Volumetric regions of interest (ROI) were manually segmented of the solid tumor components for each patient by a neuroradiologist and neuroradiology fellow. Resulting mean values for parameters from DCE (Ktrans, Kep, Ve, Vp), IVIM (D, D*, f), DSC (rCBV) and DWI (ADC) were compared using Student's t-test for high- and low-grade tumor groups based on WHO grading from pathology. For significant parameters, receiver operating characteristic (ROC) analysis with area under curve (AUC) was performed.

Results
20 subjects (mean 7 years of age, 8 females) were included. There were 9 low grade and 11 high grade tumors. Significant differences between low versus high grade were demonstrated for D (10−3 mm2/s) (1.4±0.4 vs 0.9±0.2, p=0.01), f (0.04±0.02 vs 0.07±0.02, p=0.02), ADC (10−3 mm2/s) (1.4±0.4 vs 0.9±0.3, p=0.009) and rCBV (2.2±0.9 vs 4.7±2.1, p=0.003). No significant difference was found for D* or any DCE parameter. AUC from ROC was similar for all significant parameters [D (0.81, p=0.003); f (0.80, p=0.003); ADC (0.83,p=0.001); rCBV (0.83, p=0.0005)].

Conclusions
D and f parameters from IVIM can significantly differentiate high versus low grade pediatric brain tumors similar to ADC and rCBV. Conversely, no DCE parameter was significant.

Computed Tomography versus Fluoroscopic Guided- Sacroiliac Joint Injections: A Prospective Comparative Study

A Bessar1, M Arnaout2, M Basha2
1Zagazig University, Zagazig, Egypt, 2Zagazig University, Zagazig, Sharkia

Purpose
To compare the ultimate therapeutic outcome of computed tomography (CT) -guided sacroiliac joint (SIJ) injection to that of fluoroscopic guidance.

Materials and Methods
A prospective study conducted on 52 patients who met specific inclusion criteria of SIJ pain (23 females and 29 males; mean age 46 ± 12.1 years; range 30-67 years). A mixture of 1 ml of 40 mg of methylprednisolone acetate (Depo-Medrol_; Pfizer Canada Inc., Kirkland, Quebec, Canada) diluted in 2 ml of 2% lidocaine was injected under either CT or fluoroscopic guidance. Numeric rating score (NRS) and Oswestry disability index (ODI) were assessed and recorded for each patient before the procedure and one week, and one, three, six, and 12 months after procedure. The results were compared between both groups.

Results
Baseline NRS and ODI were 7.3 ± 0.94, and 59.5 ± 16.1, respectively. Analysis of NRS one month post-procedure revealed a significant reduction from baseline in both groups: 12.5% in CT group (p =0.002) and 9.5% in fluoroscopic group (p =0.006). However, there was a significant difference in NRS between two groups at six and 12 months post-procedure (p = 0.01 and < 0.0001, respectively). Comparison of ODI at six-month post-procedure revealed that both groups had a statistically significant improvement in ODI (reduction by 51.3% and 35.4%, respectively, p < 0.0001). However, there was a significant difference in ODI between the two groups at six months post-procedure (p = 0.01).

Conclusions
CT-guided SIJ injection compares favorably with fluoroscopic guidance and offers long term pain relief.
Concerns and Recommendations for MR Imaging in Patients with Spinal Cord Stimulators

M Lee¹, I Ma¹, J Tharayil¹, S Alacano¹, R Swanger¹
¹University of Nevada, Reno School of Medicine, Reno, NV

Purpose
The purpose of this presentation is to explain the foundational understanding of the interplay between mechanical devices such as spinal cord stimulators (SCS) and MRI. This presentation also aims to describe the specific MRI conditions necessary for optimal image quality and safety in patients with SCS who need MRI.

Materials and Methods
A literature review of the current recommendation for SCS compatibility with MR imaging and a review of the Food and Drug Administration (FDA) approved spinal cord stimulation systems were performed. The literature review was completed using PubMed, the FDA website (www.fda.gov), and the SCS manufacturers' websites.

Results
The current recommendations, composed on the basis of evidence-based medicine, reveals close adherence of an MRI with a 1.5T magnet and a mean total body specific absorption rate (SAR) of 0.9 W/kg or below can ensure safety for the patient, despite the variability between different SCS manufacturers [1]. Measurement of safety includes tearing of tissues due to rotational force generated by the magnetic field, acceleration of the device towards the bore of the magnet ("missile effect"), and burns caused by overheating of the device. The FDA is responsible for approving SCS compatibility with specific MRI conditions and label such devices as MR conditional [2].
Cord Stimulator System are two examples of SCS that have been labeled as MR conditional by their manufacturers and are FDA approved. Descriptions of the MR conditions of the listed SCS are included in Table 1 [3,4]. Adherence to these MR conditions with usage of the respective SCS yields highest patient safety index and image quality. Distortion and artifacts from MRI are expected of patients with SCS, especially if FDA recommendations of specific MRI conditions are not met. In a study performed by Desai et. al., it was discovered that the MR image of patients with SCS vs. without SCS are slightly inferior in terms of picture quality, though the differences in image quality were not statistically significant [5].

Conclusions
Strict adherence to an MRI with a 1.5T magnetic bore core and a SAR of 0.9 W/kg or below can ensure patient safety despite the various SCS developed by manufacturers. Providers and technicians should be encouraged to seek specific SAR, Slew Rate and Field Strength conditions found on the manufacturers' website to yield highest safety index and optimal image quality.

Table 1. MR conditions of two FDA approved SCS that must be fulfilled in order to achieve highest patient safety.

<table>
<thead>
<tr>
<th>Spinal Cord Stimulator</th>
<th>General requirements</th>
<th>MRI requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Senza Omnia™ Spinal Cord Stimulation System (Nevro) [3]</td>
<td>- Do not perform an MRI if the patient has a device or device component from a different manufacturer attached to the Nevro IPG.</td>
<td>- Only use MR scanners with maximum spatial field gradient of 1900 gauss/cm (19 T/m) or less.</td>
</tr>
<tr>
<td></td>
<td>- Do not perform an MRI if impedance on any of the conductor path on the lead is greater than 10 kΩ.</td>
<td>- Only use MR scanners which limit gradient slew rate to 200T/m/sec per axis or less</td>
</tr>
<tr>
<td></td>
<td>- Body Temperature – If a body coil is used (transmit only or transmit/receive), do not perform a scan if the patient's body temperature is greater than 37°C. Elevated body temperature in conjunction with tissue heating ceased by an MRI scan increases the risk of excessive tissue heating, which could cause tissue damage.</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Precision™ Montage™ MRI Spinal Cord Stimulator System [4]</th>
<th>MRI systems must meet following criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- MRI magnet strength of 1.5T only</td>
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<tr>
<td></td>
<td>- Gradient slew rate per axis less than or equal to 200 T/m/s.</td>
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<tr>
<td></td>
<td>- Maximum spatial field gradient less than or equal to 40 T/m.</td>
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<td></td>
<td>- Scanner operation at or below normal operating mode limits for RF and gradient exposure: Whole body SAR must be &lt; 2.0 W/kg, Head SAR must be &lt; 3.2 W/kg.</td>
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</tbody>
</table>

*MRI examinations can be safely conducted if all the instructions provided in the table are followed. Table 1 outlines some of the major recommendations of the following SCS. Further requirements may be found on manufacturer’s website.
Counterpoint: Conventional Fluoroscopically Guided Selective Cervical Nerve Root Block: A Safe, Effective, and Efficient Modality in the Hands of an Experienced Proceduralist

F Ott¹, R Pluhm¹, K Ozturk¹, A McKinney¹, J Rykken¹
¹University of Minnesota, Minneapolis, MN

Purpose
To identify any major complications and determine the safety and clinical utility of conventional fluoroscopy-guided (CF) selective cervical nerve root block (SCNRB) performed in a university hospital and associated outpatient clinics.

Materials and Methods
Two-hundred fifty-four CF-SCNRBs were retrospectively identified over a period from 2011 to 2018 utilizing a radiology report search tool. Each procedure was performed by an experienced neuroradiologist (>10 years) performing spinal injections on a full-time basis in clinical practice. A 10-point pain scale is utilized for pre and post-procedure pain level assessment. Successful CF-SCNRB was defined as a patient-reported pain scale reduction of at least 50% and alleviation of numbness or paresthesias at two or more weeks postinjection. All clinically significant immediate and delayed complications were also recorded.

Results
Two-hundred fifty-four CF-SCNRBs were performed via an anterolateral approach with an average fluoroscopy time of 24.3 seconds for all cases. There were no aborted procedures and no major or permanent complications. There were 14 minor complications, 12 of these were periprocedural and resolved by the 2 week follow up visit. Eight of these 12 patients reported a mild increase from their usual pain in a familiar distribution. Two of the 14 minor complications were delayed in onset and also resolved by 2 weeks, albeit with uncertain clinical association. Arm numbness was not included as a complication as it is expected when exposing a cervical nerve root to a lidocaine containing mixture. One hundred eighty-five patients (75.2%) reported pain improvement greater than 50% from baseline at 15 minutes postinjection, while 61 patients (24.8%) reported a reduction of less than 50% from baseline pain at 15 minutes. In the former group with greater than 50% pain reduction at 15 min, 139 (75.1%) reported maintenance of pain reduction at 2 weeks, 46 (24.9%) reported that their pain had returned to baseline at 2 weeks. In the latter group with less than 50% pain reduction at 15 min, 26 (42.6%) reported meaningful pain reduction at 2 weeks and 35 (57.4%) reported that their pain had remained unimproved at 2 weeks. 7 of the 8 patients with radiculopathy without pain also reported resolution of their symptoms 2-weeks postinjection.

Conclusions
CF-SCNRB is an efficacious and safe outpatient procedure when performed by a skilled and experienced proceduralist.
Diagnostic performance of CT indicators of craniovertebral junction injury in children

R Olatunji¹, A Biswas², A Amirabadi³, B Ertl-Wagner²
¹The Hospital for Sick Children, University of Toronto, Toronto, ONTARIO, ²The Hospital for Sick Children, University of Toronto, Toronto, Ontario, ³The Hospital for Sick Children, Toronto, Ontario

Purpose
Craniovertebral junction injury (CVJI) occurs in 45% of children with cervical spine (C-spine) trauma. Many CT indicators of CVJI have been described but only few studies tested their performance in injured children. This study aims to assess the performance of selected CT indicators of CVJI in injured children.

Materials and Methods
C-spine CT and MRI images of consecutive children with suspected injury were retrospectively reviewed independently by two pediatric neuroradiology fellows. The Basion-Dens Interval (BDI), AtlantoDental Interval (ADI), Lateral AtlantoDental Interval (LADI), occipital Condyle-C1 Interval (CCI) were assessed on CT. MR imaging was reference standard. Mechanism of injury, treatment type and duration, and follow-up were obtained. Values of BDI, ADI, LADI, and CCI were classified as normal or abnormal based on nomograms. Statistical analysis for diagnostic tests was done using SPSS version 20.

Results
94 children [55 males, median age: 7 yr (IQR: 3-13 yr)] with C-spine injuries were included. 50/94 (53%) resulted from fall, 79/94
(80%) presented with GCS of 13-15, and neck pain was a presenting complaint in 59/94 (63%). Intraclass correlation coefficient was 0.751 (95% CI: 0.637-0.831). CCI was the single quantitative parameter with the best sensitivity for any abnormal MRI finding (58%), ligamentous injury (61%), multiple injured ligaments (65%), severe injury (54%), treatment type and duration (59%), and need for follow-up CT/MRI (63%). CCI combined with LADI (CCI-LADI) demonstrated the best sensitivity for any abnormal MRI finding (73%), ligamentous injury (78%), severe injury (71%), treatment type and duration (76%). CCI-LADI and CCI-BDI were equally sensitive to multiple injured ligaments (70%) and need for follow up CT/MRI (75%) with CCI-BDI showing the higher specificity of 42% and 44% respectively. BDI had the highest specificity for any abnormal MRI finding (100%), ligamentous injury (93%), multiple injured ligaments (91%), severe injury (87%), treatment type and duration (94%), and need for follow up CT/MRI (92%). BDI also showed the highest PPV for abnormal MRI finding (100%), ligamentous injury (67%) and multiple injured ligaments (50%). The best performing single parameters for NPV were CCI (51% and 65% respectively for ligamentous injury and multiple injured ligaments) and LADI (93%- need for follow up CT/MRI).

Conclusions
CCI was the single most sensitive quantitative CT parameter of CVJI, attaining higher sensitivity and NPV when combined with LADI.

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DTI of Chronic Spinal Cord Lesions in Children that have a Spectrum of MRI Findings Ranging from without MR abnormalities (SCWOMR) to a Variety of Intramedullary Pathology on MRI and Comparison to Clinical AIS Scores

S SAKSENA1, F Mohamed1, D Middleton1, L Kriza1, M Alizadeh1, S Shahrampour1, A Flanders2, K Talekar2, S Faro2
1Thomas Jefferson University, Philadelphia, PA, 2Thomas Jefferson University Hospital, Philadelphia, PA

Purpose
To examine the pediatric patients with spinal cord (SC) without MRI findings (SCWOMR), a variety of intramedullary SC lesions on MRI and clinical scores using DTI.

Materials and Methods
A retrospective study included 36 typically developing (TD) (mean age, 11.72±3.12) and 19 patients with clinically diagnosed chronic SC lesions (mean age, 12.16±2.91). Patients were classified into two subgroups of varying severity based on the type of SC lesion seen on anatomic MRI which included SCWOMR (n=6) and non-SCWOMR (n=13). TD and patients underwent scans using 3T Siemens MR scanner. The protocol consisted of conventional T1- and T2-weighted structural scans and axial DTI scans based on inner FOV sequence1. DTI images acquired axially using two overlapping slabs to cover the cervical and thoracic SC. Imaging parameters for each slab: 3 averages of 20 diffusion directions, 6 b0 acquisitions, b=800s/mm2, voxel size=0.8x0.8x6mm3, axial slices=40, TR=7900ms, TE=110ms, TA=8:49min and no gating. Data analysis: After motion correction2 and tensor estimation3, ROIs were manually drawn on axial fractional anisotropy (FA) maps to extract the whole cord along the cervical and thoracic SC. ROIs were drawn at intervertebral disk and mid-vertebral body level of the entire SC to compute DTI metrics. Statistical analysis: To detect differences in DTI metrics between the normal appearing SC in TD and patients in SCWOMR and non-SCWOMR groups and further divided into AIS grades A/B and C/D, a nonparametric Wilcoxon test was performed respectively. A p<0.05 was statistically significant.

Results
FA was significantly decreased whereas radial diffusivity (RD) was significantly increased in the proximal, middle and distal segments of the caudal cord and in the middle cephalad segments on comparing TD to patients with SCWOMR (Table 1). There was a significant decrease in FA in all three segments of the cephalad and proximal and middle caudal cord on comparing TD to patients with non-SCWOMR (Table 2). In SCWOMR AIS A/B group, FA demonstrated more consistent perilesional abnormal DTI findings in the cephalad and caudal cord, however SCWOMR AIS C/D group did not show perilesional FA abnormality.

Conclusions
This study shows that there are significant changes in DTI metrics in patient's where there are no MRI findings (SCWOMR) and has not been previously described. In SCWOMR AIS A/B group, FA demonstrated more consistent perilesional abnormal DTI findings in the cephalad and caudal cord compared to the AIS C/D group.
Dural venous sinus stenosis: why distinguishing intrinsic versus extrinsic stenosis matters

S Sundararajan¹, A Ramos¹, V Kishore², M Michael¹, R Doustaly², F DeRusso¹, A Patsalides¹
¹Weill Cornell - New York Presbyterian Hospital, New York, NY, ²GE Healthcare, Buc, France

Purpose
Dural venous sinus stenosis has been associated with idiopathic intracranial hypertension (IIH) and isolated pulsatile tinnitus (PT), and can be characterized as either intrinsic or extrinsic. However, these descriptors are seldom used, as an association between stenosis type and patient symptoms is not well established. The aim of this study was to review pre-procedural imaging of treated symptomatic IIH and PT patients in our institution, classify the stenosis, and assess for a trend between stenosis type and clinical presentation.

Materials and Methods
Following IRB approval, a retrospective review of patients treated with venous sinus stenting from January 2012 to January 2020 was performed. Two certified neuroradiologists reviewed all MRV imaging prior to stenting and categorized stenosis type (intrinsic or extrinsic) and length (short <3 cm, long >3 cm). The presence of sinus enlargement, venous aneurysm, internal jugular diverticulum, or prominent condylar vein was recorded in PT patients. Stent procedures details were also noted.

Results
115 IIH (107 female, mean 38.1 yo) and 40 PT (39 female, mean 32.7 yo) patients were treated. 42 sinuses were counted in the PT cohort (2 patients were bilaterally stented). Each deployed stent was 4 cm or less length. 75 of 115 (65%) sinuses in the IIH cohort had long extrinsic stenosis related to narrowing from adjacent parenchyma. Remaining 40 (35%) had short intrinsic stenosis related to arachnoid granulations or webbing. All IIH patients were treated in the dominant sinus, regardless of bilateral stenosis. 50% of IIH patients received more than 2 stents (Table 1). 34 of 42 (80%) sinuses in the PT cohort had short intrinsic stenosis. 9 of 34 had saccular aneurysms of the transverse/sigmoid junction needing stent-assisted coil embolization. 25 of 34 had post-stenotic sinus enlargement, noting associated IJ diverticula/condylar veins (Table 2). Remaining 8 of 42 (20%) possessed short segment extrinsic stenosis. No PT patient received more than 2 stents.

Conclusions
In this cohort, most PT patients possess short intrinsic stenosis while most IIH patients possess long extrinsic stenosis. This information is of high-scientific impact, as it is the first time such a pattern has been reported. Awareness of such subtypes and their potential clinical association may minimize stenosis under-recognition. Reporting stenosis subtypes can also assist interventionalists in the selection of appropriate stent construct length and size to minimize hardware.
Emergent Carotid Artery Stenting Using a Dual-Layer Micromesh Nitinol Stent Device: a Single Centre Experience

A Lamanna¹, J Maingard², H Kok³, C Barras⁴, A Jhamb⁵, D Ranatunga¹, L Slater², W Chong², R Chandra⁶, M Brooks¹, H Asadi¹
¹Austin Health, Melbourne, Victoria, ²Monash Health, Melbourne, Victoria, ³Northern Health, Melbourne, Victoria, ⁴The University of Adelaide, Adelaide, South Australia, ⁵St Vincent's Hospital, Melbourne, Victoria, ⁶N/A, N/A

Purpose
Emergent carotid artery stenting (eCAS) is increasingly being performed for the treatment of carotid artery stenosis in the acute stroke setting, particularly in the presence of a tandem intracranial occlusion. Previous series suggest that, when used emergently, dual-layer micromesh nitinol stents are associated with unacceptably high rates of acute in-stent thrombosis. This single-centre retrospective case series evaluates the safety, technical feasibility and efficacy of eCAS using a dual-layer micromesh nitinol stent to treat carotid artery stenosis in the acute stroke setting.

Materials and Methods
Ethics approval was granted by the Institutional Review Board. Clinical data of all patients who underwent eCAS using the Casper dual-layer micromesh nitinol stent system (Microvention, Terumo, Tustin, CA, USA) at a tertiary level 24-hour endovascular thrombectomy service over a three-year period (June 2016-June 2019) were retrospectively obtained and reviewed. Follow up radiological and clinical data were collected including rates of periprocedural symptomatic intracranial haemorrhage, thromboembolism and in-stent thrombosis, 24-hour NIHSS and 90-day modified Rankin scale (mRS).

Results
Thirty eCAS procedures were performed in twenty-nine patients over the study period. Median NIHSS on admission was 16 (IQR 9-20) and most patients had tandem lesions (20/30; 67%). Stent deployment was technically successful in all patients. The recanalization rate was 97% (29/30). Symptomatic intracranial haemorrhage occurred in three patients (10%), all resulting in death. No other procedure-related deaths occurred. Postprocedural acute in-stent thrombosis occurred in two patients (7%). One delayed embolic stroke occurred (3%). One patient required balloon dilatation for stent stenosis due to extrinsic compression from atherosclerotic plaque (3%). No other stent-related complications occurred. Median NIHSS at 24 hours postprocedure was 2 (IQR 0-7). Fifty percent (50%; n=13) of patients achieved functional independence (mRS 0-2) at 3-6 month clinical review.

Conclusions
eCAS using the dual-layer micromesh nitinol Casper stent is effective and technically feasible in the acute stroke setting with low rates of acute in-stent thrombosis.
Endovascular management of elderly subarachnoid hemorrhage patients: A UK experience

K Mohmoud, N Jayakumar, N Ross
1Royal Victoria Infirmary, Newcastle upon Tyne, Tyne and Wear

Purpose
Subarachnoid hemorrhage (SAH) in the elderly is a grave illness with high morbidity and mortality [1]. However, as the population grows older in most high-income countries, the incidence of elderly patients with SAH is bound to increase too. Endovascular treatment has become the mainstay of treatment for aneurysmal SAH in the United Kingdom (UK) and its advantages are well-recognised [2]. Endovascular treatment in elderly SAH patients, however, has not shown any significant benefit compared to surgical clipping [3]. The purpose of this study was to describe the experience of managing SAH in elderly (≥75 years old) patients at a tertiary neurosciences centre in the UK.

Materials and Methods
A retrospective cohort study of all patients with SAH admitted to our institution, aged 75 years and above, between the years 2014-2019 was performed. Clinical notes and imaging of eligible patients were reviewed independently by the authors. Data items collected include patient demographics, WFNS grade, aneurysm location, the presence of hydrocephalus, and pre-morbid ASA grade.

Functional outcomes were assessed through the Modified Rankin Scale (MRS) – at discharge and 6-month follow-up. Clinical outcomes included SAH complications (hypotension, rebleed), medical complications (pneumonia, stroke, etc), hospital length of stay, need for ITU admission, and procedural complications. Statistical analyses were performed on SPSS (IBM).

Results
Fifty-three patients were included. Median age was 78 (range = 75-91) and 84.9% were females. Over 80% of aneurysms were in the anterior circulation. Two-thirds (67.9%) presented with a good grade (WFNS I-II) while 22.6% had a poor grade (WFNS IV-V). Forty-seven (88.7%) were treated by endovascular therapy. The majority (91.7%) were treated within 48 hours of the ictus. More than half (56.3%) required CSF diversion for hydrocephalus on admission. Nearly half (45.3%) had one or more medical complications. The overall mortality rate was 17.0%. Less than half (46.9%) were discharged with a good functional outcome (MRS 0-2). At 6-month follow-up, almost two-thirds (64.9%) were functionally independent (MRS 0-2). Predictors of a good functional outcome were WFNS grade, pre-morbid ASA, absence of hydrocephalus, and being discharged home directly.

Conclusions
The majority of elderly SAH patients were treated with endovascular therapy at our institution. Although the mortality and morbidity remain high, two-thirds of patients achieved a good functional outcome at 6-months.

Preliminary MRI-based cellularity predictions indicate abnormal pathology in brain cancer patients at autopsy

S Bobholz, A Lowman, M Brehler, S McGarry, E Cochran, J Connelly, M Agarwal, D O’Neill, A Banerjee, P LaViolette
1MEDICAL COLLEGE OF WISCONSIN, Wauwatosa, WI, 2Medical College of Wisconsin, Milwaukee, WI, 3Medical College of Wisconsin, Wauwatosa, WI

Purpose
This study used large format tissue samples taken at autopsy to assess the relationship between multi-parametric MRI and cellular features of brain cancer tissue. We hypothesized that an MRI-based machine learning model for cellularity would be able to 1) improve delineation between tumor and treatment effect, and 2) detect abnormal pathology beyond the contrast-enhancing tumor region.

Materials and Methods
Twelve patients with pathologically confirmed brain cancer at surgery were included in this study. At autopsy, 3-D printed slicing jigs based on the clinical imaging were used to slice the brain in the same orientation of the MRI, and 34 tissue samples were taken. Following H&E staining and 40X digitization, a color deconvolution algorithm was used to segment and count cells across each slide. In-house custom software was used to align tissue samples and cell density information to the FLAIR image using manually defined control points. Tissue from ten subjects were used to develop a bagging regression ensemble algorithm to predict cellularity from T1, T1C, FLAIR, and ADC images acquired near death across each voxel. Performance was evaluated using voxel-wise five-fold cross-validation (VBCV), as well as tissue sample level and subject level leave-one-sample-out (LOSO) schemes to assess different scales of generalizability in this small preliminary training data set. We assessed model performance in two test subjects: S1, with pathologically confirmed no tumor at autopsy, and S2, with an extensive frontal lobe glioblastoma.

Results
Root mean squared errors (scaled to the cellularity standard deviation) for the training and validation sets were as follows: training=0.492, VBCV=0.730, slide-based LOSO=1.05, and subject-based LOSO=1.07. These results suggest modest validation accuracy despite some overfitting to the training data set. The model predicted no regions of cellularity in S1, despite the presence of traditional MR signatures of tumor. Additionally, the model predicted a left posterior region of moderately increased cellularity.
outside of the contrast enhancing region for S2. This corresponded to a confirmed moderate local cellularity increase in the tissue sample despite overestimated magnitude.

Conclusions
This preliminary evidence suggests that MRI-based ensemble machine learning models for cellularity may provide novel contrasts corresponding to previously inaccessible tumor pathology.

Figure 1: MRI-based cellularity predictions presented as A) example cases for training and test subjects and B) an voxel-wise MRI intensity scatterplot. For the example cases, the prediction algorithm tends to show regions of enhancement that differ substantially from any single image. The scatterplot is presented in terms of T1SUB (T1C - T1), FLAIR, and ADC values, and shows some clustering for hypercellularity around high T1SUB values, as well as concurrent low ADC and high FLAIR values.

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Progressive Multifocal Leukoencephalopathy (PML) MRI Enhancement Prevalence and Patterns – A Multicenter Retrospective Cohort Study

F Fortin1, L Letourneau-Guillon2, M Drapeau2, C Fortin2, C Renaud3, L Harraoui4, L LeBlanc5, N Khairallah6, V Martel-Laferrière2, D Rouleau2, S Grandjean Lapierre2

1Université de Montréal, Montreal, Quebec, 2CHUM, Montreal, Quebec, 3CHU Sainte-Justine, Montreal, Quebec, 4CUSM and Hôpital Charles-Lemoyne, Greenfield Park, Quebec, 5Hôpital du Sacré-Coeur de Montréal, Montreal, Quebec, 6Hôpital Maisonneuve-Rosemont, Montreal, Quebec

Purpose
To describe the prevalence and patterns of enhancement on initial MRI in adults with progressive multifocal leukoencephalopathy (PML) and various underlying immunodeficiency disorders.

Materials and Methods
After local ethics board approval, archives of five university-affiliated hospitals in Canada were searched for patients aged at least 18 years, hospitalized between January 2009 and January 2017, who had positive PCR JC virus on cerebrospinal fluid and/or a clinical diagnosis of PML on their discharge summary. Cases with confounding pathology, incomplete clinic data, and no contrast-enhanced MRI were excluded. Only definitive PML cases according to American Academy of Neurology 2013 criteria based on combined clinicoradiological findings and PCR or histopathology were analyzed, for a total of 28 patients, 15 with HIV and 13 without. Original MRI images were obtained and reviewed.
Results
Enhancement on initial MRI was seen in 13 out of 28 patients (46%). Enhancement of brain lesions was peripheral in 11 (39%), punctate in 3 (11%), nodular in 1 (4%) and diffuse in 0 patients. Even when excluding patients with potential immune reconstitution inflammatory syndrome (IRIS), enhancement was still seen on 9 out of 23 (39%) initial MRIs. No statistically significant difference was found in the proportion of HIV-positive patients (7/15, 47%) compared to HIV-negative patients (6/13, 46%) showing enhancement (p=1.00).

Conclusions
Although classically described as non-enhancing, nearly half of patients with PML showed enhancement on initial MRI. PML should therefore not be discounted on the basis of MRI enhancement.

Quantitative Magnetic Resonance Angiography Predicts Clinical Outcomes After Stenting In Patients With Symptomatic Intracranial Stenosis

Y Serulle1, H Sy1, D Khatri1, S Yerneni1, D Langer1, R Ortiz1
1Lenox Hill Hospital, New York, NY

Purpose
Intracranial stenosis accounts for 8-10% of cases that lead to ischemic stroke in the United States, and the risk of suffering stroke due to intracranial stenosis is between 7 and 24%. The Stenting and Aggressive Medical Management for Preventing Recurrent Stroke in Intracranial Stenosis (SAMMPRIS) Trial concluded that aggressive medical management is superior to percutaneous transluminal angioplasty and stenting. However, it has been argued that patients were enrolled to the trial based on lesion severity, without considering the mechanism of stroke or the status of collateral supply and brain perfusion. Quantitative magnetic resonance angiography (QMRA) is a technique that allows for non-invasive measurement of large vessel flow and velocities in the head and neck. Here, we describe procedural and clinical outcomes on a series of patients who presented with symptomatic intracranial stenosis, and were selected for intracranial stenting following a thorough evaluation of their collaterals using QMRA.

Materials and Methods
Retrospective case series of patients undergoing stenting for symptomatic intracranial stenosis and who underwent pre-procedural testing with QMRA at a single institution. Blood velocities within the vasculature of the head and neck were then calculated using an automated computerized software. Patients who demonstrated markedly decreased flow distal to the area of stenosis were selected for the procedure. Stenting was performed using the Wingspan stent. Patients were then followed up in clinic after discharge 2 weeks and then 3 months post-procedure.

Results
There were six patients with symptomatic intracranial stenosis who underwent intracranial stenting. Three patients had stenosis of the middle cerebral artery, one of the petrous portion of the internal carotid artery, and two of the intracranial vertebral artery. On these six cases, QMRA performed during the initial diagnostic workup demonstrated markedly decreased flow distal to the focal stenosis.
including distal branches, suggesting not only severe stenosis but also poor vascular collateralization. All six patients underwent successful intracranial stenting and were neurologically intact and/or improved relative to their initial presentation on clinic follow up.

Conclusions
Stenting may be a viable treatment for symptomatic intracranial stenosis, and QMRA may be a useful triage tool in the selection of patients for this procedure.

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Vascular risk profile and white matter hyperintensities, a comparison between Mexican Americans and non-Hispanic Whites of the Healthy Aging Brain in Latino Elders (HABLE) cohort.

K King¹, R Vintimilla², M Braskie³, K Wei⁴, J Hall², L Johnson², S O'Bryant²
¹Huntington Medical Research Institutes, Culver City, CA, ²The University of North Texas Health Sciences Center at Fort Worth, Fort Worth, TX, ³Keck School of Medicine of USC, Marina Del Rey, CA, ⁴Huntington Medical Research Institutes, Pasadena, CA

Purpose
Mexican Americans are diagnosed with MCI and AD at younger ages [1,2] and with more rapid disease progression [1,3] but the reasons for this disparity are unknown. Vascular disease is now recognized as contributing to onset of cognitive decline either alone in a vascular dementia or in combination as a mixed dementia alongside Alzheimer's dementia. We hypothesized that in Hispanics an increased prevalence of diabetes and other risk factors drives vascular brain insult as indicated by white matter hyperintensity (WMH) volume.

Materials and Methods
In this prospective IRB approved study, 1304 participants with written informed consent underwent clinical evaluation and 3T brain MRI (Siemens Skyra). WMH volume was measured from FLAIR using the Statistical Parametric Mapping (SPM) Lesion Segmentation Tool. Ethnicity was included as a predictor of WMH adjusted for intracranial volume (ICV) derived from Freesurfer v6.0 analysis of T1 MPRAGE, and age and sex were included as covariates. Log [WMH (ml) +1] was used achieve a more normal distribution. Additional vascular risk factors (see table 1) were then added as potential predictors in a best fit linear regression model using stepwise selection minimizing Bayesian information criterion. P values adjusted for false discovery rate with significance at P<.05 using two tailed tests.

Results
Increased Age (estimate 0.049±0.002, p<.0001) Hispanic ethnicity (estimate 0.103±0.044, p=.0197) and Female sex (estimate 0.096±0.049, p=0.0488) were associated with greater WMH (adjusted for ICV). The best fit model for predictors of WMH is shown in table 1. Sex and Hispanic ethnicity were no longer significant after inclusion of vascular risk factors. We then compared the relationship between WMH and risk factors by ethnic group, and found that increased hemoglobin A1C, a measure of chronic hyperglycemia, was a more significant predictor of WMH among Hispanics than in Non-Hispanic whites (p<.0001).

Conclusions
Hispanics had increased WMH volume, equivalent to about two years of increased age compared with Non-Hispanic whites. Elevated
HBA1C was associated with increase in WMH, which subgroup analysis showed to be seen only for Hispanics and not for Non-Hispanics. The increased prevalence of diabetes among Hispanics is associated with increased WMH volume which may contribute to the earlier onset of dementia seen in Hispanics compared with Non-Hispanic whites.

Table 1. Predictors of White Matter Hyperintensity Volume from a best-fit model of vascular risk factors. The model was then stratified by ethnicity to identify differences between Hispanics vs. Non-Hispanic Whites.

*Variables considered but which did not contribute to optimal model fit: Systolic blood pressure, body mass index, total cholesterol, high and low density lipoprotein cholesterol, triglycerides, glucose, estimated glomerular filtration rate, TSH, T4, vitamin B12, folate, albumin, bilirubin, alkaline phosphatase, AST, ALT.

(Filename: TCT_2868_Table1v2.JPG)
3D-Printed Spine Phantoms Improve Resident Confidence with Fluoroscopy-Guided Lumbar Puncture

A Ali¹, J Huynh¹, D Wang², M Hazenfield¹
¹University of Cincinnati, Cincinnati, OH, ²University of Cincinnati Medical Center, Cincinnati, OH

Purpose
3D printed anatomic models can accurately and affordably simulate a multitude of minimally invasive fluoroscopy and ultrasound-guided procedures. These phantoms help familiarize radiology residents with relevant procedural anatomy and provide a safe medium for hands-on practice prior to actual patient encounters. There are multiple published reports of 3D printed training phantoms improving user confidence and technical procedural skills. However, there are no reports of 3D printed models for training of fluoroscopy guided lumbar puncture. A 3D printed spine model for fluoroscopy-guided lumbar punctures allows residents to identify relevant procedural landmarks and successfully guide a needle along the appropriate trajectory.

Materials and Methods
We developed a 3D printed model of the spine, which we imbedded in a gelatin-based matrix. This model was used at multiple hands-on procedural training sessions led by an attending neuroradiologist. Participating residents were surveyed for comfort level assessing relevant procedural anatomy of the spine, as well as describing, performing, and teaching the procedure. We used a 5-point Likert scale to assess resident comfort level prior to and after a simulated training session.

Results
For fluoroscopy guided lumbar puncture training, 11 radiology residents participated (8 first-year residents and 3 second-year residents). We observed statistically significant improvement in confidence for all assessments performed, with the largest improvement in describing the steps and performing fluoroscopy-guided lumbar punctures.

Conclusions
In this study, we demonstrate that a 3D printed model provides an accurate representation of spine anatomy while providing residents a controlled and safe environment for practicing and developing their skills for lumbar puncture prior to real patient encounters.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Pre ¹</th>
<th>Post ¹</th>
<th>p-value²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort level with identifying anatomy of the spine under fluoroscopy</td>
<td>3.0 (2.5-4.0)</td>
<td>5.0 (5.0-5.0)</td>
<td>0.003401</td>
</tr>
<tr>
<td>Comfort level performed fluoroscopic-guided lumbar puncture</td>
<td>3.0 (2.0-4.0)</td>
<td>5.0 (4.0-5.0)</td>
<td>0.003401</td>
</tr>
<tr>
<td>Comfort level teaching fluoroscopic-guided lumbar puncture</td>
<td>2.0 (1.5-2.5)</td>
<td>4.0 (3.0-5.0)</td>
<td>0.004693</td>
</tr>
</tbody>
</table>

*(5-point Likert scale with 1 = strongly disagree to 5 = strongly agree)
† Median (IQR)
‡ Two-sample sign test

A Grading System for Assessing the Outcome of Treatment in Lymphatic Malformations of the Head and Neck

S Manna¹, D Bageac², K Nael³, A DOSHI⁴, R De Leacy⁵
¹Icahn School of Medicine at Mt. Sinai, New York, NY, ²Mount Sinai Hospital, New York, NY, ³Icahn School of Medicine at Mount Sinai Hospital, New York, NY, ⁴MOUNT SINAI ICAHN SCHOOL OF MEDICINE, NEW YORK, NY, ⁵Icahn School of Medicine at Mount Sinai, NEW YORK, NY
Purpose
Two-thirds of lymphatic malformations (LMs) in children are found in the head and neck. Symptoms include asymptomatic neck swelling, recurrent infection, dysphagia, apnea, and dyspnea. Though conventionally managed through surgical resection, percutaneous sclerotherapy has recently gained popularity due to its minimally invasive nature. Considering these trends, a standardized system of reporting outcomes is warranted to evaluate the efficacy of these treatments. However, no reproducible grading system has been designed to compare postoperative outcomes on the basis of radiological findings. We are proposing a scale using contrast enhanced MRI to assess response to treatment. The purpose of this study is to evaluate the inter-rater reliability of our proposed scale.

Materials and Methods
A proposed grading system was developed on the basis of interval changes on MRI protocol (Figure 1). Using this system, 41 consecutive cases from our institution with formally diagnosed head and neck LMs from 2005 to 2016 were retrospectively graded. Each patient had been treated with fluoroscopically guided percutaneous sclerotherapy and had received both pre- and post-treatment MRI to assess individual response to therapy. Each study was assessed and the response to treatment graded in an independent and blinded fashion by 3 experienced neuroradiologists. All differences in opinion were resolved with consensus. Inter-rater reliability was assessed using Krippendorff's α statistic, intraclass coefficient, and two-way Spearman's ρ correlation.

Results
The overall Krippendorff's α statistic was calculated to be 0.8641 (95% CI: 0.81-0.91), denoting excellent agreement among raters when the ratings were treated as ordinal variables. Both intraclass coefficients with respect to consistency and absolute agreements were 0.928 (95% CI 0.88-0.96), illustrating low variability of raters grading the same MRI with respect to overall variation. With respect to two-way Spearman's ρ correlation, every combination of individual rater pairs demonstrated statistically significant (p<0.01) linear correlations with values ranging from 0.823 to 0.907.

Conclusions
In light of the results of the present study, we recommend the use of this simple and reproducible scale to grade the response of head and neck LMs to therapy. It is our hope that the adoption of this new scale will standardize reported outcomes in LM therapy and prompt further inquiry into the question regarding optimal management.

Table 1: A Grading System for Assessing the Outcome of Treatment in Lymphatic Malformations

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Complete regression/disappearance of the lesion on cross sectional imaging</td>
</tr>
<tr>
<td>2</td>
<td>Near-complete disappearance of the lesion on cross sectional imaging</td>
</tr>
<tr>
<td>3</td>
<td>Decrease with &lt; 50% estimated volume of residual malformation</td>
</tr>
<tr>
<td>4</td>
<td>Decrease with &gt; 50% estimated volume of residual malformation</td>
</tr>
<tr>
<td>5</td>
<td>No gross interval changes or minimal change</td>
</tr>
<tr>
<td>6</td>
<td>Decrease in the malformation in one region with progression in another non-treated area</td>
</tr>
<tr>
<td>7</td>
<td>Worsening of imaging findings</td>
</tr>
<tr>
<td>8</td>
<td>Granulation in treatment bed</td>
</tr>
</tbody>
</table>

(A and B show pre- and post-sclerotherapy axial MRI images, respectively. This demonstrates a representative example of a Grade 1 response.)

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A Simple Composite Degenerative Disease Severity Score Predicts Interpretation Time for Lumbar Spine MRI

M Caton¹, W Wiggins², S Pomerantz³, K Andriole⁴
¹University of California, San Francisco, San Francisco, CA, ²Duke University Hospital, Durham, NC, ³MGH, Boston, MA, ⁴MGH and BWH Center for Clinical Data Science, Boston, MA
Purpose
Degenerative disease of the lumbar spine is a major public health concern and a significant burden in terms of both quality of life and econometrics [1]. The decision to pursue surgery or nonoperative management is complex but is heavily influenced by imaging findings, particularly lumbar MRI (LMRI) [2]. Accurate radiologist interpretation is important for clinical decision making [3]. Improving the quality and efficiency of LMRI reporting is therefore of great clinical significance across the spectrum of degenerative disease. The purpose of this investigation is to understand the relationship between image interpretation/reporting time and estimated severity/complexity of degenerative disease. We predict that cases with higher severity score will require a greater interpretation/reporting time.

Materials and Methods
Applying a custom automated NLP-algorithm to the radiologist report, we extracted stenosis severity at 3 sites (spinal canal and bilateral neuroforamina) per level for the 6 levels typically included in LMRI. (Fig 1A). Severity was ranked on a 6-point scale (0 = Normal/No stenosis, 1= mild, 2 = mild-moderate, 3 = moderate, 4 = moderate-severe, 5 = severe). For each study, this resulted in an 6x3 matrix from which a composite (summed) score (CSS) of the severity matrix was calculated. Reporting (interpretation) time was calculated as the difference between timestamps for creation and finalization of the radiology report as documented by the institution's reporting software.

Results
A total of 13,388 LMRI reports from a single academic center between 2007-2017 were included for the study. Studies with reporting times of > 60 minutes or studies interpreted with trainee-assistance were excluded from analysis due to different workflows. We identified a modest positive correlation (Correlation coefficient = 0.23, R2 = 0.05, p < 0.001) between the CSS and reporting time for LMRI interpreted without trainee-assistance. Mean reporting times vs. severity score are shown in Fig 1B. A univariate model showed that each increment in the CSS was associated with increase in reporting time by 0.32 min. Using this model, the predicted interpretation time increased by 50% for a CSS of 18 relative to a healthy spine (CSS=0).

Conclusions
We observed a positive correlation with composite score of degenerative disease severity. In conjunction with AI-based predictors of disease severity, this observation can guide workflow decisions, staffing, and resource allocation.

Access to Endovascular Thrombectomy in Manitoba (Canada): Can We Improve The Time From Onset To Groin Puncture (OTG)?

y yan1, S Ande1, E Ghirooda1, A Trivedi1, K Faiz1, J Shankar1
1University of Manitoba, Winnipeg, Manitoba

Purpose
The intra-arterial endovascular thrombectomy (EVT) significantly improve the outcome of patients with acute ischemic stroke with large vessel occlusion (LVO) in a time sensitive manner. The prolonged times to access EVT may reduce benefits for eligible patients. Therefore, we searched for ways to improve services affecting time of onset to groin puncture for endovascular thrombectomy in Manitoba.

Materials and Methods
In this retrospective cohort study, data were collected retrospectively over 8 year period (2012-2019). Two areas in the Winnipeg were defined: Group A- health areas primarily covered by comprehensive stroke Center (CSC) where patients underwent CTA followed by EVT treatment; Group B- areas primarily covered by primary stroke center (PSC) in the city with only CTA and no EVT service. Three areas in the province were defined: Group I- health areas in the Winnipeg where CSC is located; Group II- PSC located <1 hr
drive distance from Winnipeg; Group III- PSC located >1 hr drive distance. For EVT efficiency, onset to groin puncture (OTG) time and onset to CTA (OTC) time were compared among above groups using t-test and Mann-Whitney test.

Results
In Manitoba, 273 patients with ischemic stroke and large vessel occlusions either presented at CSC or transferred from PSC to CSC from 2012-2019. 2% percent (n=6) were unsuitable for EVT due to poor groin access and 267 patients (98%) were eligible for EVT. Among 199 Patients (74.5%) from Winnipeg, Group A has more efficient OTG (n=159, 146 minutes, 95% CI [124–234], P<0.001) compared to Group B (n=40, 286minutes, 95% CI [159-440]), while OTC remained similar between the groups (P=0.34). At provincial level, OTG was 20 minutes longer in group II (188 minutes [151–216], n=43, P=0.32), but 276 minutes longer in group III (444 minutes, 95% CI [354–534], n=34, P<0.001) compared with group I (168 minutes [149–196], n=190). OTC was 4 minutes longer in group II (88minutes [56–120], P=0.82) but 60 minutes longer in group III (144 minutes [110–348], P<0.001) compared with group I (84 minutes [66–116]).

Conclusions
Rapid reperfusion with EVT from areas <1 hr drive distance from CSC was delayed by longer OTG time rather than OTC time. However, patients from areas >1 hr drive distance from CSC had significant longer OTG as well as OTC time. This data provide valuable insights into our existing provincial stroke protocol. Modification in the stroke protocol to bring patients directly to CSC in areas <1 hr drive distance may help significantly reduce OTG time.

(Filename: TCT_2557_Picture3.jpg)

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Application of Deep Learning to the Diagnosis of Cervical Lymph Node Metastasis from Thyroid Cancer with CT: External Validation and Clinical Utility for Resident Training

E Ha¹, J Park²
¹Ajou University Medical Center, Suwon, Korea, Republic of, ²Ajou University School of Medicine, Suwon, Suwon

Purpose
This study aimed to validate a deep learning model's diagnostic performance in using computed tomography (CT) to diagnose cervical lymph node metastasis (LNM) from thyroid cancer in a large clinical cohort and to evaluate the model's clinical utility for resident training.

Materials and Methods
The performance of eight deep-learning models was validated using 3,838 axial CT images from 698 consecutive patients with thyroid cancer who underwent preoperative CT imaging between January and August 2018 (3,606 and 232 images from benign and malignant lymph nodes, respectively). Six trainees viewed the same patient images (n = 242) and their diagnostic performance and confidence level (five point scale) were assessed before and after computer-aided diagnosis (CAD) was included.

Results
The overall area under the receiver operating characteristics (AUROC) of the eight deep-learning algorithms was 0.846 (range: 0.784–0.884). The best performing model was Xception, with an AUROC of 0.884. The diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of Xception was 82.8%, 80.2%, 83.0%, 83.0%, and 80.2%, respectively. After introducing the CAD system, underperforming trainees received more help from artificial intelligence than the higher performing trainees (P = 0.046), and overall confidence levels significantly increased from 3.90 to 4.30 (P < 0.001).
Conclusions
The deep-learning-based CAD system used in this study for CT diagnosis of cervical LNM from thyroid cancer was clinically validated with an AUROC of 0.884. This approach may serve as a training tool to help resident physicians to gain confidence in diagnosis.

Automated Curation of Brain MRI Annotations Using Deep Learning to Unlock Future Automated Brain Tumor Segmentation

J Kim1, T Thomas2, R Young3, K Juluru3, A El-Roweim3, P Elhajjar3, Y Choi3, R Moreno3, N Swinburne3
1Weill Cornell Medical College, New York, NY, 2CUNY School of Medicine, New Hyde Park, NY, 3Memorial Sloan Kettering Cancer Center, New York, NY

Purpose
Radiologists annotate images during routine clinical work. PACS archives may contain many such annotations, which can be mined
and leveraged as training data for computer vision tasks such as lesion recognition or segmentation, overcoming the rate-limiting need for manual data labelling. However, some existing clinical annotations are irrelevant for training (e.g. mis-clicks, non-lesion findings) and must be filtered out. We hypothesized that we could train a deep learning model to automatically classify mined brain MRI line annotations as non-tumor or tumor-containing in preparation for downstream use as training data.

Materials and Methods
Over 400 de-identified axial T1 post-contrast brain MR images and corresponding clinical line annotations were imported into a research computing system. Line annotations were squared to form bounding boxes, which were overlaid on the referenced images and classified as non-tumor or tumor-containing by a neuroradiologist. These images and labels were utilized as training data for a VGG-16 classifier after being randomly split into training (60%), test (20%), and validation (20%) subsets. To combat class imbalance, a combination of image augmentation, image cropping, class weight adjustments, and oversampling were investigated. The Matthews Correlation Coefficient (MCC) was computed to compare iterations and guide model fine tuning.

Results
Applying standard augmentation methods was superior (MCC=0.3052) to no-augmentation (MCC=0.2130). Automatically computing class weights (MCC=0.2574) was better than manually setting class weights (MCC=0.1528). Cropping images around their bounding boxes (MCC=0.6743) was superior to not-cropping (MCC=0.0851). Random oversampling of non-tumor annotations (MCC=0.6743) was superior to SMOTE (MCC=0.2153). No horizontal flipping nor zoom (MCC=0.7754) was better than any combination of flips and zooms (MCC 0.5399 to 0.6892). The final optimized model had a predictive performance (MCC=0.7754) superior to the unmodified VGG-16 model (MCC=0.2130).

Conclusions
Image augmentation, random oversampling, cropping images around bounding boxes, and auto-computing class weights can vastly improve a deep learning model's ability to classify radiologic image annotations as non-lesion or lesion-containing. These methods represent important potential components of a curation pipeline for transforming large-scale, noisy clinical annotations into training data for radiology computer vision tasks.
Back to the Drawing Board: Evidence that Advanced Motor Cortex Pathology in Amyotrophic Lateral Sclerosis causes Whole Brain Systemic Effects

A Wang\textsuperscript{1}, S NIOGI\textsuperscript{2}
\textsuperscript{1}Weill Cornell Medicine, New York, NY, \textsuperscript{2}Department of Radiology, Weill Cornell Medicine, New York, NY

Purpose
Recent studies have demonstrated that excessive oxidative stress in motor neurons due to iron accumulation in the motor cortex (MC)
results in loss of white matter (WM) microstructural integrity along the pyramidal tract in amyotrophic lateral sclerosis (ALS). While ALS is classically considered a disease restricted to the motor system, we examined potential systemic manifestations by measuring WM integrity and iron accumulation using diffusion tensor imaging (DTI) and quantitative susceptibility mapping (QSM) throughout the brain to provide greater insights into ALS pathophysiology.

Materials and Methods
ALS and age/sex-matched control MRI exams were identified in a preexisting institutional database. WM integrity was estimated from DTI fractional anisotropy (FA) values in 23 regions throughout the brain using the Reproducible Objective Quantification Scheme. Iron deposition was measured on QSM using manual tracing in all 23 regions and bilateral MC. Control FA values were used to compute Z-scores. Associations between FA Z-scores and iron concentrations were performed using non-parametric Spearman-Rho correlations.

Results
40 ALS (mean age 63±9, 16 F) and 35 controls were obtained. Increasing MC iron deposition was significantly associated with increased iron deposition in 20 regions after controlling for multiple comparisons (p<0.002, all 23 regions p<0.005). In the centrum semiovale, decreased WM integrity was associated with iron concentration (right p=0.124 R=0.434, left p=0.007 R=0.520). Additionally, increased FA in the presence of increased iron deposition was identified in frontal WM pathways (right uncinate fasciculus p=0.009, R=0.407, genu of corpus callosum, p=0.008, R=0.412).

Conclusions
Iron accumulation outside the MC may reflect unrecognized systemic effects of ALS. Decreased WM integrity in motor neurons and increased WM integrity in frontal WM pathways may reflect pathologic mechanisms from oxidative stress and preservation of higher order cognitive domains.

![Figure 1](TCT_1482_Figure1.jpg)
Bleomycin sclerotherapy in the treatment of ranulas: A case series and review of the literature

S Manna¹, D Bageac², R De Leacy³
¹Icahn School of Medicine at Mt. Sinai, New York, NY, ²Mount Sinai Hospital, New York, NY, ³Icahn School of Medicine at Mount Sinai, NEW YORK, NY

Purpose
A ranula is a mucus-filled salivary pseudocyst that forms in the floor of the mouth, commonly arising from the sublingual or submandibular salivary glands following obstruction or trauma. Complete excision is currently considered the first-choice therapy but has the potential for complication related to rupture and damage to nearby structures. As such, minimally invasive approaches such as percutaneous sclerotherapy have been investigated. While ethanol and OK-432 therapy have been the most reported sclerosants in the literature, bleomycin has recently shown promise as a sclerosing agent. We aim to contribute to the literature by assessing the efficacy and safety of our technique through our experience with 18 patients over the last decade.

Materials and Methods
This retrospective study evaluated 18 patients with intraoral and plunging ranulas treated by percutaneous bleomycin ablation between January 2009 and September 2019. Treatment outcome was assessed in 18 patients followed for at least 6 months. The primary endpoint was treatment result which was stratified into three groups--complete resolution, partial resolution, or recurrence. Secondary endpoints included bleomycin dosage and complications. The Chi Square and Kruskal Wallis tests were used for comparison of the factors according to the outcome.

Results
The study evaluated 12 males and 6 females with a median age of 23.5 years (range, 13–39 years). At a final follow-up of at least 2 months (6.5 ± 5.5 months), 4 patients demonstrated complete response (22%), 2 patients demonstrated partial response (16%), and 11 patients demonstrated recurrence or regrowth of the lesion (61%). There were no statistically significant associations between outcomes and history of prior treatment, number of treatments, lesion size and type of ranula. No complications were noted.

Conclusions
Our findings indicate that bleomycin, while effective and safe for use in various head and neck malformations, may be ineffective in the treatment of ranulas, especially when compared to other sclerosants reported in the literature. Promising future directions include cohort studies in which bleomycin and/or other sclerosants are injected not only into ranula cysts but also the offending gland, similar to the surgical paradigm. If recurrence and complications rates are low, this could represent a powerful technique for interventional radiologists in the treatment of ranulas.
Correlation of Baseline NLR and CTP Imaging Selected Patients with Large Vessel Occlusion Ischemic Stroke

M Aly\(^1\), R Abdalla\(^1\), M Potts\(^2\), M Hurley\(^3\), A Shaibani\(^4\), S Ansari\(^3\)

\(^1\)Northwestern University, Chicago, IL, \(^2\)Northwestern University - Feinberg School of Medicine, Chicago, IL, \(^3\)Northwestern University Feinberg School of Medicine, Chicago, IL, \(^4\)Northwestern University Feinberg School of Medicine, Chicago, IL

Purpose
Neutrophil-Lymphocyte Ratio (NLR) is an inexpensive biomarker to assess inflammation in various diseases. Cerebral infarction results in an inflammatory response with pro-inflammatory chemokines, activating leukocytes for trans-endothelial migration to ischemic tissue. Meta-analyses have suggested baseline NLR is a promising predictor of ischemic stroke clinical outcome (1). We studied the relationship of baseline NLR parameters in patients with large vessel occlusion (LVO) stroke that underwent CTP imaging selection prior to endovascular treatment (ET).

Materials and Methods
We reviewed our prospective stroke intervention database from Nov 2015 to June 2019 for patients that underwent ET for LVO with an admission NLR. Patients were excluded from the study if they had history of corticosteroid use or infectious/systemic disease prior to stroke. We studied patient demographics, risk factors, NIHSS on admission, imaging data (ASPECTS, CTP with RAPID analysis of

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(A, C) Initial T2-weighted MRI shows a 5.8 x 3.0 x 2.4 cm plunging ranula (arrows) in the right submandibular space on coronal and axial imaging.
(B, D) Follow-up T2-weighted MRI obtained 1 year after bleomycin sclerotherapy depicts total shrinkage of the plunging ranula.
rCBF < 30%, Tmax > 6s, and mismatch ratio), and 90 day clinical outcomes (mRS). Statistical analysis was performed with SPSS version 17, univariate analysis was conducted between age, NLR, NIHSS, data from imaging and mRS using correlation coefficient.

Results
Seventy-eight patients met inclusion criteria (mean age, 67 ± 19; F:39%, mean NIHSS, 17 ± 6), with majority anterior circulation LVO (n=74/95%). A significant positive correlation between NLR and core infarction volume (rCBF<30%) was identified (p=0.046), with a negative correlation control between ASPECTS and rCBF<30% (p=0.035). There was no correlation between NIHSS and ASPECTS (p=0.94) or rCBF< 30% (p=0.83), but a trend toward significance with Tmax>6s, or the total volume of ischemic tissue (p=0.09). Predictably, in this cohort of CTP selected patients with favorable core infarct volumes (mean 22.6 ± 24.9 cc) NLR did not correlate with 90-day mRS (p=0.703), since all patients underwent ET with high rates of recanalization.

Conclusions
NLR is an inexpensive and readily available biomarker that correlates with CTP predicted core infarction volume in LVO ischemic stroke. However, in CTP selected patients with relatively small core infarct volumes, NLR may not predict 90 day mRS as endovascular treatment salvages ischemic tissue, minimizes final infarct volume, and suggests follow-up NLR may be more valuable predictor of clinical outcome.

CT Perfusion for Acute Ischemic Stroke: An Institutional Experience of Implementing a Low Cardiac Output Acquisition Protocol

S Moran, J Hartman, J Sharp, M Mossa-Basha

Purpose
To develop and evaluate the performance of a CT perfusion (CTP) protocol that would adequately avoid truncation of time-density curves in patients with low cardiac output.

Materials and Methods
Patients with acute stroke who underwent CTP with RAPID (iSchema-View, Menlo Park, CA), were retrospectively reviewed. Initially, our institution used a standard CTP protocol with a 5 second delay after contrast injection followed by a 60 second imaging acquisition phase. Our low cardiac output (LCO) protocol, introduced in 2018, included a scan delay of 7 seconds followed by a 75 second imaging acquisition window. Selection of the standard or LCO protocol was determined by the patient's test dose enhancement peak. For cases with an enhancement peak of 15 seconds or less, the standard CTP protocol was selected; whereas, the LCO protocol was used for peaks greater than 15 seconds. RAPID output data was evaluated for technical adequacy. Studies with technical limitations were excluded. Time-density curves (TDC) were assessed for early truncation. Studies in which the TDCs main maintained a negative slope or did not reach a baseline were considered to have early truncation. Echocardiography data was reviewed, and patients with an ejection fraction less than 50% were considered to have reduced ejection fraction (rEF).
Results
Between 9/14/17 and 5/20/18, 210 patients underwent the standard protocol. Of these, there were 12 non-diagnostic cases (5.7%) due to early truncation of the TDCs (Table 1). Between 5/21/18 and 6/30/19, after LCO protocol introduction, 222 CTP studies for acute stroke were performed. Of these, there were 6 cases (2.7%) with early truncation. Of note, 5 of the 6 cases with early truncation underwent the LCO protocol; however, only 2 cases had documented rEF. Prior to introducing the LCO protocol, 27 rEF patients underwent the standard protocol. Of these, there were 5 non-diagnostic cases (18.5%) due to early truncation of the TDCs (Table 2). After the introduction of the LCO protocol, 31 rEF patients underwent the low CO protocol. Of these, there were 2 cases (6.5%) with early truncation. Of note, 6 rEF patients during this period did not undergo the LCO protocol, and none of these patients had early truncation.

Conclusions
Patients with a delayed enhancement peak can be selected to undergo a LCO CTP protocol, thus reducing the number of exams with early truncation and resultant inaccurate CTP results, while keeping radiation dose as low as reasonably achievable for other patients.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Low Cardiac Output Protocol</th>
<th>Post-Low Cardiac Output Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Exams</td>
<td>210</td>
<td>222</td>
</tr>
<tr>
<td>Exams with Early Truncation</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Early Truncation Percentage (%)</td>
<td>5.7</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Table 1. Early truncation pre- and post-implementation of a low cardiac output CTP protocol.*

<table>
<thead>
<tr>
<th></th>
<th>Pre-Low Cardiac Output Protocol</th>
<th>Post-Low Cardiac Output Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Exams for rEF Patients</td>
<td>27</td>
<td>31</td>
</tr>
<tr>
<td>Exams with Early Truncation</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Early Truncation Percentage (%)</td>
<td>18.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

*Table 2. Early truncation in rEF patients pre- and post-implementation of a low cardiac output CTP protocol.*

Deep-learning based Significant Stenosis detection from Multi-planar Reformatted Images of traced Intracranial arteries

K Han¹, L Chen², D Geleri², M Mossa-Basha², T Hatsukami², C Yuan²
¹Fudan University, Shanghai, China, ²University of Washington, Seattle, WA

Purpose
To automatically detect significant intracranial artery stenosis in Computed Tomography angiography (CTA) images.

Materials and Methods
Figure 1 shows our overall pipeline. Centerline Extraction We adopted a skull-stripping method[1] to extract brain regions from CTA images and trace arteries of interest using iCafe[2]. To reduce spurious branches or fragments, we designed an optimizing algorithm based on the intensity, direction, and length of the artery. Manual editing is then performed to ensure tracing quality. Stenosis Classification Network The centerline is partitioned into segments, and a set of MPR views for each one is generated by Multi-planar reformation[3]. A deep-learning neural network (shown in Figure 2) is built to classify a single MPR view into significant or non-significant stenosis. (significant stenosis: luminal narrowing≥50%) Then, for each vessel segment, we classify each of the six MPR views with this network. A voting mechanism is used: if equal or more than N MPR views of the segment were classified as stenosis (N as voting number), this segment is considered stenotic. Figure 3 shows our classification framework. Our model can also be used for MRA images. Dataset We evaluated our method with a dataset of clinical intracranial CTA scans of 15 patients (20 significant)
and MRA scans of 15 patients (23 significant). We focused on the non-calcified stenosis in the main arteries (MCA, ACA, BA, and PCA). Our training dataset contains a total of 5784 MPR views from 964 artery segments with augmentation. Each slice of the MPR volume was labeled by two experienced radiologists. We trained the stenosis detection model using different data settings. (Metrics: sensitivity, specificity, and accuracy. Positive: with stenosis. Negative: without stenosis). We also evaluated the detection performance with voting number from 1 to 6 on the CTA/MRA combined dataset.

Results
The results are shown in Figure. 4. Table 1 illustrates the classification performance of our proposed network tested with different data settings. The best result is achieved when CTA and MRA images are combined. Table 2 shows the performance of our framework under different voting numbers.

Conclusions
In this study, we present a deep-learning based framework for automatic ICA stenosis detection using Multi-planar reformatted(MPR) CTA images and introduce MRA images to better leverage the multi-modality data for developing a more generalized and robust model.

Depletion of Neuromelanin: Visual Rating Scale and its Diagnostic Performance

N Shin¹, Y Nam¹, Y CHOI², J Jang¹, J Yoon³, B Kim¹, K Ahn¹
¹SEOUl ST. MARY's HOSPITAL, Seoul, Korea (the Republic of), ²SEOUl ST. MARY's HOSPITAL, SEOUL, Korea, Republic of, ³Seoul St. Mary's Hospital, Seoul, Korea (the Republic of).

Purpose
The pathological hallmark of Parkinson's disease is the progressive loss of neuromelanin (NM) containing dopaminergic neurons in the substantia nigra (SN). Although MRI techniques for detecting NM have been introduced, lack of criteria for diagnosing NM
depletion is one of the biggest obstacles to clinical application. Therefore, we aimed to suggest a qualitative rating scale for diagnosing NM depletion and to compare the NM depletion detected on MRI and the nigrostriatal dopaminergic degeneration revealed by dopamine transporter (DAT) imaging.

Materials and Methods
Twenty-nine patients with parkinsonian symptoms who underwent both simultaneous nigrosome and NM imaging and DAT imaging were recruited. NM was considered "intact" when the hyperintense structures on NM imaging had (1) ventral and lateral convexity with (2) clear margin and (3) preserved dorsolateral signal intensity equally to ventromedial aspect; and "possibly reduced" and "definitely reduced" when they did not meet one and at least two of the three criteria, respectively. Two neuroradiologists independently evaluated the NM appearance and disagreements were settled by consensus. Diagnostic performances of the NM appearance for predicting the DAT imaging findings and degenerative parkinsonism were calculated.

Results
Among 29 patients, 20 patients had degenerative parkinsonism (17 PD, 2 atypical parkinsonism, 1 dementia with Lewy bodies). Nine had non-degenerative parkinsonism or other neurodegenerative disease (2 normal pressure hydrocephalus, 1 cerebellar ataxia, 1 drug induced parkinsonism, 1 essential tremor, 2 Alzheimer's dementia). For predicting impaired nigrostriatal dopaminergic function on DAT imaging, the sensitivity (SN), specificity (SP), positive predictive value (PPV), and negative predictive value (NPV) of any reduced NM on MRI was 97.7%, 85.7%, 95.6%, and 92.3%, respectively. For predicting degenerative parkinsonism, the SN, SP, PPV, and NPV was 100%, 66.7%, 87.0%, and 100%, respectively. Interobserver agreement for diagnosis of any reduced NM on MR was almost perfect (k = 0.838).

Conclusions
NM depletion could be diagnosed on MRI using a qualitative visual assessment with high diagnostic accuracy for predicting degenerative parkinsonism and nigrostriatal dopaminergic function. In this study, we suggest a visual rating scale for diagnosing NM depletion on MRI which could be easily to use in clinical practice.

1966

Diagnostic benefit of repeated FNA according to US patterns in low risk thyroid nodules initially diagnosed as atypia/follicular lesion of undetermined significance

W Paik1, D Na1
1Gangneung Asan Hospital, Gangneung-si, Gangwon-do

Purpose
To determine the diagnostic benefit of repeated fine-needle aspiration (RFNA), according to the US patterns in thyroid nodules initially diagnosed as atypia/follicular lesion of undetermined significance (AUS/FLUS).

Materials and Methods
This study included 273 consecutive nodules in which follow-up RFNA was performed among 502 thyroid nodules (≥1 cm) initially diagnosed as AUS/FLUS from January 2010 to December 2014. The diagnostic benefit of obviating unnecessary diagnostic surgery was determined when the RFNA cytology result was benign. We assessed the rate of diagnostic benefit, surgery decision (RFNA result of category 4, 5, 6), and conclusive diagnostic result (RFNA result of category 2,4,5,6) on RFNA according to US patterns of nodules defined by Korean Thyroid Imaging Reporting and Data System (K-TIRADS).

Results
The diagnostic benefit of benign RFNA result was found in 49% in K-TIRADS 3, 37.8% in K-TIRADS 4, and 28% in K-TIRADS 5 nodules, and there was a decreasing trend of the diagnostic benefit rate on RFNA with increasing K-TIRADS score (P=0.034). The surgery decision was made in 3.4% in K-TIRADS 3, 11.2% in K-TIRADS 4, and 28% in K-TIRADS 5 nodules (P<0.001). There was no difference of conclusive RFNA results among K-TIRADS scores (p=0.773). The AUS/FLUS subcategory and nodule size was not significantly associated with the diagnostic benefit of RFNA. The false negative rate of benign cytology result of the first RFNA was 1.7%~2.3% according to the criteria of final benign diagnosis.

Conclusions
The diagnostic benefit of RFNA to obviate unnecessary surgery was found at least 28% in initially diagnosed AUS/FLUS nodules. Therefore, repeated biopsy may be helpful to reduce the unnecessary diagnostic surgery even in AUS/FLUS nodules with high suspicion (K-TIRADDS 5) US pattern.
Endovascular Management of Persistently Bleeding Oropharyngeal Tumors: Experience at a Tertiary Care Neurovascular Center

M. Cox¹, N. SEDORA-ROMAN², B. Pukenas¹
¹Hospital of the University of Pennsylvania, Philadelphia, PA, ²HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA

Purpose
Oropharyngeal bleeding is a known complication of oropharyngeal tumors, particularly after chemoradiation. Bleeding from these tumors can be difficult to treat conservatively, and surgical options are limited by prior radiation and decreased mouth opening. As such, neurointerventionalists are often consulted for hemostasis [1]. In this abstract, we detail our experience using endovascular therapy for hemostasis in patients with persistently bleeding oropharyngeal tumors.

Materials and Methods
After IRB approval, a retrospective review of our imaging and medical record database was performed.

Results
Embolization of bleeding oropharyngeal tumors was performed in 25 patients. All the tumors referred for embolization were...
refractory to conservative hemostatic measures and poor surgical candidates. Transfemoral arterial access was obtained in all cases. The most common artery involved was the lingual artery, followed by the facial artery. 150-250 micron particles were used in the vast majority of cases (96%), with coils and Onyx used in the remainder. At the end of embolization, there were no further episodes of bleeding. One patient had recurrent bleeding 4 months after embolization, due to tumor progression. There was an intraprocedural perforation of a lingual artery branch in one patient, which was embolized successfully. There were no other complications, including no stroke or blindness.

Conclusions
Endovascular embolization of bleeding oropharyngeal tumors is safe and effective. In some patients, it may be the only lifesaving option.

55M with persistent oropharyngeal Bleeding

![CTA neck showed a necrotic right base of tongue mass, previously irradiated. Microcatheter injection of the right lingual artery showed a small pseudoaneurysm of the distal lingual artery. This was successfully embolized with 150-250 micron particles, with immediate cessation of bleeding. There were no complications, and the patient had no further episodes of bleeding.](TCT_2660_ENTTumorEmbo.gif)

1917

**Entropy of Posterior Fossa Pediatric Brain Tumors on T1 weighted MRI images**

P Tang

1KK Women's and Children's Hospital, Singapore, Singapore

Purpose
To evaluate the entropy of malignant and benign posterior fossa pediatric brain tumors on pre and post contrast T1 weighted MRI images using TexRad.

Materials and Methods
Annonymised pediatric posterior fossa tumors consisting of 11 malignant and 2 benign pediatric brain tumors were used in this pilot project. Single operator manually outlined tumor as the region of interest on the axial pre and post contrast T1 images with largest tumor cross section. Separate regions of interest were used to demarcate normal cerebellar tissue on the same axial pre and post contrast T1 weighted MRI images. Texture entropy values ratios of tumor to normal tissue were generated across all filters (SSF 0,2,3,4,5,6) using commercially available TexRad software. Entropy ratios more than 1 indicate tumor is more heterogenous than normal tissue.

Results
On pre contrast T1 weighted sequences, Entropy ratios of low grade tumors exceed 1 across all filters (ranging from 1.26+/-0.01 to 1.39+/-0.15). Entropy ratios of high grade tumors exceed 1 across all filters (ranging from 1.33+/-0.10 to 1.44+/-0.09). Entropy ratios of high grade tumours are higher than those of low grade tumours across all filters on pre contrast T1 weighted MRI images (differences range from 0.03 to 0.09). On post contrast T1 weighted sequences, Entropy ratios of low grade tumors exceed 1 across all filters(ranging from 1.10+/-0.44 to 1.37+/-0.12). Entropy ratios of high grade tumors exceed 1 across all filters (ranging from 1.48+/-0.13 to 1.52+/-0.14). Entropy ratios of high grade tumors are higher than those of low grade tumours across all filters on post contrast T1 weighted MRI images (differences range from 0.15 to 0.39). The differences in entropy ratios between high and low grade tumours are higher on postcontrast T1 images than on precontrast T1 weighted images across all filters.

Conclusions
Entropy values of high grade tumours are higher than those of low grade tumours across all filters on pre and post contrast T1
weighted MRI images. The differences in entropy ratios between high and low grade tumours are higher on postcontrast T1 images than on precontrast T1 weighted images across all filters.

1671

Expeditied Communication of CT Results to Stroke Service Using a Shared Messaging Application: Our Experience

C Sanchez¹, A Su¹, A Prater¹, J O'Keefe¹, M Zygmont¹, R Peterson¹
¹Emory University School of Medicine, Atlanta, GA

Purpose
At our institution, timely communication of acute stroke protocol CT results to the stroke team have historically been hampered by limited information in the electronic medical record at time of imaging, multiple zones in the Emergency Department, inconsistent or delayed responses to paging, and competing demands on the radiologist in a high-volume setting. The goal of our project is to assess the utility of a shared, HIPAA compliant messaging system, available as a smartphone application, for facilitating rapid notification of critical results.

Materials and Methods
In the summer and fall of 2018, we spearheaded an initiative to promote adoption among neuroradiology attendings and radiology residents of a messaging system already in use among members of the neurology stroke team and mobile stroke unit. A unique dictation template was created to document communication using this messaging system within the radiology report, distinct from the standard template for communication of critical findings. Following this, we collected data for the period of 1/1/2019-2/12/2019 to determine whether the messaging system decreased time elapsed between image acquisition and read-back, compared to communication via conventional channels (phone and paging).

Results
We identified 100 CTs using a filtered worklist, 70 with documented read-back. Use of the messaging system was noted on 23 cases (33%), with read-back time range of 0:12 to 1:09 (h:mm), greater than one hour for 3 cases (13%). For the remaining 47 cases, use of conventional channels resulted in a wider read-back time range of 0:11 to 2:52, greater than 1 hour for 16 cases (34%). Overall, use of the messaging system was associated with a 29% reduction in average read-back time. Of note, the system was adopted almost exclusively by attendings and used by a resident in only one documented instance.

Conclusions
Adoption of the messaging system by radiologists was associated with decreased average read-back time. We attribute this improvement primarily to a decreased number of very prolonged read-back times and to the ready availability of clinical information at time of imaging review. Our results suggest that the messaging system provides a means of circumventing systemic barriers in the stroke imaging communication workflow. Given this encouraging finding, our next step will be to identify barriers to adoption among residents in our training program, with the goal of maximizing usage and further decreasing average time to notification.

Figure: Read-back time, average and range, using shared messaging system versus conventional phone and paging (h:mm)

(Filename: TCT_1671_ASNR2020abstractfigure.jpg)
Factors and Health Outcomes Associated with Imaging Choice of Acute Ischemic Stroke Patients

J Wang1, A Boltyenkov2, G MARTINEZ3, J Katz4, A Hoang5, P SANELLI6
1Northwell Health, Mhasset, NY, 2Siemens Healthcareers, Mhasset, NY, 3SIEMENS HEALTHCAREERS, MANHASSET, NY, 4Northwell Health, Manhasset, NY, 5NORTHWELL HEALTH NSUH, MANHASSET, NY

Purpose
Acute ischemic stroke (AIS) presents an ongoing challenge for population health and availability of healthcare resources. Imaging plays a critical role in both diagnosis and treatment decisions in AIS, but optimal utilization regarding advanced imaging with angiography and perfusion using either CTAP or MRAP remain uncertain according to national guidelines. Although CTAP and MRAP each have unique benefits and risks in the AIS setting, the effect of this risk-benefit tradeoff on health outcomes and utilization of resources is unknown. This study analyses the factors associated with imaging preferences and the related health outcomes.

Materials and Methods
We performed a retrospective study on an AIS registry consisting of consecutive patients admitted to our institution from November 1, 2011, through October 1, 2018. Imaging and treatment selections and modified Rankin Score (mRS) at discharge were the main outcomes. Independent variables include age, gender, race-ethnicity, and NIH stroke score (NIHSS) at admission. Multivariable logistic regression models were performed. P<0.05 was considered statistically significant.

Results
1884 patients with curated imaging data during hospitalization were included. Among them, 32% were ≥80 years old, 47.4% female, 15.53% black, 60.3% white, and 24.4% with NIHSS≥10 at admission. CTAP and MRAP were performed in 21.1% and 72.2% patients, respectively. 46.1% received thrombolytics (IV-tPA), 1.3% had endovascular therapy (EVT), and 52.7% were not treated. The two clinical outcomes were independent functionality at discharge (mRS0-2) at 48.4%, and patients expired in hospital at 7.1%. Adjusted by all the factors, regression models showed that patients with NIHSS≥10 were more likely to receive CTAP (p<0.0001, OR=3.39) and less likely to receive MRAP (p<0.0001, OR=0.48); whereas age ≥80 was less likely to receive CTAP (p<0.0001, OR=0.37) or MRAP (p<0.0001, OR=0.37), NIHSS≥10 (p<0.0001, OR=0.15) and IV-tPA (p=0.0006, OR=0.69) were negatively related to independent functionality at discharge, and MRAP (p<0.0001, OR=1.97) was positively related to it. NIHSS≥10 (p=0.0212, OR=1.69) were positively related to mortality, while utilization of MRAP showed a negative relationship (p<0.0001, OR=0.26) with it.

Conclusions
Higher NIHSS was positively associated with mortality and utilization of CTAP, while it is negatively associated with MRAP. MRAP was positively related to independent functionality at discharge. Older age was negatively associated with CTAP or MRAP utilization.

Feasibility of Percutaneous Trans-Sacral Hiatus Puncture of the Lumbosacral Subarachnoid Cistern. An Initial Neuroimaging Morphometric Study

A Trinh1, S Hashmi2, T MASSOUD3
1Stanford University School of Medicine, Stanford, CA, 2N/A, N/A, 3STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose
Lumbar puncture (LP) is used to access the subarachnoid space (SAS) for cerebrospinal fluid withdrawal and injection of drugs or imaging agents. LPs can be challenging, and imaging guidance is often necessary. However, a standard fluoroscopic LP may be impossible in the presence of severely distorted lumbar spines or surgical hardware and fusion, e.g. in patients with spinal muscular atrophy (SMA) requiring intrathecal molecular therapy. There are few case reports of SAS spinal anesthesia via the sacral hiatus. Here we test the feasibility of image-guided percutaneous trans-sacral hiatus puncture and access to the lumbosacral SAS by initial morphometric analysis of the curvature of the sacral canal relative to the sacral hiatus (where needle enters) and the caudad end of the cistern (at SAS puncture). We hypothesized that relatively straight sacra might allow the unhindered passage of a standard spinal needle for SAS puncture.

Materials and Methods
We retrospectively analyzed lumbosacral spine midsagittal CT-myelogram images of 30 normal subjects. We digitally measured sacral curvature between S1 to S5 using two methods (a lower angle signifies a straighter sacrum). We also measured the midsagittal sacral canal surface area, the vertebral level of lumbosacral thecal sac termination, and the distance from sacral hiatus to the most caudal aspect of the thecal sac (dead space). We tested the effect of patient sex on the measured dependent variables using two-way ANOVA, and performed linear regressions with age against each of the dependent variables, with significance set at p<0.05.

Results
The study cohort comprised F:M=24:6 subjects, and a mean age of 40.2 years. The mean sacral curvature was 53.6°; only one patient had a sacral curvature >90°. Most sacral hiatuses were at the S4 level. The mean dead space was 53mm, and most thecal sac terminations were at low S1. These results did not differ significantly between sexes. There was a significant difference between the
mean sacral canal areas in both sexes (M=899.7mm2, F=698.3mm2, p=0.001). There were no significant correlations between age and sacral curvature, dead space, or surface area.

Conclusions
Despite sacral curvature, the combination of lower S1 thecal sac termination and a straight trajectory of the lower sacral canal points to the theoretical feasibility of percutaneous trans-sacral hiatus puncture and access to the lumbosacral SAS. We will extend this initial analysis to include SMA patients prior to clinical translation.

1125

IDH1 Mutation Prediction using MR-based Radiomics in Pretreatment Glioblastoma: Comparison between Manual Delineation and Fully Automated Deep Learning-based Approach of Tumor Segmentation

Y CHOI1, Y Nam2, J Jang2, N Shin2, K Ahn2
1SEOUL ST. MARY’S HOSPITAL, SEOUL, Korea, (Republic of), 2SEOUL ST. MARY’S HOSPITAL, Seoul, Korea (the Republic of)

Purpose
Isocitrate dehydrogenase-1 (IDH1) mutation status is an important prognostic marker of glioblastoma. This study aimed to determine whether MR-based radiomics of glioblastoma can predict IDH1 mutation and to compare predictive performances between manual and fully automatic deep-learning segmentations.

Materials and Methods
Sixty-one glioblastoma patients with pretreatment T2-weighted MRI were retrospectively collected and trained via a deep neural network (V-Net) (development set). An independent external cohort of 137 glioblastoma patients from the Cancer Imaging Archive was also included (test set 1, n=46; test set 2, n=91). Test set 1 was used to calculate dice similarity coefficients (DSC) between two segmentation methods. From test set 2, radiomics were extracted for IDH1 status prediction; then, relevant features were used to build receiver operating characteristics curves with areas under the curve (AUC). The AUCs from manual and V-Net segmentation were compared via likelihood ratio test.

Results
Among 152 patients, 17 patients (11.2%) had IDH1 mutations. Seven features (6.5%) showed significant differences between IDH1 mutation and wildtype. The mean DSC of test set 1 was 0.78±0.14 (range, 0.34-0.94). V-Net segmentation of the test set 2 yielded similar performance in predicting IDH1 mutation status compared to the manual segmentation (AUC=0.819 in V-Net vs. 0.834 in manual; P=0.393). The optimal cut-point of AUC yielded sensitivity and specificity of 77.1% and 87.5% for manual segmentation and 68.7% and 87.5% for V-Net segmentation.

Conclusions
V-Net showed robust glioblastoma segmentation capabilities as compared to the manually segmented reference; radiomics features extracted from V-Net yielded similar performance to those from manual segmentation in IDH1 prediction.
IMPACT OF TRANSFER STATUS ON THE CLINICAL OUTCOMES OF ACUTE STROKE PATIENTS TREATED WITH ENDOVASCULAR THERAPY

A Boltyenkov1, J Wang2, A MALHOTRA3, G MARTINEZ4, A Hoang5, J Katz5, P SANELLI6
1Siemens Healthineers, Manhasset, NY, 2Northwell Health, Manhasset, NY, 3YALE UNIVERSITY SCHOOL OF MEDICINE, NEW CANAAN, CT, 4SIEMENS HEALTHINEERS, MANHASSET, NY, 5Northwell Health, Manhasset, NY, 6NORTHWEST HEALTH NSUH, MANHASSET, NY

Purpose
It is unknown if bypassing primary stroke centers (PSC) in favor of EVT (mothership) produces better clinical outcomes than the transport to the nearest PSC for IV-tPA and then transfer to an EVT-capable center (drip-and-ship) for LVO patients. Our aim was to examine if the transfer status of EVT patients is associated with clinical outcomes.

Materials and Methods
We retrospectively analyzed 176 consecutive AIS patients with LVO (76 mothership and 100 drip-and-ship) admitted to our comprehensive stroke center from November 2011, though October 2018. The outcome variable was the modified Rankin Score (mRS) at 90 days to assess functional disability. Statistical analysis employed a multivariable logistic regression model, to compare the mothership and drip-and-ship groups; p<0.05 was considered statistically significant. Independent variables included SOT, NIHSS, age, transfer status, gender, race, ethnicity, diabetes, obesity, hypertension, dyslipidemia, TICI 2b-3, driving time to an EVT-capable center.

Results
Covariate analyses revealed that the mothership and drip-and-ship groups were not statistically different in the independent variables. Even though clinical outcomes at 90 days were better in the mothership group, with 36% (26/72) achieving functional independence (mRS 0-2) compared with 29% (29/99) in the drip-and-ship group, this difference was not statistically significant (OR=1.36, P=0.35). Subgroup analysis was performed among patients who received IV-tPA before EVT, mRS 0-2 was achieved in 36% (17/47) of mothership patients compared to 32% (23/72) of drip-and-ship patients, although this difference was not statistically significant (OR = 1.2, P=0.63). In the subgroup analysis of the EVT-alone patients, functional independence was more common in the mothership group 36% (9/25) compared to the drip-and-ship group 22% (6/27), although this difference was not statistically significant (OR = 1.97, P=0.28). After multivariable logistic regression, the predictive factors for favorable outcomes (mRS 0-2) were NIHSS at presentation (OR=0.85, P<0.0001), absence of diabetes (OR=7.16, P=0.005), and if driving time from stroke onset scene is within 12 minutes from the EVT-capable center (OR=5.69, P=0.043).

Conclusions
Our institutional data indicate that the transfer status had no impact on clinical outcomes of patients treated with EVT. Functional independence after EVT is associated with better NIHSS score, absence of diabetes, and proximity (<12 minutes drive) to EVT-capable center.

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1742

Increasing the Frequency of Hospital Pre-Alerts in Acute Stroke
Purpose
Stroke is the major cause of long-term disability in adults, and the second leading cause of death worldwide. The sending of a 'pre-alert' message in suspected stroke patients travelling to hospital via ambulance can significantly improve the timeliness of diagnosis and treatment. To implement a quality improvement plan in order to increase the number of pre-alerts from ambulance staff in cases of suspected stroke. Study the impact that increasing pre-alerts has on key stroke time metrics and compare these to targets set by our institution. Monitor the prevalence of pre-alerts in subsequent months to ensure the numbers are sustained. Targets: Door to CT in 15mins (admission to first CT brain imaging) Door to needle in <45mins (admission to treatment with thrombolysis) Door to decision in <30mins (admission to decision regarding thrombectomy).

Materials and Methods
The Dublin Fire Brigade (DFB) and the National Ambulance Service (NAS) were contacted, while education was arranged for Beaumont triage and Emergency Department (ED) staff regarding the importance of pre-alerts for FAST-positive patients. Data was prospectively collected on all FAST-positive calls originating in Beaumont Hospital. Details recorded include all key time metrics and radiological patient data. The results were presented at monthly FAST meetings, and circulated back to DFB, NAS and the ED department.

Results
A significant improvement can be seen in the stroke time metrics for pre-alerted patients compared to non-pre-alerted patients from March-September 2019 (Figure 1). A sustained number of pre-alerts were achieved during this period (Figure 2). We were able to achieve 2 out of 3 targets with the improved time metrics from pre-alerts.

Conclusions
Our audit cycles showed a dramatic improvement in key stroke time metrics corresponding to an increasing number of pre-alerts. Successful cooperation, education and regular audit will likely lead to improved clinical outcome for these patients with a debilitating condition. We will continue to audit our stroke data to monitor the implementation of our quality improvement plan. Future improvement plans will aim to increase pre-registered patients to further shorten time-to-imaging and treatment.

Figure 1

<table>
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<th>Door to CT (min)</th>
<th>Door to CTA (min)</th>
<th>Door to CTP (min)</th>
<th>Door to IV+rtPA (min)</th>
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Figure 2

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<tr>
<td></td>
<td>3%</td>
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2365

Intrathyroidal thymic tissue completely replacing a thyroid lobe
B Branstetter¹, J Lai²
¹UPMC, Wexford, PA, ²University of Pittsburgh School of Medicine, Pittsburgh, PA

Purpose
Ectopic thymus resulting from incomplete thymic descent is a well-described phenomenon. Residual thymic tissue can remain at any point along the path of descent from pharynx to anterior mediastinum. The most frequent site of ectopic thymus is along the inferior aspect of right thyroid lobe. When found in unusual locations, ectopic thymus may present a confusing radiologic appearance that can lead to an incorrect diagnosis or unnecessary surgery. Occasionally, ectopic thymus can arise within the thyroid gland itself, or even completely replace the thyroid. In this report, we present a case of intrathyroidal thymus in which the normal thyroid was completely replaced, mimicking an iodine-depleted thyroid (Figure 1, A and B). We also show complementary cases of ectopic thymus elsewhere in the neck (Figure 1, C and D).

Materials and Methods
N/A

Results
Case Report: A healthy 8-year-old male presented with palpable mass / asymmetry in the lower anterior neck. A thyroid mass was suspected clinically. Ultrasound was performed, which revealed asymmetry of the thyroid lobes, but no discrete mass. The patient then underwent MRI, which demonstrated asymmetric signal in the thyroid lobes. A contrast-enhanced CT showed no iodine content in the right thyroid bed, with tissue that mimicked the CT, MR, and ultrasound findings of the normal cervical thymus in the lower left neck. A diagnosis of ectopic thymus was made, and the patient was advised to follow up clinically.

Conclusions
Ectopic thymic tissue may be found within the parenchyma of the thyroid gland, where it can mimic a more concerning thyroid mass. It may alternatively replace an entire thyroid lobe, and mimic thyroiditis or malignancy. Ectopic thymic tissue may also be seen along the descent pathway of the fetal thymus, where it can mimic malignant lymphadenopathy. A high level of suspicion is needed to avoid overtreatment of these lesions, which will normally involute with time.
Neuroimaging in LVAD patients: Is a baseline Head CT necessary?

A Albar1, A Bansal1, D Ledet1, M Alhasan2, J Milburn1, A Steven1
1Ochsner Clinic Foundation, New Orleans, LA, 2Ochsner clinic foundation, New Orleans, LA

Purpose
Left ventricular assist devices (LVAD) can be a lifesaving intervention for heart failure patients, serving as a bridge to transplant or destination therapy. However, there are inherent risks associated with utilizing a mechanical circulatory support. In particular, the altered hemodynamics, thrombotic tendency, and required anticoagulation result in complications such as ischemic infarctions and intracranial hemorrhage (1,2). At our institution, it is standard practice to obtain a non-contrast Head CT as a baseline study prior to LVAD placement. We explore the clinical utility of this practice.

Materials and Methods
Retrospective analysis of the neuroimaging and electronic medical records of 255 consecutive patients who underwent LVAD placement at a single institution spanning a four year time frame (January 2014-December 2018). Patients were analyzed for rates of ischemic infarction (small or large territory) and intracranial hemorrhage (parenchymal, subarachnoid, or subdural). Each case with positive findings, was reviewed by a CAQ neuroradiologist to assess whether the baseline CT was required to establish the diagnosis.

Results
Of the 255 patients 15 were excluded due to incomplete data or loss of follow up. The age range was 20-77 year old with median age of 55 year old. 62 out of 240 did not require repeat head CT (26%). 135 out of 240 didn't have any acute or indeterminate findings (56%). 19 patients developed intraparenchymal hemorrhage (8%). 18 patients developed SAH (8%) and 12 patient developed SDH (5%). 21 patients developed acute ischemic change (9%). In those 21 patients, 8 were large vessel territory infarcts and remaining 13 small infarcts. Median duration of LVAD support at the time of ischemic stroke was 321 days (range 2-1477 days). None of the hemorrhages required baseline imaging for diagnosis. 4 infarcts (2%) required comparison to baseline CT head to determine diagnosis, all small.

Conclusions
Our study demonstrates similar rates of ischemic stroke and intraparenchymal hemorrhage to previously published data (3,4). A pre-operative baseline CT head was helpful in identifying 4 patients with small territory infarctions. It wasn't necessary to make a diagnosis of hemorrhage or stroke in most of our patient population and did not seem to alter management in any patients. Short term follow up neuro imaging in patients with clinical suspicion for stroke and indeterminate initial CT head findings could be a helpful tool to diagnose small ischemic infarcts.

(1) Subdural hematoma. (2) Ischemic stroke with hemorrhagic conversion. (3) Intraparenchymal hemorrhage.

New Adjacent Level Vertebral Fractures after Vertebroplasty or Kyphoplasty: A Literature Review.

T Nguyen1, J Milburn2, R Chandra3, R De Leacy4, J Hirsch5
1Ochsner Health System, New Orleans, LA, 2Ochsner Clinic Foundation, New Orleans, LA, 3Monash University, Melbourne, Australia, 4Icahn School of Medicine at Mount Sinai, NEW YORK, NY, 5Massachusetts General Hospital, Boston, MA
Purpose
Percutaneous vertebroplasty (PVP) and balloon kyphoplasty (BK) are common treatments for osteoporotic vertebral compression fractures (VCFs). A concern surrounding these procedures is the development of post-intervention adjacent level fractures. Currently, the incidence of new adjacent level VCFs after treatment is not well known. In this study, we aimed to assess the incidence of new adjacent level VCFs after PVP or BK compared to non-surgical or sham intervention for patients enrolled in PVP or BK randomized control trials (RCTs).

Materials and Methods
A literature search was conducted in Ovid MEDLINE and PubMed online scientific publication databases from their date of inception until November 2019. RCTs comparing PVP or BK to non-surgical or sham intervention were identified. Those reporting the incidences of new and adjacent level VCFs after treatment were included.

Results
A total of thirteen RCTs were identified. Five RCTs that included a total of 1152 patients reported incidences of new adjacent level fractures. These findings are summarized in Table 1. Incidences of adjacent level fractures ranged from 1.5-11.1% in patients treated with PVP, and 0-16% in the control arms. There was a 23.7% incidence of adjacent level fracture after BK compared to 16.7% after non-surgical management. Seven RCTs that included 950 patients reported incidences of any new VCF. These findings are summarized in Table 2. The VAPOUR trial did not report numbers of new VCF but stated there was no difference in new fracture incidences between the two arms.

Conclusions
Although the data is limited, the incidence of new adjacent VCF after treatment with PVP or BK in the RCTs literature is similar to non-surgical or sham intervention. Additionally, incidence of any new VCF after PVP or BK is also similar to control treatments. However, Blasco et al commented that 82% of new VCF in the PVP arm were adjacent to the treated level. Additional research is required to determine risk factors for VCFs after PVP or BK.
Normative Age-Related Neuroimaging Morphometry of the Mammillothalamic Tracts to Aid Deep Brain Stimulation Procedures

S Ghaderi Niri, A Khalaf, T MASSOUD

Stanford University School of Medicine, Stanford, CA, STANFORD UNIVERSITY SCHOOL OF MEDICINE, STANFORD, CA

Purpose

Neuromodulation using deep brain stimulation (DBS) in the anterior nucleus of the thalamus (ANT) is an option in the treatment of medically refractory focal epilepsy. The mammillothalamic tracts (MTTs, bundles of Vicq d’Azyr) are known projections from the mammillary bodies (MBs) to the ANTs. Since the ANTs may be atrophied in epilepsy, it has been recently proposed that targeting the
MTTs as they terminate into the ANTs could be used as a proxy for the locations of the ANTs. However, there are no studies addressing the conspicuity and morphometry of the MTTs on MRI. Prior preliminary functional MTT studies used only diffusion tensor tractography, and there are limited MTT evaluations using structural MRI. We investigated the normative age-related 3T MRI morphometrics of the MTTs and adjacent MBs in healthy subjects, prior to future evaluation in patients with epilepsy.

Materials and Methods
We retrospectively analysed magnified axial T2-weighted images of 80 individuals for bilateral MTT conspicuity, diameter (mm), area (mm²), shape (round or ovoid), location (distance from third ventricle surface), and symmetry of the MTTs, as well as size and separation of the MBs. We also measured Evans’ index (EI) to account for global brain atrophy. We tested the effect of independent variables (sex and MTT side) on the measured dependent variables using two-way ANOVA, and performed linear regressions with age as the independent variable for each of the dependent variables, with significance set at p<0.05.

Results
The study cohort comprised F:M=44:36 subjects, with a mean age of 45.3 years. All EI's were normal at <0.3. Only two MTTs were inconspicuous. The mean dimensions for all MTTs were: diameter=1.83mm, area=2.04mm², and distance from 3rd ventricle=3.07mm. MTTs were bilaterally symmetrical in shape, divided equally between round and ovoid. The mean MB area=14.32mm². There were no statistically significant interactions found between the effects of sex/laterality and MTT diameter or area, but the right MTT diameter was larger than the left, and males had larger MTT areas than females. Linear regression showed that males had significantly larger MB areas compared to females (p=0.039).

Conclusions
This is the first report of normative age- and sex-related MRI morphometrics for the MTTs to guide future DBS treatments. Additional studies in patients with medically refractory focal epilepsy will determine if the MTTs and adjacent MBs may be atrophied in proportion to the ANT.

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Pineal Cysts: Prevalence and significance in a large sample of typically developing adolescents

R Nillo¹, Y LI¹, M OLARU², A RAUSCHECKER³, C Hess⁴, L SUGRUE⁵
¹University of California, San Francisco, San Francisco, CA, ²UNIVERSITY OF CALIFORNIA - SAN FRANCISCO, SAN FRANCISCO, CA, ³UCSF RADIOLGY, SAN FRANCISCO, CA, ⁴UCSF, San Francisco, CA, ⁵UCSF, SAN FRANCISCO, CA

Purpose
While pineal cysts are among the most common incidental findings (IFs), their significance is controversial. Some reports suggest association with headaches and/or sleep disturbances and advocate follow-up or even surgical intervention, while others suggest these cysts have no clinical significance. Small sample sizes coupled with heterogeneous study populations limit report interpretability. Structural brain imaging performed as part of the Adolescent Brain and Cognitive Development (ABCD) study offers an opportunity to explore the prevalence and significance of IFs in US adolescents. Here we report the prevalence of pineal cysts in ABCD and test whether they negatively impact sleep quality.

Materials and Methods
We examined baseline brain MRIs of all 11,922 typically developing adolescents (ages 9-10) enrolled in ABCD available in the NDA 2.0.1 release. All scans were screened for IFs by board-certified neuroradiologists using a standardized system that included description of pineal cysts. Parents reported sleep measures for their children using the Sleep Disturbance Scale for Children, a validated questionnaire for sleep disorders.

Results
Pineal cysts were present in 7.5% of subjects with an average maximum cyst diameter of 7.7mm (Figure 1C). We found no association between pineal cysts and sleep disturbance scores once subjects were matched for confounding demographic factors (Figure 1A). In particular, the prevalence of pineal cysts did not change significantly across our primary sleep disturbance measure – sleep duration — with a trend towards higher prevalence as sleep duration increased (Figure 1B). Finally, in subjects with measurable pineal cysts there was no relationship between cyst size and scores of sleep initiation/maintenance (Figure 1D) or excessive somnolence (Figure 1E).

Conclusions
We found a 7.5% prevalence of pineal cysts in a large population of 11,922 US adolescents, with an average cyst diameter of 7.7mm. We found no evidence to support the hypothesis that pineal cysts are associated with pineal dysfunction manifest as disordered sleep. Our results suggest that in the absence of secondary effects, such as hydrocephalus from mass effect on the cerebral aqueduct, pineal cysts identified on routine MRI brain imaging reflect normal variation in brain anatomy and warrant no specific intervention or follow-up. More broadly, our results suggest the potential of large imaging studies such as ABCD to clarify the significance of incidental findings on brain imaging.
Potential use of 18F-THK5351 PET to identify astrogliosis in neurological diseases

K Ishibashi1
1Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan

Purpose
The positron emission tomography (PET) radioligand, 18F-THK5351, was initially developed to target tau aggregation present in neurofibrillary tangles. However, 18F-THK5351 was recently shown to bind to monoamine oxidase B (MAO-B) with relatively high affinity (1-3). MAO-B is highly expressed in the outer mitochondrial membrane of astrocytes. MAO-B concentration increases during a process referred to as "astrogliosis", which comprises a wide spectrum of changes in astrocytes occurring in response to brain injury and disease. Therefore, 18F-THK5351 accumulates in lesions undergoing astrogliosis, as demonstrated recently in an autopsy case study (3). We here show the potential use 18F-THK5351 PET to identify astrogliosis in neurological diseases.

Materials and Methods
Three patients were included. A 26-year-old woman (patient 1) with relapsing-remitting multiple sclerosis (MS) underwent 18F-THK5351 PET during a remission period. A 72-year-old man (patient 2) underwent 18F-THK5351 PET 27 days after lacunar infarction. A 41-year-old man (patient 3) underwent 18F-THK5351 PET 2 years after a right middle cerebral artery infarction.

Results
For the patient 1, small regions with elevated uptake of 18F-THK5351 were scattered in the brain. The foci of 18F-THK5351 accumulations corresponded anatomically to MS plaques (Figure 1A). For the patient 2, intense uptake of 18F-THK5351 was observed on the infarct lesion (Figure 1B). For the patient 3, intense uptake of 18F-THK5351 was observed along the ipsilateral pyramidal tract from the corona radiata to medulla (Figure 1C), possibly reflecting Wallerian degeneration accompanied with astrogliosis.

Conclusions
For all three patients, 18F-THK5351 was accumulated in the lesions where astrogliosis should occur. Therefore, 18F-THK5351 PET is potentially useful to identify astrogliosis in neurological diseases, although further pathological assessments are required.
Purpose
The presence of intra-orbital metallic foreign bodies (IMFBs) is a contraindication to magnetic resonance imaging (MRI), as IMFBs may injure the retina during scanning. Unfortunately, methods of excluding IMFBs are inconsistent across institutions. Our institution takes a cautious approach, screening patients for a variety of reasons, including history of injury and activities involving metal. Many patients with IMFB have inadvertently undergone MRI, yet the incidence of injury due to IMFB remains rare. Orbital x-rays prior to MRI are likely done more often than necessary to safely identify patients with contraindications to MRI, exposing patients to excess radiation and imaging delays. Although the risk from radiation itself is low, the inconvenience to the patient and the hospital system can be substantial.

Materials and Methods
49,276 patients were identified who underwent orbital x-rays for MRI clearance from January 1998 to December 2018. 20,578 of these reports were available for review to determine the rate of positive examinations. The studies of patients not cleared were further reviewed to determine if clearance was denied due to danger of an IMFB or another finding. The screening questionnaires of patients who were denied clearance were then reviewed to determine the initial indication for screening.

Results
Of the 20,578 reports reviewed, 20,353 were of patients undergoing orbital x-ray studies prior to MRI. Of these, 190 (0.93%) were not cleared to undergo subsequent MRI. Only 74 patients (0.36%) were prevented from undergoing MRI due to high suspicion of an IMFB, while 116 (0.57%) were not cleared because of incidental findings not related to an IMFB. Fifty-one (0.25%) patients were subsequently cleared on repeat orbital x-ray or CT, and 12 (0.06%) patients underwent MRI even though their orbits were not cleared. An additional 7 patients (0.03%) underwent a pre-MRI orbital x-ray after an MR study was initiated and metal artifact noted.

Conclusions
Pre-MRI orbital plain films rarely identify IMFB and may not be necessary in many patients who undergo screening. More focused screening protocols are needed. There is evidence some patients can undergo MRI safely despite apparent contraindications found during pre-MRI screening. Orbital x-rays often have artifacts that necessitate repeat scans. Screening methods have allowed some patients to undergo MRI despite IMFB; our study found no injuries as a result.

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Procedural Advanced Practice Clinicians Potentially Boosts Productivity and Efficiency in Diagnostic Neuroradiology

Z Berg¹, T Hutchins²
¹University of Utah, Salt Lake City, UT, ²University of Utah, Neuroradiology, salt lake city, UT

Purpose
The practice of hiring advanced practice clinicians (APCs) in radiology has increased across the country over the past decade. Our goal is to identify the increased productivity in diagnostic neuroradiology by having procedural APCs work up and perform lumbar punctures (LPs) during daytime clinical service.
Materials and Methods
We retrospectively examined at how many LPs were performed by APCs in one calendar year. We estimated that a day time shift neuroradiologist signs off approximately 5.27 MRI studies per hour. We developed a calculation based on the number of LPs performed per year, MRI volume per hour, and work Relative Value Unit (wRVU)/MRI to calculate a yearly MRI wRVU surplus from APC daytime LP service. wRVU were averaged using (Current Procedural Terminology) CPT codes for our most common diagnostic neuroradiology MRI studies. Yearly total APC performed LP wRVU surplus was calculated using an average 1.5 wRVU per LP. The sum of the yearly MRI wRVU surplus and yearly APC performed LP wRVU yields a gross total wRVU surplus generated from an APC lead LP service.

Results
For MRI wRVU yearly surplus, we used the following equation: (MRI/hr)x(LP time in hrs)x(#LP performed per year)x(wRVU/MRI).
Using an average 5.27 MRI studies are signed off per hour, a total LP time of 1 hour, 368 APC LPs per year, and 1.98 wRVU/MRI, we calculated a total yearly MRI wRVU surplus of 3839.9. This estimates a rough compensation of $261,228 (calculated from the average payment rate per wRVU over the past 12 months). A total of 368 LPs were performed in 2018 by APC alone, which calculated a total LP wRVU of 552 and an estimated compensation of $37,553. Together, this calculates a gross total wRVU surplus of $3914.9 and an estimated rough compensation of $298,781 (calculated from the average payment rate per wRVU over the past 12 months).

Conclusions
The addition of procedural APCs in diagnostic neuroradiology performing LPs improves productivity by allowing diagnostic neuroradiologists to interpret more high wRVU studies. We have proved this by showing increased wRVU generation from diagnostic neuroradiology, when otherwise neuroradiologists would spend time working up and performing lumbar punctures. We recognize the indispensable benefit of having APCs available to run a consult service, work up each patient, and the availability to answer provider and patient questions, which also increases diagnostic neuroradiology efficiency and overall improved patient care.

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Quantitative susceptibility mapping (QSM) as a biomarker to evaluate repeated traumatic brain injury

K Gillen1, L Guo1, T Nguyen1, R Jafari1, Y Wen1, X Mao1, E Chang1, J Cho1, Y Wang1, D Shungu2, A Tsiouris3
1Weill Cornell Medicine, New York, NY, 2Weill Cornell Medicine, NEW YORK, NY, 3New York-Presbyterian - Weill Cornell Medical Center, New York, NY

Purpose
Patients with repeated traumatic brain injury (rTBI) accumulate brain iron, which can predispose them to neurodegenerative diseases such as Parkinson's disease (PD), Alzheimer's disease, and chronic traumatic encephalopathy (CTE).1 Excess iron can co-localize with neurofibrillary tangles (NFTs) and activated microglia,3 and is detectable by quantitative susceptibility mapping (QSM), an MRI technique that permits iron quantification.4 We have shown that QSM reflects iron overload in multiple sclerosis (MS), and investigated the presence of iron overload in rTBI. We analyzed QSM images from athletes with or without repeated head trauma to measure iron in the substantia nigra (SN) and red nucleus (RN). Our findings indicate that QSM can be a non-invasive biomarker for rTBI.

Materials and Methods
This was a retrospective image analysis of QSM from age- and sex-matched athletes with (n=6; 45.7 ± 6.6 years) or without (n=4; 46.5 ± 12.7 years) repeated head trauma. Subjects had a non-contrast 3T MRI of the brain as part of participation in an IRB-approved study. T1w images and QSM were registered and processed for automated subcortical segmentation. Regions were refined by a neuroradiologist; average susceptibilities and volumes were calculated for each region. SN and RN were traced manually. Unpaired t-tests were performed to compare susceptibilities in individual voxels between cohorts. p < 0.05 was considered statistically significant.

Results
QSM identified increased susceptibility in the SN and RN (p < 0.001; Figs 1&2) in athletes in the experimental cohort as compared to the controls. This increase in susceptibility was not due to an increase in volume, as there were no differences in volume between the structures (Fig 2b). There were no significant differences in susceptibilities in the caudate, putamen, or globus pallidus in the two cohorts (Fig 2a).

Conclusions
Susceptibility increased in the SN and RN in athletes with repeated head trauma as compared to controls. Increased susceptibility can reflect iron in microbleeds and activated microglia, and potentially within p-tau and NFTs. However, in our subjects, the iron localization is unknown, but warrants further investigation, as iron-positive microglia express pro-inflammatory markers3, and secretion of pro-inflammatory cytokines can lead to neurodegeneration in the SN, a feature of PD, dementia pugilistica, and CTE. Therefore, individuals with rTBI should be monitored closely for the possible development of neurodegenerative diseases.
Role of perilesional contrast leakage around ring-enhancing lesion in differentiating neurocysticercosis from neurotuberculoma

A Garg¹, K Kaur², L Sebastian³
¹All India institute of Medical Sciences, New Delhi, Delhi, ²All India institute of Medical Sciences, New Delhi, New Delhi, Delhi, ³All India Institute of Medical Sciences, NEW DELHI, Delhi

Purpose
Ring-enhancing lesions (RELS) is one of the common imaging finding in neurocysticercosis (NCC) and neurotuberculosis; and differentiating between them is challenging. Perilesional contrast leakage around ring-enhancing NCC has been described rarely.¹ The aim of our study is to study the role of perilesional contrast leakage around RELs in differentiating NCC from neurotuberculoma.

Materials and Methods
This IEC approved retrospective study included 133 patients with imaging findings of RELs (114- NCC; 19- neurotuberculomas). The diagnosis of NCC was confirmed by stringent criteria as detailed elsewhere² and neurotuberculoma was based on presence of

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meningitis and supportive CSF and imaging findings. Medical records of these patients were reviewed for clinical presentation and treatment history. On imaging lesion morphology, location, number, degree of perilesional edema and enhancement pattern in form of leakage of contrast beyond the margins of the ring seen on T1 and T2-WI was studied. The solitary lesions were classified as solitary discrete RELs (SD-RELs) when a well-defined lesion was seen, solitary conglomerate RELs (SC-RELs) when two or more ring lesions, or ring/rings plus disc lesions were present contiguously and multiple RELs (M-RELs) when two or more lesions are present in different location of the brain. Follow-up scans were evaluated for enhancement pattern, resolution of lesions and surrounding edema.

Results
Out of total of 114 patients with NCC, the lesion morphology was SD-REL in 26, SC-REL in 67 and M-RELs in 21 patients. The lesion morphology in 19 patients of neurotuberculoma was M-RELs in 14, SC-RELs in 3 and SD-RELs in 2 patients. Thirty six out of 114 patients (31.6%) had perilesional contrast leakage (Fig 1) and 78 patients (68.4) had no perilesional contrast leakage. Out of 36 patients with perilesional contrast leakage, the lesion morphology was SC-RELs in 29, SD-RELs in 4 and M-RELs in 3 patients. Perilesional contrast leakage was present in 29 out of 67(43.3%) of SC-RELs, 4/26 (15.4) SD-RELs and 3/21 (14.3%) cases M-RELs. None of 19 cases with neurotuberculoma showed perilesional leakage of contrast. Fig 1 shows a case of right frontal NCC (thin arrows in a-c) with perilesional leakage of contrast (thick arrow in c).

Conclusions
Perilesional leakage of contrast may be a helpful differentiating feature between RELs of NCC and neurotuberculoma. SC-RELs tend to show perilesional contrast leakage more often than SD-RELs.
Simultaneously Classification of Brain Tissues and White Matter Hyperintensity in Magnetic Resonance Imaging Through the Use of Self-learning Method

C CHEN¹, H Chen², J Chai¹
¹Taichung Veterans General Hospital, Taichung, Taiwan, ²Taichung Veterans General Hospital, Taichung, Taiwan

Purpose
White Matter Hyperintensity (WMH) can usually be detected and diagnosed using Magnetic Resonance Imaging (MRI). It has been pointed out that this affliction is associated with stroke, cognitive impairment, dementia, and even the increased risk of death being very relevant. This study proposes a new self-learning method, Iterative Linear Constrained Minimum Variance (ILCMV), for simultaneously classifying brain tissues and white matter hyperintensities in MRI. This self-learning algorithm can reduce the cumbersome manual operation and improve the efficiency of physician diagnosis and recognition, thereby assisting clinically to make appropriate treatment decisions and prognosis tracking.

Materials and Methods
The synthetic brain images in BrainWeb are used for quantitative evaluation of the proposed ILCMV method, while the real brain MR images are used for visual assessment. The imaging protocol included three high-resolution 3DT1WI, T2WI and FLAIR or proton density (PD)MR images. In this study, we also explore the effect of the ILCMV method when combined with different spatial filters on brain normal tissue, along with WMH classification.

Results
The experimental results suggest that the Gaussian filter is most suitable for the ILCMV methods, if considering the criterion of computational time. Otherwise, the classification is best when ILCMV is combined with a Gabor filter. In addition, the average Dice Similarity Indexes (DSI) of CSF/GM/WM volume measurement by using the ILCMV method combined with a Gaussian filter, were 0.936/0.948/0.975 respectively in synthetic MR images with all noise level, and offered better results than those from previous literature. The classification results of real brain MRI for CSF, GM, WM and WMHs were shown in Figure 1 as a visual assessment. Illustration of Figure 1. The classification results of CSF, GM, WM, and WMH by using the ILCMV self-learning method in real brain MRI. They simultaneously have soft and hard classification results. From left to right in the images are the soft classification results of CSF, GM, WM, and WMH, with the color image being the hard classification result.

Conclusions
The self-learning ILCMV method not only simultaneously classifies brain normal tissues and WMH lesions in MR brain images, but we also found that the computational time is faster than those from previous literature. It is our belief that this technology has never been implemented for the classification of brain tissue and WMH in MRI application.

Suspected metallic embolization distal to coiled intracranial aneurysms detectable by susceptibility weighted magnetic resonance imaging

Y Cho¹
¹Seoul National University Hospital, Seoul, Seoul

Purpose
After endovascular coiling of intracranial aneurysms, round dark parenchymal lesions believed to be particulate metal are sometimes encountered in magnetic resonance imaging (MRI) studies of the brain. We used susceptibility weighted imaging (SWI) to assess the frequency of such occurrences, in addition to exploring likely causes and clinical implications.

Materials and Methods
We reviewed 700 MRI studies performed between September 2018 and March 2019 at our institute as follow-up monitoring of coiled intracranial aneurysms. Any sizeable (>5 mm) rounded dark-signal lesions encountered were presumed to be metallic. The magnitudes and locations of such lesions were recorded. In patients with these lesions, pertinent procedural documentation was screened for
devices used, including coils, microcatheters, microguidewires, and stents. Medical records were also examined to determine if any related symptoms ensued.

Results
Twenty patients (2.8%) exhibited a total of 25 lesions on SWI. Diameters ranged from 5-11 mm (median, 8 mm). All but two lesions were located at brain regions downstream from aneurysms, but all lesions occupied vascular territories of vessels used to place guiding catheters. Other than the Synchro 14 (Stryker Corp, Kalamazoo, MI, USA), which was routinely deployed, no device was regularly used in patients with SWI-detectable lesions; and none of the affected patients developed focal neurologic symptoms as a consequence.

Conclusions
Although the origins remain unclear, distal embolization of particulate metal distal to coiled cerebral aneurysms is occasionally observed in follow-up MRI studies. Such lesions, however, have no apparent clinical impact.

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Swallow Tail Sign Prediction using Deep Learning

G da Silveira¹, E Alves², L Tibana³, I Pan⁴, F Kitamura⁵, N Abdala⁶, H Carrete Jr⁷, D Costa⁸
¹Universidade Federal de São Paulo, São Paulo, Brazil, ²Unifesp, São Paulo, São Paulo, ³UNIFESP, São Paulo, SP, ⁴The Warren Alpert Medical School of Brown University, Providence, RI, ⁵Diagnósticos da América (DASA), São Paulo, Sao Paulo, ⁶UNIFESP, São Paulo, São Paulo, ⁷Universidade Federal de Sao Paulo, São Paulo, SP, ⁸Hospital Sao Luiz-Reve D'Or - Fleury group- Unifesp, São Paulo, São Paulo

Purpose
The 'Swallow Tail Sign' is a well-established marker used in the diagnosis of Parkinson disease and dementia with Lewy Bodies. Our purpose was to create an algorithm, through Artificial Intelligence, that could predict the presence or absence of this sign, using a multi-echo sequence on MRI.

Materials and Methods
This project was approved by the Institutional review board. Eighty patients were scanned using a 3T MRI scanner (Achieva, Philips), with a multi-echo sequence. A TE of 33 ms was chosen after visual inspection. Three cases were excluded due to intense motion artifact. Of the 77 remaining patients, 53 had confirmed nigrosome 1 alterations (absent Swallow Tail Sign) and 24 were healthy (categorized by neuroradiologists with 20 and 15 years of experience). They were annotated with bounding boxes around the nigrosome 1 in at least one slice to generate the images for algorithm classification (this task was done by neuroradiologist with 6 years of experience). The resulting dataset contained 237 images of the 77 patients, 137 of which were positive (absent Swallow Tail Sign). A NASNet was trained from scratch in 8 folds (cross-validation) to predict a normal or abnormal nigrosome 1.

Results
The model achieved a good mean AUC of 90.46% in the test set with 6.94% standard deviation.

Conclusions
Though trained in a small dataset, this cross-validated study shows that a deep learning model is able to predict the presence or absence of the 'Swallow Tail' sign.
Purpose
Tuberculous spondylitis, also known as Pott's disease, is a common form of skeletal tuberculosis caused by the agent Mycobacterium tuberculosis, producing osteomyelitis of the vertebral body and diskitis. In 2018, 80,000 cases of tuberculosis (TB) were notified in Brazil and nearly 11,200 presented extrapulmonary involvement, with the spine being one of the most frequently affected sites. Despite HIV's strict correlation with TB, Pott's disease is also seen in immunocompetent patients. The purpose of this paper is to provide a comprehensive assessment of the imaging aspects of Pott's disease, approaching its differential diagnosis, which include fungal infection, metastasis and pyogenic spondylodiscitis.

Materials and Methods
This series include compelling cases from our service that presented strong clinical radiological suspicion of TB of the spine, underwent appropriate medical treatment culminating with improvement in symptoms. We have performed an extensive survey of literature and demonstrated the pathogenesis through simple illustrations, focusing on imaging patterns and clinical radiological correlation.

Results
Spinal TB mainly affects the thoracic segment of vertebral column and is often first seen in radiographs as lytic lesions and collapse of the anterior-inferior portion of the vertebral body. This condition is often mistaken by compression fractures in the context of back pain or neurological deficits, delaying diagnosis and initiation of anti-tuberculosis treatment. We have associated pathogenesis, anatomy and imaging findings through the stages, from the earliest signs of the disease to destruction of disk space and herniation, vertebral collapse producing vertebra plana, fluid collections, progressive kyphosis and gibbus formation.

TB or Not TB

H SILVA¹, L Nelli², N Andrade Gonçalves²
¹Faculdade de Medicina de Marília - FAMEMA, Marília, Brazil, ²Faculdade de Medicina de Marília - FAMEMA, Marília, Brazil
Conclusions
After the introduction of combination chemotherapy agents, the course of TB has changed and its incidence has been falling at about 2% per year, although it remains endemic and a leading cause of mortality in many countries. Pott's disease recognition in early stages can be a challenge, for that reason it is important to raise awareness of its existence and its differential diagnosis, since it's a preventable and curable disorder. Early detection can improve treatment outcomes, avoiding permanent spinal damage.

The Utility of Dual Energy CT Angiography (DECTA) in the Setting of Acute Ischemic Stroke.

K Moulton¹, S Naqvi¹, G Bell¹, N Sahota²
¹University of Saskatchewan, Saskatoon, Saskatchewan, ²University of Saskatchewan, Saskatoon, SK

Purpose
Early signs of acute ischemic stroke (AIS) in the setting of large vessel occlusion (LVO) on non-enhanced CT (NECT) include loss of grey-white matter differentiation, cortical hypointensity, and parenchymal edema, which are seen due to a combination of cytotoxic and ionic edema. Although NECT can be obtained rapidly, it has been shown to lack sensitivity in detecting overall extent of infarct, particularly in the setting of hyperacute ischemic stroke, and has only moderate inter-reader reliability. Dual-energy CT angiography (DECTA) is a novel imaging application that allows simultaneous assessment of pial vasculature and parenchymal perfusion through iodine uptake in the setting of LVO, in a matter analogous to the 'capillary' or 'parenchymal' phase of digital subtraction angiography (DSA). To our knowledge, no study has assessed the use of DECTA in the assessment of ischemic stroke. The purpose of this pilot project is to assess the feasibility of predicting final infarct volume with DECTA in comparison to conventional NECT in the setting of AIS.

Materials and Methods
124 patients presenting with large vessel occlusion at a tertiary hospital during September 1, 2018 to October 31, 2019 were scanned using DECTA. DECTA images were acquired at 80 and 140 kV using a three-material decomposition algorithm during the second phase of CTA, timed at a delay of three seconds after peak arterial phase CTA. The second phase of CTA was chosen to most closely approximate the capillary phase of DSA. The DECTA images were compared with conventional NECT and follow-up CT or DWI performed greater than 24 hours after the patient's presentation.

Results
In our experience, DECTA detected extent of infarction with more conspicuity than conventional non-enhanced CT in multiple LVO cases, particularly with respect to assessing M1-M6 MCA cortical involvement within the ASPECTS paradigm. The extent of infarct...
on DECTA generally correlated well with follow-up CT or DWI. Figure 1 demonstrates a distal M1 left MCA thromboembolic occlusion. The established infarct volume at presentation is more conspicuous on DECTA in comparison to NECT. DWI 2 days later, following timely mechanical thrombectomy with TICI 3 reperfusion, correlates well with DECTA.

Conclusions
This project demonstrates the feasibility of DECTA as a novel tool that can supplement conventional NECT in determining the extent of early infarction. Further work is warranted to more comprehensively investigate the clinical utility of DECTA in the setting of AIS.

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The Value of Susceptibility Weighted Image in Parkinson's Disease : a Correlation Study with 18F-FP-CIT PET

H Kang¹, Y Kim¹
¹Seoul Veterans Hospital, Seoul, Korea, Republic of

Purpose
Our study was intended to demonstrate the different signal intensity (SI) pattern of the basal ganglia seen on susceptibility weighted imaging (SWI) between that of Parkinson's disease (PD) and Normal control groups, and to correlate it with 18F fluorinated-N-3-fluoropropyl-2-b-carboxymethoxy-3-b-(4-iodophenyl)nortropane positron emission tomography (18F-FP-CIT PET).

Materials and Methods
21 normal controls and 39 patients with PD underwent SWI, and 18F-FP-CIT PET were included. The SI was measured on SWI in the caudate nucleus head, anterior and posterior halves of the putamen using a region-of-interest (ROI) on both sides. The normalized regional glucose metabolism (standardized uptake value, SUV) was measured on co-registered 18F-FP-CIT PET images using the
ROI obtained with SWI. Analysis included a group-level comparison of the SI values obtained on SWI, and these results were correlated with the SUV on 18F-FP-CIT PET.

Results
The mean values of the SIs of the anterior half of the right putamen and the posterior half of the left putamen on SWI differed significantly between the two groups (P < 0.0083, respectively) (Table 1). The SUV on co-registered 18F-FP-CIT PET images of the all locations also differed significantly between normal controls and PD (P < 0.0083, respectively). There was a moderate degree of positive correlation between the SI on SWI and the SUV on co-registered 18F-FP-CIT PET of the left caudate nucleus head in PD (r = 0.401, P = 0.011) (Table 2). There was a moderate degree of positive correlation between the SI on SWI and the SUV on co-registered 18F-FP-CIT PET the whole basal ganglia regions except right caudate nucleus head in total (Table 2).

Conclusions
In conclusion, the low SI seen in the putamen on SWI may differentiate PD from normal controls. Furthermore, low SI in the basal ganglia on SWI correlated with hypometabolism on 18F-FP-CIT PET. Therefore, SWI could be a potential complementary diagnostic tool to 18F-FP-CIT PET for differentiating these conditions.

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Tumor Growth Curves Differentiate Between Simple vs. Complex IDH Mutant 1p/19q Intact Lower Grade Astrocytomas

T Thomas¹, R Moreno², T Bale³, J Kim⁴, I Mellinghoff², A Skakodub², N Swinburne³, A Bhatia³, R Young³
¹CUNY School of Medicine, New York, NY, ²Department of Radiology, Memorial Sloan Kettering Cancer Center, New York, NY, ³Memorial Sloan Kettering Cancer Center, New York, NY, ⁴Weill Cornell Medical College, New York, NY, ⁵Memorial Sloan Kettering Cancer Center, New York, NY

Purpose
Gliomas are graded per histopathology and mutation by the 2016 World Health Organization (WHO) into grades I-IV according to the degree of malignancy. The WHO grading system provides prognostic information and treatment guidance, however, may not accurately predict outcomes in lower grade (grades II-III) gliomas, particularly, in IDH mutant gliomas. We propose the novel characterization of IDH mutant lower grade astrocytomas into simple versus complex mutation groups. We hypothesize that the complex tumors will have more rapid growth than the simple tumors.

Materials and Methods
We analyzed patients who consented to prospective genomic profiling and were found to have IDH mutant 1p/19q intact lower grade astrocytomas (n=36). A neuropathologist further classified patients' tumors as either simple or complex depending on accompanying mutations and histopathologic features, including copy number variations, ATRX loss, TP53 loss, and CDKN2A loss. Tumors were manually segmented on axial FLAIR images on treatment naïve scans obtained prior to surgery, chemotherapy or radiation therapy. All segmentations were verified by an experienced neuroradiologist and edits were made as necessary. Growth curves were calculated as change in tumor volume (cm3) over time and comparisons between complex and simple tumor groups were made using paired two-tailed t-tests with p=0.05.

Results
The complex tumors had greater median rate of growth (0.4 cm3/month) than the simple tumors (0.15 cm3/month, p=0.025) and had older median age at presentation (41 versus 33 years, p=0.045). The complex group also trended towards larger median initial tumor volumes (18.7 cm3 versus 12.7 cm3, p=0.37) although this did not reach significance.

Conclusions
Our results suggest that further characterization of IDH mutant 1p/19q intact lower grade astrocytomas into complex and simple molecular groups may stratify aggressive subtypes that are more rapidly growing. Further research is necessary to understand the potential differences in prognosis and implications for treatment.
Tumor recurrence versus Post-treatment changes in head and neck tumors: Can Dynamic Contrast Enhanced Perfusion MRI help in the differentiation?

E Rawie1, A Srinivasan2
1Michigan Medicine, Ann Arbor, MI, 2Univ. Of Michigan Health System, Ann Arbor, MI

Purpose
Conventional structural MRI is often insufficient to distinguish between early tumor progression and pseudoprogression in tumors of the head and neck. This study aimed to ascertain the different dynamic contrast enhanced (DCE) perfusion MRI characteristics of progression and pseudoprogression and thereby assist treating physicians with the selection of appropriate therapy.

Materials and Methods
In this retrospective IRB approved study, all consecutive head and neck MRI reports from January 2014 to June 2019 were searched for the terms: ‘malignancy’, ‘squamous cell carcinoma’, ‘mucoepidermoid carcinoma’, ‘adenoid cystic carcinoma’, ‘adenocarcinoma’, ‘chordoma’, ‘chondrosarcoma’ and ‘sinonasal undifferentiated carcinoma.’ The inclusion criteria were those who 1) had primary malignancy treated with surgery or chemoradiation and either 2) subsequent recurrence/progression by imaging/biopsy or 3) subsequent stability by imaging for at least 1 year. Scans were excluded if a second head and neck tumor type was diagnosed during the time period in which the patient was observed for this study or if DCE MRI was not performed or was deemed inadequate due to motion/poor contrast bolus. One board certified neuroradiologist who was blinded to the clinical and pathological data except for the location of the imaging abnormality placed multiple ROIs within the lesion on post-contrast T1-weighted images and translated this to the perfusion images generated on Olea Sphere software. The perfusion parameters calculated included Ktrans, Vp, Ve, Kep, Wash-in (WI), Wash-out (WO), and Area under the curve (AUC). For each site, the average tumor perfusion parameters were then weighted against their corresponding reference parameters. Statistical differences between the parameters were evaluated with non-parametric Mann Whitney test using SPSS software.

Results
26 patients (11 with tumor recurrence and 15 without) were included. Tumor locations included nasopharynx, oral cavity, oropharynx, maxillary sinus, parotids and orbit. Significant differences between the recurrent and benign categories were seen in Ktrans (0.27 vs 0.15), AUC (140650 vs 73697), WI, WO, Vp (0.11 vs 0.06) and Ve (0.46 vs 0.30) (all p values <0.05) but not with Kep. The largest areas under the curve on ROC analysis were 0.85 and 0.81 for AUC and Ktrans respectively.

Conclusions
DCE MRI parameters can assist in differentiation of post treatment changes from tumor recurrence. We will add more patients and compare DCE with DWI and conventional metrics.

Value of delayed post-contrast 3D FLAIR MRI in patients with acute vestibular syndrome

D Park1
1Hanyang University Guri Hospital, Guri, Gyeonggido

Purpose
This study aims to evaluate the affected labyrinth including vestibule and semicircular canals on delayed post-contrast 3D FLAIR MRI in patients with unilateral acute vestibular syndrome (UAVS).

Materials and Methods
118 patients who presented with UVAS and underwent labyrinthine MR imaging, including 3D FLAIR MR images before and 4 hour after Gadolinium injection, were retrospectively analyzed, focusing on asymmetric affected labyrinthine enhancement. Vestibular function tests including the caloric and video head impulse tests were performed. Inter-reader agreement tests were performed.

Results
A delayed enhancement of the affected vestibule and/or semicircular canals on 3D FLAIR MRI was observed in 97 out of 118 ears (82.2%, p < 0.001), but delayed enhancement of the cochlea was observed in 42 out of 118 ears (35.6%). The duration of spontaneous nystagmus was significantly longer in the patients with enhancement, especially the whole labyrinth including the vestibule and semicircular canals (P<0.05).

Conclusions
The enhancement of affected labyrinth of vestibule and/or semicircular canal on delayed post-contrast 3D FLAIR MRI was presented in patients with UAVS. The degree of its enhancement may be associated with the duration of spontaneous nystagmus. The delayed affected labyrinthine enhancement in patients with UAVS could be the MR imaging biomarker for the initial and prognostic values for UAVS.
Scientific Abstracts
Abstracts originally accepted as oral presentations; presented virtual as ePosters.

Note: Abstracts are published below in their originally scheduled oral presentation sessions.

Scientific Abstract Session: AI
1133

Deep Learning AI Technology Matches Lumbar Spine Image Quality at About 1/3 of the Scan Time

L Tanenbaum1, W Gibbs2, S Bash3, L Wang4, H Gandhi2, P Gulaka4, A Shankaranarayanan5, T Zhang4

1RadNet, Inc., new york, NY, 2Mayo Clinic Scottsdale, Pasadena, CA, 3RadNet, Inc., Encino, CA, 4Subtle Medical, Menlo park, CA, 5Subtle Medical Inc, Menlo Park, CA

Purpose
To evaluate the performance of deep learning AI (DLAI) to match routine lumbar spine MRI image quality at highly reduced scan times.

Materials and Methods
With IRB approval and patient consent, 27 consecutive patients (49+/-16 years old; 17 male) underwent standard of care (SOC) lumbar spine MRI exams on one of 3 different clinical 1.5T scanners. All subjects underwent an additional accelerated 2D sagittal T2 series processed by an FDA cleared convolutional neural network based deep learning AI application trained on multivendor MR platforms (SubtleMR™). The sagittal T2 scan times averaged 2:12 (SOC) and 0:49 (DLAI - 2.7x acceleration). 54 image series (27 SOC and DLAI) were randomized and independently rated by two board-certified neuroradiologists for (1) perceived SNR, (2) anatomy/pathology conspicuity, (3) motion artifacts, and (4) overall image quality on a 5-point Likert scale (1: non-diagnostic, 2: poor, 3: diagnostic, 4: good, 5: excellent). A two-sided paired t-test was performed with P<0.05 considered as statistically significant.

Results
The average scores for perceived SNR, anatomy/pathology conspicuity, motion artifacts, and overall image quality (SOC/DLAI) were 5.0/4.9, 5.0/4.9, 4.9/4.8, 5.0/4.9 respectively for reader 1, and 4.4/4.3, 4.8/4.5, 4.7/4.7, 4.4/4.2 for reader 2. No statistically significant difference between DL-accelerated scans and standard scans were present for all criteria and both readers.

Conclusions
Deep learning AI technology can match routine lumbar spine MR image quality at approximately 1/3 of the scan time.
Prediction of Clinically Relevant Glioblastoma Genetic Biomarkers Using Automated Deep Learning Segmentation-Based Radiomics Feature Extraction

E Calabrese¹, J Villanueva-Meyer¹, S Cha¹
¹University of California San Francisco, San Francisco, CA

Purpose
Glioblastoma is typically associated with a guarded prognosis; however, recent studies have identified several genetic biomarkers that are associated with more favorable outcomes. For example, isocitrate dehydrogenase (IDH) mutations confer improved survival, particularly with maximal tumor resection. Unfortunately, genetic testing is expensive and requires tumor sampling. Radiomics analysis, particularly when combined with automated deep learning-based feature extraction, holds promise for non-invasive identification of clinically relevant glioblastoma genetic biomarkers.

Materials and Methods
We analyzed preoperative MRI and tumor genetic test results from 199 patients with glioblastoma. MRI data included pre- and post-contrast T1, T2, FLAIR, ASL, SWI, and 55-direction DTI (Fig 1A). Genetic biomarkers included mutations of IDH, ATRX, PTEN, TP53, CDKN2 and TERTc, EGFR amplifications, MGMT promoter methylation, and chromosome 7/10 aneuploidy. Radiomics features were extracted from MR images using a fully automated deep learning-based tumor segmentation algorithm (Fig 1B) combined with PyRadiomics 2.2.0. Half (100) of the cases were used to train random forest models to predict genetic biomarker status from radiomics features. The remaining 99 cases were used to assess model accuracy.

Results
Receiver operating characteristic (ROC) analysis showed that radiomics-based prediction of IDH mutations performed the best with sensitivity of 88.9%, specificity of 91.0%, and area under the curve (AUC) of 0.97 (Fig 1C). The most important features were FLAIR kurtosis within the tumor core and large area emphasis of the entire tumor. ATRX mutation prediction had similar performance with sensitivity of 99.9%, specificity of 79.1%, AUC of 0.95, and most important features of T1 post-contrast value and DWI skewness within the tumor core. Chromosome 7/10 aneuploidy and PTEN mutation ROCs had AUCs of 0.79 and 0.65, respectively. Inference of other genetic biomarkers was similar to random chance (Fig 1D).

Conclusions
In this study we were able to accurately and non-invasively predict the status of glioblastoma genetic biomarkers from preoperative MRI using fully automated deep learning-based radiomics feature extraction. Our model was particularly accurate for predicting IDH mutations in glioblastoma, which have a significant effect on both survival and disease treatment. The fully automated nature of this method allows straightforward application to prospective studies, in real time, and on larger datasets.
WHITE MATTER LESION SEGMENTATION USING DEEP LEARNING AND MRI.

C BANGALORE YOGANANDA¹, B Wagner², G Murugesan², S Nalawade², A Madhuranthakam², J Maldjian³
¹University of Texas Southwestern Medical Center, DALLAS, TX. ²University of Texas Southwestern Medical Center, Dallas, TX. ³University of Texas Southwestern Medical Center, N/A

Purpose
The purpose of this study was to develop a fully automated deep learning method for white matter lesion segmentation using T2-Flair MR Images.

Materials and Methods
The network was trained on 100 T2-Flair MR Images from the AADHS 1 study and tested on a held-out set of 100 T2-Flair MR Images from the DHSmind study. The images for the AADHS study were acquired on a 3.0T Siemens scanner and the images for the DHSmind study were acquired on a 1.5T GE scanner. White matter lesions for these images were manually segmented by expert neuroradiologists. Data preprocessing steps included (a) N4BiasCorrection to remove the RF inhomogeneity and (b) Intensity Normalization to 0-mean and unit variance. A patch-based 3D dense variational Auto-encoder (WM-net) was designed to learn the local structures, decompose the segmentation problem and segment white matter lesions (Figure 1). To evaluate the generalizability of the network, a 3-fold cross validation was implemented using only the AADHS images. The dataset was randomly shuffled and equally split into 3 groups as training (33 images), validation (33 images) and testing (34 images). Each fold represented a new training phase from a unique combination of the three groups. However, the network performance is only reported on the held-out testing group for each fold (which is never seen by the algorithm during training for that fold). The network was then retrained on all 100 AADHS images and tested on the held-out 100 DHSmind images. For performance comparison white matter lesion segmentations were also generated using the lesion segmentation toolbox (LST).

Results
The WM-net demonstrated a mean cross-validation dice score of 0.908 ± 0.010 in segmenting the white matter lesions (Table 1) compared to manual segmentation ground truth. The network achieved a dice score of 0.918 on the held-out dataset of 100 DHSmind subject compared to ground truth manual segmentation, outperforming the segmentations generated by the LST (Table 2).

Conclusions
We demonstrate a deep learning algorithm for white matter lesion segmentation with very high accuracy compared to manual segmentation, outperforming the LST toolbox. Although the network was trained on images acquired at 3.0T, it demonstrated excellent performance on images acquired at 1.5T. Segmentation time for a new subject is on the order of 30 seconds, making this approach viable for clinical implementation and tracking of white matter lesion load.

(Filename: TCT_1764_All_figures_together.JPG)
Autonomous Spatial Alignment of Historical MRI Examinations Improves Reading Efficiency and Confidence in Brain Tumor and Multiple Sclerosis Follow Up Evaluations

J Choi1, M Furman1, A Hart1, T Liang1, S Tumuluru1, J Tutman1, C Jaimes1, R Robertson1, B Scherrer1
1Boston Children's Hospital, Boston, MA

Purpose
Historical examinations are routinely used to evaluate disease evolution in conditions such as multiple sclerosis (MS) and brain tumors (BT). Unfortunately, variations in patient positioning and slice orientation between scans can make comparisons challenging, reducing reading efficiency and confidence. We sought to evaluate the impact of a tool that actively and automatically aligns historical examinations while a patient is being scanned.

Materials and Methods
We built a tool (Auto-Align, AA) that continuously builds a detailed historical database of all DICOM MR series for each patient (via a DICOM forwarding rule), and autonomously aligns newly acquired brain MRI series with the patient's available historical examinations. To evaluate this tool, we identified 20 MS and 20 BT patients with at least 3 prior studies that were aligned by AA and sent to an internal research PACS database. 6 radiology fellows participated in the study and were provided a randomly sampled list of 20 patients to review with and without the AA tool. The readers were asked to complete 2 tasks: 1. A monitoring task simulating a follow up MRI where the need for gadolinium (Gd) injection would be determined while the patient is in the scanner, and 2. A historical comparison assessment where readers were asked to compare the reference study to two priors and evaluate change in number and size of lesions. Readers were asked to record the time it took to complete each task and to grade their confidence for each case. Average relative differences in reading time and confidence with and without AA were estimated. Statistical significance was calculated for decreased reading time and improved confidence with the AA tool via a one-tailed t-test (p<0.05).

Results
For the monitoring task, AA resulted in a significant reduction in reading time (-24%) without a significant change in reader confidence. For the historical comparison assessment, AA resulted in significant reduction in reading time (-28%) with increased confidence (+19%).

Conclusions
Auto-Align is an effective tool to improve reading efficiency and increase confidence when comparing multiple prior examinations. Utilization of this tool could improve efficiency of radiologists and radiology departments; increase detection of subtle disease evolution over time; and facilitate active patient monitoring, which in turn could decrease gadolinium administration in patients requiring serial follow up examinations.

![MS Patient, comparison of reference scan to prior scan](Filename: TCT_1963_ASNR-Abstract-Pic.jpg)
Effects of biopsy variance on radiomic analysis.

E Diller¹, J Parker¹
¹Indiana University School of Medicine, Indianapolis, IN

Purpose
There is an interest in the field of radiomics and radiogenomics to correlate imaging features with histopathologic features, in attempts to better understand imaging signatures, predict treatment response, and ultimately patient prognosis. Most of the literature draws on data sets that utilize single-location histopathology, failing to account for tumor heterogeneity often observed in higher grade tumors. The purpose of this study was to investigate if multi-location histopathology correlates with prognostic factors with less variance than single-location histopathology.

Materials and Methods
We accessed retrospective data from IVYGap and analyzed biopsy data from 42 patients diagnosed with glioblastoma. Each patient had at least five unique biopsy sections with at least one H&E slide. We randomly selected unique biopsies from each patient, and incrementally increased the number of biopsies multi-location analysis. Eleven H&E features were investigated for correlation to overall survival (OS) and progression free survival (PFS). Statistical tests included Pearson's correlation, and Bartlett's test for equal variances.

Results
For correlation between PFS and H&E feature perinecrotic zone (p=0.036) there was significant variation from the number of biopsies. For correlation between OS and H&E features leading edge (p=0.026), hyperplastic blood vessels in leading edge (p=0.011), and microvascular proliferation (p=0.003) there was significant variation from the number of biopsies.

Conclusions
Radiomic and radiogenomic findings are frequently grounded by H&E features from a single biopsy site. Our results demonstrate that the correlation between H&E features and prognostic measures vary significantly between single and multi-location biopsy.

Automated Extraction of Date and Time from Communication Statements in Free Text Radiology Reports for Use in “Code Stroke” Head CT Quality Control

R Gorniak¹, C Roth¹, A FLANDERS¹
¹Thomas Jefferson University, Philadelphia, PA
Purpose
Accurately measuring interpretation time of head CTs is an important quality metric in acute stroke care where rapid administration of thrombolytics may be necessary and delays in CT interpretation may prolong the time to drug delivery. While the times of preliminary or final report generation are readily available, they do not capture the time of actual result communication. Typically, communication is documented in the report, but is not queryable. An automated method to extract the date and time of communication stated in radiology reports was developed. The success rate and impact on measured time of interpretation was calculated. In addition, utility for detecting errors in communication statements was explored.

Materials and Methods
1,656 reports from head CTs acquired during a "code stroke" in a teaching hospital over the course of 2 years were used. A python script was developed to extract the communication statement from the reports using various communication signal phrases. Preprocessing to optimize date/time detection was performed and the subsequent string was passed to dateutil, an open source python package which can parse most date/time formats. The extracted communication date/time was manually compared to the report to evaluate accuracy and determine error types.

Results
Communication correctly detected in 1244 (75.1%). No communication correctly detected in 327 (19.7%). Error present in 85 (5.1%). Of cases with errors, 4 were related to the inability of the algorithm to detect nonstandard communication statements and 81 were because of erroneous or incomplete communication statements in the report, including wrong date (35), time only (21), typo (13), AM/PM mismatch (10) and blank template (2). Average time from study completion to communication was 9.3 min, to prelim report was 20.5 min, and to final report was 87 min. Of reports with a communication statement, the communication time was earlier than final or prelim time for 1213 studies (97.5%).

Conclusions
This method successfully extracts communication date/time from CT reports. Compared to preliminary or final report time stamps, this more accurately represents the true time of information delivery to the stroke team. Interpretation time based on communication time is typically quicker than times based on prelim or final time stamps. Additionally, this method could be used to automatically detect errors in communication statements and monitor compliance with department policies regarding communication in acute stroke.

Purpose
The human brain is a highly complex nonlinear chaotic system, with multi-scale complex dynamics that are reflected in the resting-
state functional MRI (rs-fMRI) signal. Although rs-fMRI has found extensive research applications, its clinical utility remains limited, partly due to the complexities involved in analysis of the recorded signal and partly due to a dearth of disease-specific data. In this study we attempt to partially address these issues by applying the statistical power of deep neural networks to rs-fMRI data. We develop a model for the unsupervised compression of rs-fMRI data into an interpretable latent space and apply this towards a general framework for the detection and possible localization of anomalies in the brain dynamics underlying the rs-fMRI signal. The hope is that this could eventually be used in the detection and diagnosis of neurological disorders such as epilepsy.

Materials and Methods
We develop an anomaly detection paradigm for rs-fMRI using a novel deep neural network architecture that involves a multi-scale unsupervised recurrent-convolutional variational adversarial generative model with attention. We train our network on normal subject rs-fMRI data from two large independent open-source functional datasets (Human Connectome Project and 1000 Functional Connectomes) in order to learn and model the underlying brain dynamics. We then apply the trained model to functional data from patients with autism spectrum disorder (ABIDE I and ABIDE II datasets) in order to identify and localize disease.

Results
Our neural network is able to successfully model the rs-fMRI signal and compress it into an interpretable latent space. Application of the model to patient data demonstrates that our unsupervised anomaly detection paradigm can achieve near state-of-the-art accuracy similar to supervised models. We show that the latent variable landscape is altered with disease and can be mapped back into anatomic space for potential disease localization.

Conclusions
We develop a novel unsupervised deep learning model for anomaly detection in rs-fMRI data and show that it is able to appropriately model the underlying brain dynamics and successfully detect anomalous signal from patients with autism spectrum disorder with accuracy similar to supervised classification. Our model compresses the data into an interpretable latent space, suggesting that this type of approach might be valuable not only for disease detection but also potentially for localization of lesions and affected networks.

Scientific Abstract Session: Pediatric Spine
1580

Development of Pediatric Spinal Cord White Matter Atlas: Preliminary Analysis

S Shahrampour1, B De Leener2, D Middleton1, M Alizadeh1, L Krisa1, A FLANDERS3, S Faro4, J Cohen-Adad2, F Mohamed1
1Thomas Jefferson University, Philadelphia, PA, 2Poly technique Montreal, Montreal, Quebec, 3THOMAS JEFFERSON UNIVERSITY HOSPITAL, PHILADELPHIA, PA, 4Thomas Jefferson University Hospital, Philadelphia, PA

Purpose
The purpose of this work is two-folds: 1) To create and develop white matter (WM) atlas of pediatric spinal cord. 2) To obtain atlas based normative values of diffusion tensor imaging (DTI) parameters for various white matter tracts of the healthy pediatric spinal cord.

Materials and Methods
DTI data of 10 healthy subjects (6-16 yrs) were acquired at 3T in 2 slabs using inner VO1 spin echo EPI pulse sequence. Acquisition: The parameters for each slab is, FOV=164 mm, phase FOV=28.4% (47 mm), 3 averages of 20 diffusion directions, 6 b0 acquisitions, b=800 s/mm2, voxel size= 0.8x0.8x6 mm3, number of slices =40, TR = 7900 ms, TE=110 ms, acquisition time= 8:49 minutes. Processing: All data were preprocessed using Spinal Cord Toolbox (SCT) [1]. A slice-wise motion correction was performed on all the diffusion images (i.e. smoothing along z axis, outlier detection). The data were then registered to the PAM 50 from SCT toolbox [2]. Next using non-rigid deformations, a series of affine transformations were estimated between the b0 image, the anatomic data and the template. The combined transformations were then used to co-register PAM50, WM atlas to the patient specific space. Quantification: The DTI indices of FA (Fractional Anisotropy) and MD (Mean Diffusivity) were then measured for the following WM tracts: left and right dorsal fasciculus gracilis, dorsal fasciculus cuneatus and lateral corticospinal tract (CST). The values were computed at a single slice centered at the C3 vertebral body. The mean, standard deviation and coefficient of variation (COV) of the measurements were then compared between tracts. An ANOVA test was performed to test the effect of laterality (left/right) and functionality (motor/sensory).

Results
The figure shows WM atlas overlaid onto a b0 image. The selected WM tracts are illustrated in this figure (green(1): right CST, green(2): left CST, dark blue(3): right fasciculus cuneatus, dark blue(4): left fasciculus cuneatus, red(5): right fasciculus gracilis, red(6): left fasciculus gracilis, yellow: gray matter, light blue: unlabeled white matter). Results of ANOVA using FA show no effect for laterality (p=0.74) and no effect for functionality of tracts (p= 0.85).

Conclusions
To the best of our knowledge, this work is the first to create WM atlas of pediatric spinal cord. This method eliminates the need for manual ROI analysis of WM tracts which increases accuracy of the measurements. Future work with a larger cohort as well as assessing other DTI indices (RD and AD) is warranted.

<table>
<thead>
<tr>
<th>Group</th>
<th>WM tracts</th>
<th>FA (Average SD)</th>
<th>MD (Average SD)</th>
<th>MD Coefficient of Variation (CV) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WM right lateral corticospinal tract</td>
<td>0.56 ± 0.09</td>
<td>1.27 ± 0.20</td>
<td>16.2</td>
</tr>
<tr>
<td>2</td>
<td>WM left lateral corticospinal tract</td>
<td>0.80 ± 0.08</td>
<td>1.17 ± 0.14</td>
<td>12.2</td>
</tr>
<tr>
<td>3</td>
<td>WM right fasciculus cuneatus</td>
<td>0.64 ± 0.08</td>
<td>1.34 ± 0.18</td>
<td>15.6</td>
</tr>
<tr>
<td>4</td>
<td>WM left fasciculus cuneatus</td>
<td>0.66 ± 0.08</td>
<td>1.13 ± 0.15</td>
<td>13.5</td>
</tr>
<tr>
<td>5</td>
<td>WM right fasciculus gracilis</td>
<td>0.65 ± 0.06</td>
<td>1.20 ± 0.19</td>
<td>16.4</td>
</tr>
<tr>
<td>6</td>
<td>WM left fasciculus gracilis</td>
<td>0.86 ± 0.07</td>
<td>1.20 ± 0.19</td>
<td>16.4</td>
</tr>
</tbody>
</table>

Table shows the mean, standard deviation and the coefficient of variation.

FA for selected WM tracts

MD for selected WM tracts

(Filename: TCT_1580_final_im.jpg)
CSF-lymphatic Fistula as an Etiology of Spontaneous Intracranial Hypotension in a Pediatric Patient with History of Kaposiform Lymphangiomatosis

K SODERLUND1, M Mamlouk2, V Shah3, W Dillon4
1UCSF MEDICAL CENTER, MILL VALLEY, CA, 2N/A, Dublin, CA, 3University of California San Francisco, San Francisco, CA, 4Univ of California, San Francisco Med Ctr, San Francisco, CA

Purpose
- Highlight CSF-lymphatic fistula as a rare etiology of SIH in a child - Demonstrate the importance of a systematic approach to localization of spinal CSF leaks in patients with SIH, to include dynamic CT myelography

Materials and Methods
A 9 year-old ex-full-term female with remote history of kaposiform lymphangiomatosis presented with chronic headaches. She first reported intermittent positional headaches at age 6 years. Brain imaging in June 2019 showed findings of intracranial hypotension, which was proposed as an etiology for her chronic headaches. Conventional CT myelography did not localize a site of CSF leak. Dynamic CT myelography performed with the patient prone showed rapid filling of a CSF lymphatic fistula at right T10-T11 nerve root sleeve, communicating with a lymphovascular structure in the right T10-T11 epidural and paraspinal space, which in turn communicated with the thoracic duct. Her CT findings are compatible with a CSF-lymphatic fistula, we believe causing the patient's chronic headaches and imaging findings of intracranial hypotension. The patient underwent surgical ligation of her right T10 nerve root. The patient continued to have headaches after surgery, but at the time of abstract submission, the patient is still only two weeks out from surgery and her long term course is yet unknown.

Results
MRI brain and spine without contrast: imaging findings of intracranial hypotension with brainstem slumping, venous engorgement, and low-lying cerebellar tonsils; no findings to suggest a spinal leak identified in the spine Dynamic CT myelogram: large CSF-lymphatic fistula arising from the right T10-T11 neural foramen, contiguous with the thoracic duct.

Conclusions
SIH in children is rare, and most commonly due to ruptured meningeal diverticula and dural ectasia (1). CSF-lymphatic fistulas as an etiology for spinal CSF leaks are exceedingly rare. A case report by Adler et al (2) describes 1 known case of intra-osseous CSF-lymphatic fistula. To our knowledge, additional cases have not been reported. However, association of "Chiari 1 malformation" in patients with Gorham disease have been reported. We assume the underlying pathophysiology related to prior kaposiform lymphangiomatosis is responsible for the CSF-lymphatic fistula in this child. Our case highlights this rare entity and demonstrates the importance of the use of multimodality imaging and dynamic CT myelography for localization of spinal CSF leaks.

Imaging and Management of Iatrogenic Pseudoaneurysm and Arteriovenous Fistula in a Neonate Post Lumbar Puncture

J Kang1, M Ngo1
Purpose
Known complications of traumatic lumbar punctures include epidural hematoma and subarachnoid hemorrhage. This case highlights the first reported instance of traumatic spinal pseudoaneurysm and arteriovenous fistula detected on neonatal spinal ultrasound. Herein, we will review the imaging findings and discuss the management of these rare complications of a traumatic lumbar puncture in a pediatric patient.

Materials and Methods
We present a 19-day-old full-term male who was admitted for fever of unknown origin. As part of the infectious initial infectious work-up, several lumbar punctures were attempted, but were unsuccessful at obtaining CSF. Subsequently, a diagnostic spinal ultrasound was performed to evaluate the lower spinal canal anatomy and contents which demonstrated an extramedullary vascular mass at the L3 level. CT angiography and MRI of the spine confirmed the presence of a pseudoaneurysm. Conventional spinal angiogram revealed two separate lumbar arteries supplying a pseudoaneurysm and an AVF, which were successfully embolized with Onyx.

Results
US demonstrated an anechoic extramedullary lesion with the spinal canal at L3. Doppler images demonstrated pulsatile, to-and-fro flow within the lesion, supplied by a vascular structure in the ventral epidural space. CT angiography, MRI, and conventional angiography confirmed the presence of a pseudoaneurysm and arteriovenous fistula in the spinal canal supplied by a lumbar artery radicular branch.

Conclusions
This is the first reported instance of a post-traumatic intraspinal pseudoaneurysm and arteriovenous fistula demonstrated on a neonatal spinal ultrasound.
Spinal Epidural Edema: A Common Finding in Imaged Newborns

A Ceylan¹, C Ozutemiz², H Huang², N Rubin², D Nascene³
¹Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, NA, ²University of Minnesota, Minneapolis, MN

Purpose
The posterior epidural space is an anatomical space which contains mostly fat and blood vessels. We noted a number of spinal MRIs demonstrating T2-hyperintense thickening of the posterior epidural space of the cervical and thoracic spine in newborns after birth that resembles an epidural hematoma in an adult. To our knowledge, there is no study that explains this entity. Our aim is to describe the appearance and frequency of this finding and explore any possible associations.

Materials and Methods
Retrospectively, spinal and brain MRIs of 194 newborns, obtained within 1 week of life, were evaluated by a resident and attending neuroradiologist using sagittal T2 and STIR sequences. 103 were excluded for the following reasons: motion (39), incomplete spine imaging (37), lack of sagittal T2WI/STIR (23) or lack of clinical data(4). Presence of T2 hyperintense edema in the spinal epidural space was assessed. The thickness of the spinal canal and epidural collection in the cervical/thoracic spine were measured. A research fellow evaluated the electronic medical records for birth history involving patient gender, gestational age, birth method, fetal position, birth complication, maternal age and neurologic sequelae. Clinical characteristics of the two groups with and without fluid collections were compared. Student t-test is used for numeric variables and chi-square test is used for categorical values. Follow-up exams were evaluated if available.

Results
A posterior epidural T2-hyperintense collection/edema was present in 56 (61%) of 91 included patients. A difficult delivery history was significantly higher in the group with posterior fluid collection (47% vs 25%, P=0.04). Spinal canal diameter was similar in both groups (P=0.35). Mean thickness of the epidural collection was 2.4 mm (0.7-8mm) in positive cases. No difference was found between groups regarding gender, gestational age, birth weight, birth method, fetal position, birth complication, mother age and neurological sequelae (P>0.05). In 7 of 8 cases with follow up imaging, the epidural collections completely resolved. In one child imaged at 3 months, an epidural collection persisted, but decreased from 3 mm to 1.3 mm.

Conclusions
T2 hyperintense thickening of the cervical and thoracic posterior epidural space is often seen in the newborns immediately after birth (61% in our sample), and is significantly more frequent in those cases with difficult delivery history.

Spontaneous Epidural Hemorrhage during MRI

A MCALLISTER¹, J Jones², E Sribnick³
¹1637
Purpose
Display a case of an accumulating spontaneous epidural hematoma of the upper thoracic spine. The accumulation of the hematoma was directly observed during an MRI examination.

Materials and Methods
A 12 year old female presented to the ED with acute on chronic mid thoracic back pain with new onset numbness and tingling in the thorax and lower extremities. Prior to MRI, she was ambulatory. An MRI examination of the thoracic and lumbar spine was ordered. During the examination she reported increased pain and had excessive motion. Following this period of increased pain, sequences demonstrated a new upper thoracic epidural collection, compressing the spinal cord, which was not visible on the images obtained earlier in the exam. Following imaging, the patient was noted to have new onset lower extremity weakness and was not able to stand. The patient was taken emergently to the operating room for C7 right hemilaminectomy, T1-T3 bilateral laminoplasty, and T4 right hemilaminectomy for evacuation of the epidural hemorrhage. Her paresthesias and weakness returned to baseline following the surgery. Multiple spinal catheter angiograms have failed to demonstrate a cause for the hemorrhage. A coagulopathic workup was normal. She has had no recurrence to date and is now neurologically intact on exam.

Results
Images obtained early in the examination, sagittal T2 (A) and Sagittal T1 (B), demonstrate mild heterogeneity in the epidural space (Yellow arrow and green arrows), but no large epidural collection. Images obtained after a reported event of acute worsening of pain/excessive motion during the same examination, sagittal STIR (C) and Sagittal T1 post contrast (D), demonstrate the interval development of a large epidural hematoma extending from the C6-C7 disc space through T4 resulting in thoracic spinal cord compression (blue and white arrows).

Conclusions
Imaging appearance of an accumulating spontaneous spinal epidural hematoma during an MRI exam.
cohort were compared to an external cohort used to develop prediction rules for surgical intervention. External validity of the prediction rules was assessed.

Results
195 eligible subjects were included in the study, 37 of whom failed observation and required surgery while 158 underwent successful observation. The surgical cohort had significantly thicker (p<.001) and higher volume (p<.001) EDH, increased midline shift (p<.001) and higher likelihood of mass effect (p<.001). There was a significantly higher residual neurologic deficit rate (54% versus 23%, p<.001) and in-hospital mortality (5% versus 0%, p=.035) amongst the surgical group. There were significant differences in patient demographic, clinical and imaging characteristics between the internal and external cohorts. Using the predictive rules externally developed yielded a positive predictive value of 97.7% (95% CI=93.3-99.5%), negative predictive value of 24.5% (95% CI=16.2–34.4%), specificity of 88.5% (95% CI=69.9–97.6%), and a sensitivity of 63.8% (95% CI=56.6–70.5%) for successful observational therapy.

Conclusions
The current study validates previously developed prediction rules for safe observation of pediatric EDH in a cohort with distinct characteristics from the external cohort. Specifically, patients with no mass effect, EDH volume <15 mL and no neurological deficits are at low likelihood to fail observation.

(Filename: TCT_1279_algorithm.jpg)

1274
11:42AM - 11:48AM

Retroclival Epidural Hematoma in Pediatric Trauma Patients is a Sign of Tectorial Membrane Stripping Injury
Purpose
A traumatic retroclival epidural hematoma is a rare sign of significant cervical flexion-extension injury in the pediatric population. The purpose of our study was to identify pediatric patients with a retroclival epidural hematoma, record the hematoma size and extent, and examine the major cranio cervical ligaments for injury.

Materials and Methods
Pediatric patients who suffered a retroclival epidural hematoma were identified retrospectively using the keywords 'clivus,' 'epidural hematoma,' and 'retroclival' included in head CT reports between 2012 and 2018 using Nuance mPower software. The cervical and brain MRI exams for these patients were reviewed for cranio cervical ligament injury by two CAQ certified neuroradiologists. Detailed descriptions of patient injuries were recorded along with demographic information, clinical history, patient management, and outcome.

Results
Ten pediatric patients were identified with an acute, post-traumatic retroclival epidural hematoma with an average anteroposterior size of 4.4 mm and craniocaudid size of 4.3 cm. All of our patients with a retroclival epidural hematoma demonstrated either a stripping (90%) or partial stripping (10%) injury of the tectorial membrane. Disruption of the additional major cranio cervical ligaments (alar ligament, transverse ligament, longitudinal ligaments and ligamentum flavum) was relatively rare with the most common associated ligament injuries involving the anterior atlanto-occipital membrane, apical ligament, and interspinous ligaments. None of our patients suffered a cervical cord injury and additional significant intracranial trauma was uncommon. The majority of patients were managed conservatively with excellent clinical outcomes.

Conclusions
A post-traumatic retroclival epidural hematoma in the pediatric population is a rare injury often identified initially by head CT and easily overlooked by the radiologist. We propose that a retroclival epidural hematoma in the pediatric population is a direct result of a significant flexion-extension force with a subsequent stripping injury of the tectorial membrane from the posterior clivus. Pediatric patients with a post-traumatic retroclival epidural hematoma on initial head CT should undergo cervical MRI to evaluate the integrity of the tectorial membrane and other cranio cervical ligaments.

2631

Predicting Outcomes in Pediatric Cranio cervical Dissociation

A Yeo1, A Munoz1, J Baerg1, U Oyoyo1, B Bartnik-Olson1, P KIM1, S Harder1
1Loma Linda University Medical Center, Loma Linda, CA

Purpose
Cranio cervical dissociation (CCD) is an injury with significant morbidity and mortality. The cranio cervical junction is a complex region with various measurements for determining abnormalities in the settings of trauma. Chang et al found increased accuracy in detection of CCD by adding the bilateral atlanto-occipital intervals in adults. We hypothesize that an atlanto-occipital interval sum (AOI index) greater than or equal to 7 mm would predict a poor outcome in the pediatric trauma population.

Materials and Methods
We retrospectively selected pediatric patients with history of CCD, diagnosed between January 2004 and July 2016. The CT AOI index was obtained. Survivors and non-survivors were compared with death as an endpoint using simple descriptive statistics and correlations analysis.

Results
Twenty-five pediatric patients with CCD were identified; Sixteen survived (64%) and nine died (36%). Of the sixteen survivors, twelve patients had AOI of < 7 mm and four patients had AOI >= 7 mm. Of the 9 deceased patients, two patients had AOI of < 7 mm and seven patients had AOI >= 7 mm. Odds ratio calculated for AOI index < 7 mm are 10.5 times more likely to survive when compared to patients with AOI index >= 7 mm (95% CI 1.5-72.81)

Conclusions
An AOI index of >= 7 mm is a indicator of poor prognosis in the setting of pediatric CCD.

Scientific Abstract Session: Spine Degenerative & Imaging Techniques

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Characterizing Cortical Alterations and Functional Reorganizations in Patients with Cervical Spondylotic Myelopathy

C Wang1, L Holly2, T Oughourlian1, J Yao1, C Raymond1, N Salamon3, B Elingson1
1, 2, 3: University of Florida College of Medicine - Jacksonville, Jacksonville, FL

Purpose
A traumatic retroclival epidural hematoma is a rare sign of significant cervical flexion-extension injury in the pediatric population. The purpose of our study was to identify pediatric patients with a retroclival epidural hematoma, record the hematoma size and extent, and examine the major cranio cervical ligaments for injury.

Materials and Methods
Pediatric patients who suffered a retroclival epidural hematoma were identified retrospectively using the keywords 'clivus,' 'epidural hematoma,' and 'retroclival' included in head CT reports between 2012 and 2018 using Nuance mPower software. The cervical and brain MRI exams for these patients were reviewed for cranio cervical ligament injury by two CAQ certified neuroradiologists. Detailed descriptions of patient injuries were recorded along with demographic information, clinical history, patient management, and outcome.

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Conclusions
A post-traumatic retroclival epidural hematoma in the pediatric population is a rare injury often identified initially by head CT and easily overlooked by the radiologist. We propose that a retroclival epidural hematoma in the pediatric population is a direct result of a significant flexion-extension force with a subsequent stripping injury of the tectorial membrane from the posterior clivus. Pediatric patients with a post-traumatic retroclival epidural hematoma on initial head CT should undergo cervical MRI to evaluate the integrity of the tectorial membrane and other cranio cervical ligaments.

2631

Predicting Outcomes in Pediatric Cranio cervical Dissociation

A Yeo1, A Munoz1, J Baerg1, U Oyoyo1, B Bartnik-Olson1, P KIM1, S Harder1
1Loma Linda University Medical Center, Loma Linda, CA

Purpose
Cranio cervical dissociation (CCD) is an injury with significant morbidity and mortality. The cranio cervical junction is a complex region with various measurements for determining abnormalities in the settings of trauma. Chang et al found increased accuracy in detection of CCD by adding the bilateral atlanto-occipital intervals in adults. We hypothesize that an atlanto-occipital interval sum (AOI index) greater than or equal to 7 mm would predict a poor outcome in the pediatric trauma population.

Materials and Methods
We retrospectively selected pediatric patients with history of CCD, diagnosed between January 2004 and July 2016. The CT AOI index was obtained. Survivors and non-survivors were compared with death as an endpoint using simple descriptive statistics and correlations analysis.

Results
Twenty-five pediatric patients with CCD were identified; Sixteen survived (64%) and nine died (36%). Of the sixteen survivors, twelve patients had AOI of < 7 mm and four patients had AOI >= 7 mm. Of the 9 deceased patients, two patients had AOI of < 7 mm and seven patients had AOI >= 7 mm. Odds ratio calculated for AOI index < 7 mm are 10.5 times more likely to survive when compared to patients with AOI index >= 7 mm (95% CI 1.5-72.81)

Conclusions
An AOI index of >= 7 mm is a indicator of poor prognosis in the setting of pediatric CCD.
Purpose
Progressive cervical cord compression leads to cervical spondylotic myelopathy (CSM), which is manifested by motor dysfunction, sensory loss, and neck pain, ultimately decreasing independence and quality of life. It has already been demonstrated that CSM will result in upstream microstructural damages. We hypothesized that, in response to cortical alterations, neurological function is preserved by cerebral reorganizations and that such changes are associated with symptom severity, as measured by the modified Japanese Orthopedic Association score (mJOA) and the neck disability index (NDI).

Materials and Methods
Diffusion spectral imaging (DSI) of 49 CSM patients (mean age 58) and 28 healthy controls (HCs, mean age 36.2) were collected. In addition, 36 out of 49 CSM patients and 17 out of 28 HCs underwent a rs-fMRI protocol. We evaluated regional differences in DSI measurements between CSM patients and HCs, as well as Pearson correlations of DSI measurements with symptom severity. Analysis of rs-fMRI was also performed to investigate the association of functional connectivity (FC) and NDI. Significance was set at P<0.05.

Results
Generally, lower generalized fractional anisotropy (GFA) values were observed in CSM patients in microstructures responsible for sensory and motor integration (Fig. A), including the cerebellar and cerebral peduncles, the genu and splenium of the corpus callosum, and certain fiber tracts. In addition, CSM patients showed higher normalized quantitative anisotropy (NQA) values in the body and the splenium of the corpus callosum and along the corona radiata, but lower NQA values in the genu of the corpus callosum and along the posterior thalamic radiation fibers (Fig. B). Correlation analysis demonstrated functional reorganization occurred in response to structural alterations, where increased FC was associated with worsened neck disability within the bilateral post- and precentral gyri, and SMA (Fig. C), and decreased NQA values were associated with increased mJOA scores along representative fibers, such as the right cingulum and the right posterior corona radiata (Fig. D).

Conclusions
CSM patients with neurological impairment experience cortical alterations and functional reorganization in cerebral white matter fibers. The evaluation metrics proposed in this observational study may serve to quantitatively reflect the pathological conditions of the spinal cord, thus providing imaging biomarkers that more reliably predict a patient's long-term prognosis.
Cortical Alterations and Functional Reorganization in Patients with Cervical Spondylosis Following Surgical Decompression

S Islam1, C Wang1, L Holly2, N Salamon3, B Ellingson1
1University of California, Los Angeles, Los Angeles, CA, 2University of California, Los Angeles, Santa Monica, CA, 3UCL, Los Angeles, CA

Purpose
Cervical spondylosis (CS) can result in compression of the spinal cord, causing long-term neurological impairment and persistent neck pain. Early intervention, based on imaging features, has been frequently advocated to avoid further neurological deterioration. However, the cortical changes and functional reorganization following surgical decompression remain unknown. We hypothesized that patients who have undergone surgical decompression will show reduced functional reorganization as well as increased cortical thickness.

Materials and Methods
3D T1 MRI scans were collected from 16 neurologically intact, healthy volunteer (HCs; mean age=29.4), 20 asymptomatic patients...
(Asy; mean age=60.7; mJOA=18), and 14 patients who underwent surgery (Post-Op; mean age=50.4). Cortical thickness was calculated using a statistical paired/unpaired T-test to identify the significant structural changes associated with surgical decompression. In addition, resting-state fMRI data were also collected and processed to identify reorganization in functional connectivity (FC). Significance was set at P<0.05.

Results
No significant differences in cortical thickness were identified between Post-Op CS patients and HCs, but following surgery both the lateral occipital and medial temporal cortices were thinner in the Post-OP CS patients than in the asymptomatic CS patients (Fig. A). When compared to HCs, the asymptomatic CS patients exhibited greater cortical atrophy within the caudal and rostral middle frontal cortices, and the lateral and medial orbitofrontal cortices, greater cortical strengthening in the temporal, supra marginal, lingual and parahippocampal cortices (Fig. B). The paired t-test of CS patients showed that those who underwent surgery exhibited thicker cortices (Fig. C) and increased FC (Fig. D) within regions responsible for memory, language, and visual processing, such as the cuneus, the lingual cortex, and the orbitofrontal cortex.

Conclusions
CS patients displayed cortical thickness and functional connectivity changes following surgery. Obtained quantifiable metrics, which can serve as potential biomarkers in predicting patient's response to therapy, highlight that early intervention is essential to successfully avoiding further neurological deterioration.

(Filename: TCT_2371_PrePost.jpg)
Purpose
Inter-body graft subsidence can be a sign of vertebral body fusion failure. It has been shown that the type of interbody graft used can contribute to subsidence [1]. We hypothesize that bone mineral density (BMD) can also contribute to subsidence, and that patients with decreased bone mineralization (osteopenia/osteoporosis) may have an increased incidence of graft subsidence.

Materials and Methods
Retrospective review of patients who underwent discectomy and interbody fusion between 1/2009-10/2019. Graft subsidence was graded according to modified Marchi criteria[2] with no subsidence scoring 0, minor subsidence scoring 1, major subsidence scoring 2; minor (Marchi 0/I) and major (Marchi II/III). Cases of graft subsidence were assessed in the context of DEXA derived T-scores from either pre-operative or post-operative imaging within a 12-mo. timeframe. Association of subsidence among the three BMD groups was assessed using the Chi-square test for independence. The severity of subsidence among the three BMD groups was assessed using the Kruskal-Wallis test, with Dunn's multiple comparisons post-test also performed.

Results
4863 patients had interbody fusion in the study's timeframe, of which 58 had a pre-operative or post-operative DEXA scan within a 12-mo. timeframe for the evaluation of BMD and fracture risk. Of the 58 patients, 18 had normal BMD for age, 22 were osteopenic, and 18 were osteoporotic. Among the BMD groups, there was graft subsidence in 1 patient within the normal BMD group, 7 in the osteopenia group, and 15 in the osteoporosis group. Chi-square test for independence demonstrated a statistically significant association between presence of subsidence and BMD (P<0.0001). Mean subsidence severity scores for the normal, osteopenia, and osteoporosis groups were 0.06, 0.32, and 1.28, respectively. There were statistically significant differences among the severity of subsidence in the three BMD groups, with statistically significant differences between the normal/osteopenia groups versus the osteoporosis group (P<0.001). There was no statistically significant difference in severity of subsidence between the normal and osteopenia groups, however (P>0.05) (Fig.2).

Conclusions
There is an association between subsidence and bone mineral density. Severity of subsidence is statistically greater in patients with osteoporosis as compared to those with normal BMD/osteopenia.

Transitional Lumbosacral Anatomy: An Independent Assessment of Proposed Enumeration Systems

P Rabiei¹, S Khanpara¹, L Ocasio¹, R Riascos¹, K WESTMARK²
¹The University of Texas Health Science Center at Houston, Houston, TX, ²The University of Texas Health Science Center at Houston, HOUSTON, TX

Purpose
Vertebral segmentation anomalies are a major factor in wrong-level spine surgery. Although whole-spine imaging (WSI) allowing vertebral segment enumeration (VSE) from C2 caudally is considered the "gold-standard", it is often not obtained with lumbosacral spine MRIs (LS-MRI). So how diagnostic are the VSE methods that do not rely on WSI in detection of vertebral anomalies?

Materials and Methods
This is a retrospective analysis of 313 adult patient LS-MRIs and whole-body CT scans (WBCT), performed independently by 3 neuroradiologists, to evaluate for transitional anatomy and enumerate vertebrae on LS-MRI using the iliac crest tangent sign (ICTS) 1 and L5 nerve root morphology (L5NRM) 2 to identify the 24th segment. Comparison was made to original imaging reports and the gold standard enumeration. (Figure. 1)

Results
Of 313 patients, only 81% were modal with 24 PSV and no transitional vertebrae. 36 (11.5%) had a non-modal number of PSV, most
commonly complete lumbarization of S1 resulting in 25 PSV (3.8%). LS transitional anatomy was present in 12%, most commonly partial sacralization of L5 (7.3%). In 6%, the number of PSV was non-modal with an otherwise normal appearing lumbosacral junction. Patients with lumbosacral transitional vertebrae (LSTV) had a 6X increase incidence of an anomalous number of PSV. Use of L5NRM to identify the 24th segment was inconclusive in 8.6% of patients due to anatomic or technical factors with respective accuracy, sensitivity and specificity of 99%, 85% and 100% if 23 PSV; 97%, 98% and 84% if 24 PSV; and 97%, 84% and 98 if 25 PSV were present. The ICTS had a high specificity (95%) for S1 lumbarization but lacked sensitivity (59.3%). Original LS-spine MRI reports failed to note transitional anatomy in 67%. In 45% of the cases, both CT and MRI reports incorrectly enumerated vertebrae relative to the gold standard and 52% of reports noting transitional anatomy did not emphasize the variant in the conclusion.

Conclusions

Although whole-spine imaging with enumeration from C2 caudally continues to be the gold-standard for VSE, L5NRM is very helpful in confirming the identity of the 24th segment regardless of segmentation anomalies. The ICTS was highly specific for S1 lumbarization, however it lacked sensitivity and was less accurate than L5NRM. LS-spine MR reports frequently failed to identify LSTV and incorrectly enumerated vertebrae.

(Filename: TCT_2508_LSTV.jpg)
even when LSTV were identified, the vertebrae were incorrectly numbered almost a third of the time. Using these parameters to create a standard algorithm using AI/machine learning may have value in improving the accuracy of vertebral numbering.

Feasibility of 3D Broadband IR-prepared Ultrashort Echo-time Bone Imaging for Evaluation of Ossification of the Posterior Longitudinal Ligament

M Azuma¹, T Hirai¹, Z Khant¹, M Yoneyama²
¹Miyazaki University, Miyazaki, Miyazaki, ²Philips Japan, Tokyo, Tokyo

Purpose
Magnetic resonance (MR) bone imaging using an ultrashort echo-time (UTE) has gained attention for the detection and assessment of bone pathology as an alternative to computed tomography (CT). We evaluated the feasibility of 3D broadband inversion-recovery-prepared UTE (3D IRP UTE) bone imaging for assessing ossification of the posterior longitudinal ligament (OPLL).

Materials and Methods
The study population consisted of 18 consecutive patients with cervical and/or thoracic OPLLs (9 women, 9 men; age range 47-86 years; mean age 68 years). They underwent CT studies and 3T 3D IRP UTE bone imaging. The latter is based on an IR-prepared segmented multispoke UTE 3D stack-of-stars radial turbo field echo (TFE) sequence. The imaging parameters were sagittal or coronal acquisition, voxel size = 1.4 x 1.4 x 2.5 mm, field-of-view = 400 x 400 mm, TFE shot interval = 250 ms, flip angle = 16°, turbo factor = 11, TR/TE = 2.6/0.09 ms, TI = 84 ms, and total acquisition time = 7 - 10 min depending on the body habitus. Sagittal multiplanar reconstructed images were generated for 3D IRP UTE bone imaging and CT. Two readers independently reviewed the 3D IRP UTE bone images for the type of OPLL (continuous, segmental, mixed, localized). Interobserver and intermodality agreement was assessed by κ statistics and the confidence interval (CI).

Results
On CT scans, continuous (n=1), segmental (n=5), mixed (n=10), and localized types (n=2) were identified for OPLL classification. Interobserver agreement was good for the OPLL type (κ = 0.80; 95% CI, 0.62-0.99). Intermodality agreement was also good (κ = 0.71; 95% CI, 0.44-0.98).

Conclusions
For the assessment of OPLL, the information yielded by 3D IRP UTE bone imaging and CT is similar. Our preliminary study suggests that 3D broadband IR-prepared UTE bone imaging may be useful for assessing OPLL.
Purpose
Whole spine MRI (WS-MRI), consisting of concurrent imaging of the cervical, thoracic, and lumbar spine, is a topic of heightened interest due to uncertainty regarding its value. Here, for the first time, we explore the utility of WS-MRI in the context of multimodality imaging in the ED at two large tertiary care centers in the Northeast.

Materials and Methods
Records of 356 patients who received a WS-MRI and who underwent at least 1 additional imaging modality in the evaluation of the spine (e.g. CT, X-ray), were reviewed. In brief, the % of patients, stratified by chief complaint (CC) and physical examination findings (PE), in whom the major finding on WS-MRI differed from major findings across other imaging modalities, was calculated. A major finding was that of the highest clinical significance in the Impression of the radiological report. These subsets were further stratified into patients who were admitted for a spine-related issue and those who were not (discharged, admitted for a non-spinal issue).

Statistical analyses consisted of the cumulative distribution function (CDF) or complement of the distribution function (CCDF).

Results
The following is %s of patients admitted to the hospital for a spine-related issue, stratified by CC and PE, in whom the major finding on WS-MRI differed from that on other modalities: CC "fever/infection" (0%), CC "pain" (21%), CC "sensory" (21%), CC "trauma" (31%), CC "bowel/bladder" (43%); PE "none/normal" (17%), PE "tenderness" (22%), PE "sensory" (44%), and PE "motor" (44%). Of these, PE "tenderness" (p<0.01) and "none/normal" (p<0.05), were statistically significantly low %s (differences in major findings between WS-MRI and other modalities were lower than expected by chance). "Motor" abnormality, both as CC and PE, and "bowel/bladder" on PE, were found to be statistically significantly high %s (p<0.05 & p<0.001, respectively). Conversely, in 52% of patients with CC "pain," or in 51% with "tenderness" or 60% with normal findings on PE, WS-MRI failed to reveal an additional major finding, regardless of disposition. A notable outlier was "bowel/bladder" on PE, in which in only 11% of cases did WS-MRI fail to reveal an additional major finding (p<0.05).

Conclusions
WS-MRI in the ED may be overutilized, although in those with motor and/or bowel/bladder abnormalities, it is more likely to be of...
value. While WS-MRI may play an important exclusionary role in the ED, in certain clinical settings, less resource-intensive studies may be substituted to the same end.

### Table 1: Percentages of patients in whom WS-MRI revealed additional major findings

<table>
<thead>
<tr>
<th>Chief Complaint (CC)</th>
<th>% No Additional Findings from MRI</th>
<th>% Additional Findings without Spine Admission</th>
<th>% Additional Findings with Spine Admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>51.5</td>
<td>27.3</td>
<td>21.2</td>
</tr>
<tr>
<td>Sensory</td>
<td>42.9</td>
<td>35.7</td>
<td>21.4</td>
</tr>
<tr>
<td>Motor</td>
<td>40.9</td>
<td>4.5 (†)</td>
<td>54.5 (*)</td>
</tr>
<tr>
<td>Bowel/Bladder</td>
<td>42.9</td>
<td>14.3</td>
<td>42.9</td>
</tr>
<tr>
<td>Fever/Infar</td>
<td>50.0</td>
<td>50.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Trauma</td>
<td>47.7</td>
<td>21.5</td>
<td>30.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Exam Finding (PE)</th>
<th>% No Additional Findings from MRI</th>
<th>% Additional Findings without Spine Admission</th>
<th>% Additional Findings with Spine Admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenderness</td>
<td>51.2</td>
<td>26.7</td>
<td>22.1 (††)</td>
</tr>
<tr>
<td>Sensory</td>
<td>43.5</td>
<td>13.0</td>
<td>43.5</td>
</tr>
<tr>
<td>Motor</td>
<td>38.9</td>
<td>16.7</td>
<td>44.4 (*)</td>
</tr>
<tr>
<td>Bowel/Bladder</td>
<td>11.1 (†)</td>
<td>0.0</td>
<td>88.9 (***))</td>
</tr>
<tr>
<td>None</td>
<td>60.0</td>
<td>22.9</td>
<td>17.1 (†)</td>
</tr>
</tbody>
</table>

† = p < 0.05; †† = p < 0.01 by CDF. * = p < 0.05; *** = p < 0.001 by CCDF. CDF assesses for the significance of a negative association, i.e. the low percentage of patients with tenderness on PE who have additional findings from WS-MRI and are subsequently admitted for a spine-related issue is statistically significant. Conversely, CCDF assesses for the significance of a positive association, i.e. the high percentage of patients who had additional findings from WS-MRI who were subsequently admitted for a spine-related issue was statistically significant.

(Pilename: TCT_2245_Slide1.jpg)

### Aging and Degenerative Lumbar Spine Disease: a Population-Based Substudy

J Puig1, J Vilanova2, C Biarnes2, R Ramos-Blanes3, J Garre-Olmo4, R Pamplona5, E Camacho-Ramos6, A Jimenez-Pastor6, A Alberich-Bayarri6, M Essig7, S Pedraza2

1IDI-IDIBGI, Girona, Spain, 2IDI-IDIBGI, Girona, 3IDI-Girona, 4IDIBGI, Girona, 5IDIBGI-IAS, Girona, 6University of Lleida-IRBLleida, Lleida, Lleida, 6QUIBIM, Valencia, Valencia, 7University of Manitoba, Winnipeg, Manitoba

**Purpose**

Relentless changes associated with aging progressively affect the entire spine, especially the lumbar segment. The process of aging starts in the disc, and a complex interplay of biochemical and biomechanical factors create a cycle in which degenerative lumbar spine disease (DLSD) progressively develops. Magnetic resonance (MR) imaging, the main tool for evaluating DLSD, shows the status of disc and bone and their impact on foraminal/spinal canal stenosis. We evaluated DLSD according to age and sex in a substudy of a population-based study.

**Materials and Methods**

We recruited participants ≥50 years for a population-based study with the aim of creating a large repository of whole-body MR images to enable us to assess associations between imaging phenotype measures and a wide range of biopsychosocial and cardiovascular parameters as well as metabolomics, lipidomics, microbiomics, frailty, and other changes related to aging. All imaging studies were obtained on a 1.5 T MRI system (Vantage Elan, Canon Medical Systems, Japan); two radiologists assessed sagittal T2-weighted images for 10 degenerative findings (disc hydration, disc space height, high intensity zone, disc herniation, endplate changes, bone...
marrow changes, foraminal stenosis, canal stenosis, facet joint degeneration, and spondylolisthesis) at all lumbar levels by 2 radiologists. Participants were grouped by age (50-64, 65-74, and ≥75 years).

Results
We included 780 participants [56% men; mean age 67.1±6.5 years (range 50-84 years)]. The prevalences of the following degenerative findings (reported as men/women aged 50-64 years, 65-74 years, ≥75 years) were: complete disc dehydration (28%/31.5%, 33%/32%, 37%/56%), severely reduced disc space height (16%/20%, 19%/20%, 20%/15%), diffuse endplate changes (6%/10%, 11%/8%, 15%/4%), anterolisthesis (15%/17.5%, 15.5%/23%, 30%/51%), retrolisthesis (15%/9%, 17%/13%, 11%/2%), severe canal stenosis (1%/0%, 3.5%/2.5%, 8%/2%), and compressive foraminal stenosis (8%/5%,15%/8%, 18%/9%).

Conclusions
Most DLSD features are more prevalent in men than in women, especially after 75 years. Anterolisthesis is more prevalent in women and retrolisthesis in men. Early MR features of DLSD and sex-related differences can be used as biomarkers of biological age; as age is a major risk factor for many degenerative diseases, these biomarkers could be used to identify individuals with increased risk of developing age-associated diseases or disabilities.

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Outcomes of Vertebral Augmentation for the Treatment of Osteoporotic Vertebral Compression Fractures Among the Commercially Insured

M O'Reilly1, L Gold1, D Kallmes2, P Heagerty1, J Jarvik1
1University of Washington, Seattle, WA, 2Mayo Clinic, Rochester, MN

Purpose
750,000 people/yr in the U.S. sustain osteoporotic vertebral compression fractures (OVCF). Vertebroplasty and kyphoplasty, collectively termed vertebral augmentation (VA), continue to be utilized as treatments for OVCF. Since 2009 strong evidence has emerged challenging the efficacy of vertebroplasty.(1) Kyphoplasty does not have a compelling evidence base to support/reject its use. Prior publications have examined the role of VA primarily in over 65's. Notably, there is a knowledge gap regarding VA in younger patients.

Materials and Methods
We used retrospective propensity matched analysis of patients with OVCF in the IBM MarketScan® Database of Americans with employer-provided health insurance from 2008-2017. 149 million individuals were screened to identify acute thoracic and lumbar OVCF using ICD-CM 9/10 codes excluding those with confounders such as neoplasm, infection or recent transportation accidents. We compared those treated with VA versus no VA matched based on age, gender, region, year of fracture, comorbidities, hospital admission at index fracture, and prior pain medication usage. We assessed 1year rates of major medical complications, opioid medication usage and total resource utilization after VA and an analogous date in the control group.

Results
After exclusions we identified 14,995 patients with OVCF with 2556 (17%) treated with VA. After propensity score development we selected 2308 matched pairs with an average age of 57. The median time from fracture to VA was 18 days (IQR 5-43). Rates of major medical complications were similar between VA and controls (16.4% vs 16.9%; OR, 0.9; 95% CI, 0.7-1.1). One-year post procedure opioid medication prescriptions were significantly higher in those treated with VA (58% vs 51%; OR, 1.4; 95% CI, 1.2-1.7). Median post procedure total resource utilization was higher in the VA group at $25,700 vs $21,800.

Conclusions
VA is used in younger patients with OVCF. We used propensity score matching in an attempt to reduce the bias due to confounding or selection of intervention. Those treated with VA had similar rates of major medical complications. Although a purported benefit of VA is pain relief, those treated were statistically significantly more likely to have been prescribed opioids. Total resource utilization (excluding procedure costs) are also much higher in the VA group. In summary, younger patients with osteoporotic spine fractures undergoing VA use more opioids and incur higher medical costs post fracture than similar patients not getting VA.

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Bias in Machine Learning: Using Stroke Imaging as Test bed

S Ghaderi Niri1, Y Xie2, M Wintermark1, G Zaharchuk2
1Stanford University School of Medicine, Stanford, CA, 2Stanford University, Stanford, CA, 3Stanford, San Carlos, CA
Purpose
As we develop AI systems, it is critical to train these systems with data that is unbiased. AI systems are only as good as the data we feed them and bias in AI systems has become a known issue. Bias in AI systems mainly occurs in the data and/or in the algorithmic model. One challenge is that the data that algorithms are trained on are not always sufficiently diverse or may present geographic variations. In respect to algorithmic models, they require many features to yield a useful prediction and are prone to overfitting. They can potentially incorporate biases that exist only in the training dataset. We have access to stroke datasets from two distinct different geographical locations: Switzerland and the USA. We wanted to explore how well AI algorithms translate across these groups based on the precise training sets used. We also wanted to assess for potential biases, including sampling or spectrum bias and demographics.

Materials and Methods
When making treatment decisions for patients with acute ischemic stroke, timely and accurate outcome prediction plays an important role. The decision-making process involves numerous biomarkers including image features and demographics information. We investigated the home built extreme gradient boosting (XGB) machine, which was pre-trained on 512 patients from Switzerland to predict modified Rankin Scale (mRS) at 90 days using 23 biomarkers available at admission +/- additional biomarker (NIHSS at 24 hours). A total of 142 acute ischemic stroke cases from US (Defuse-3 study) which had all the 24 biomarkers were selected and the XGBoost was used for binary prediction of mRS. 5-fold cross validation was applied to estimate model performance.

Results
For Switzerland data, binary prediction of mRS>2, using biomarkers available at admission, the XGB had AUC of 0.756 and with adding the NIHSS at 24 hours, the XGBoost's AUC improved to 0.866. For US data, using biomarkers available at admission, the AUC was 0.702 and with adding the NIHSS at 24 hours, the AUC improved to 0.889. When comparing the ROC curves at admission and when adding NIHSS score at 24 hours, the P-values are 0.98 and 0.99.

Conclusions
This is one of the few reports of evaluating potential AI bias in field of neuroradiology. Additional studies, especially with different types of Machine learning are required to be performed to assess for the potential algorithm bias and to minimize it before their widespread clinical use across the world.

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End-to-End Automated Medical Image Analysis on the UCSF Clinical PACS

J Colby¹, J RUDIE¹, A RAUSCHEKER¹, L SUGRUE¹, J Lupo¹, J Crane¹, C Hess¹, J Villanueva-Meyer¹
¹UCSF, San Francisco, CA

Purpose
The availability of state of the art algorithms for analyzing spatial image data, and the high performance computing resources needed to train them, are quickly reaching the point of commoditization. Therefore, increasing relative importance is shifting to the training data/annotations needed to drive these models, and to the engineering solutions needed to deploy these models as real-world products at the point of care.
Materials and Methods
Here we present engineering development work on an end-to-end platform for automated image analysis on our clinical PACS. A simple extensible web application front end is used to enter study accession number (hookable from PACS), choose application (e.g. glioma segmentation, metastasis detection, etc.), prescribe analysis options, and submit the analysis request. Once study data are extracted from PACS, machine learning tools are used to identify the desired series based on fitting an application-specific ensemble tree model (e.g. gradient boosted trees or random forest) to the DICOM header data. Raw imaging data are preprocessed using best practices for data parallel pipelining, provenance, and reproducible research (i.e. nipype). An inference model server is used to expose a variety of custom pre-trained deep learning models through a common application programming interface. Results (e.g. segmentation label maps for the glioma context) are post-processed to generate structured data ready for warehousing, and stored for potential tune up and retraining on problem cases. Finally, using R Markdown and a customized LaTeX report template, we generate automated dynamic analysis reports according to our institutional brand graphic identity (for automated delivery to the referring clinician, or for upload back into the EMR or PACS). Importantly, these components are fully containerized, and deployed as a scalable production-ready cluster via the docker swarm orchestration framework.

Results
The schematic of this application framework, together with representative output from the glioma segmentation context, is displayed in Figure 1.

Conclusions
Using open source software tools and commodity hardware, this project demonstrates the broad accessibility with which state of the art methods for medical image analysis may be integrated into the clinical radiology enterprise.
3D Convolutional Neural Network for Automated Detection and Segmentation of Intracranial Metastases for Gamma Knife Radiosurgery

J RUDIE1, J Colby2, A RAUSCHECKER3, D Weiss4, B Laguna2, L SUGRUE5, C Hess2, J Villanueva-Meyer6
1University of California, San Francisco, San Francisco, CA, 2UCSF, San Francisco, CA, 3UCSF RADIOLOGY, SAN FRANCISCO, CA, 4University of Pennsylvania, Philadelphia, PA, 5UCSF, SAN FRANCISCO, CA, 6University of California - San Francisco, San Francisco, CA

Purpose
There is considerable opportunity to translate artificial intelligence methods into clinical practice in order to improve the accuracy, efficiency and reproducibility of radiologic interpretations. A particularly tedious and time sensitive task requiring high sensitivity/specificity by neuroradiologists is detecting intracranial metastases on stereotactic radiosurgery treatment planning studies.

Materials and Methods
We trained a 3D convolutional neural network (CNN) to detect and segment intracranial metastases in patients who underwent MRI for stereotactic radiosurgery treatment planning. The sample consisted of 238 brain MRI studies of patients with intracranial metastases collected from 5 different scanners. A total of 2007 metastases were manually segmented by neuroradiologists (sizes ranging from 0.005 cm3 to 36 cm3). We utilized a U-Net architecture with 3-channel input consisting of 3D 80x80x80 mm patches from T1pre, T1-post, and T1pre-T1-post subtraction images, and four encoding and decoding layers (Fig A).

Results
The median Dice score for segmenting enhancing metastases was 0.70 (Interquartile rage: 0.60-0.80). Example cases and predicted segmentations are shown in Fig B. There were strong correlations between manually segmented and predicted lesion volumes (R=0.98) and between the number of manually segmented and predicted metastases (R=0.95; Fig C, upper panels). Sensitivity for metastases larger than 0.5 cm3 was 100%. Overall, there was a 16.6% rate of false positives, and a 37.1% rate of false negatives. Better Dice scores were strongly correlated with larger metastasis volume on a logarithmic transformed scale for each patient (R=0.67) and for individual metastases (R=0.72; Fig C, lower panels).

Conclusions
A multichannel 3D CNN performed well at both detecting and segmenting brain metastases, but will require more training cases and further network optimization to improve detection of very small metastases. This avenue of research seeks to decrease human bias and increase workflow efficiency by incorporating advances in artificial intelligence into everyday radiology practice.
Gadolinium Retention Reduction through the Use of Artificial Intelligence to Synthetically Boost Low Dose Contrast Enhanced MRI Images of the Brain

M KUHN1, J Patriarche2, D Patriarche2, A Kuhn3, A Kuhn4

1UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE AT PEORIA, PEORIA, IL, 2A.I. Analysis, Inc., Seattle, WA, 3Medical College of Wisconsin, Wauwatosa, WI, 4Yale University School of Medicine, New Haven, CT

Purpose
Concern regarding the discovery of gadolinium retention in the brain and other organs and controversy that this may be the cause of gadolinium deposition disease has led to the development of various preventative strategies. We propose lowering the dose from what has traditionally been considered to be a full dose of gadolinium based contrast media and utilizing artificial intelligence processes to "synthetically" boost the signal from enhancing lesions which show blood brain barrier breakdown on low dose contrast enhanced brain MRI to approach or even surpasses the quality of a full dose. We studied 60 patients who underwent fractional low dose brain MRI studies and compared their synthetically enhanced low dose images with the cumulative full dose images to see if artificial intelligence algorithms might successfully be applied to reduce gadolinium retention while maintaining image quality.

Materials and Methods
60 adult patients were included in this study. All patients initially received either a half, third, quarter, tenth, twentieth or fortieth dose of gadobenate dimeglumine intravenously and then an axial post-enhanced T1 weighted sequence was acquired. Immediately following this, a second volume of gadobenate dimeglumine was administered which resulted in a cumulative full dose (0.1 mmol/kg). Post-enhanced T1 weighted images were then obtained in axial, coronal and sagittal planes and a post-enhanced three dimensional T1-weighted BRAVO sequence was also obtained. The low dose images underwent synthetic boost enhancement processing using artificial intelligence genetic algorithms and machine learning techniques including intensity normalization, bias field correction, scaling, segmentation and registration. These synthetic images were then compared with the cumulative full dose images by three blinded readers to evaluate a) overall image quality, b) degree of enhancement and c) lesion count.

Results
Synthetic boost enhanced images which were obtained at half, third and quarter dose demonstrated equal or better image quality and identical lesion count with the full dose images. Tenth, twentieth and fortieth doses were effective in demonstrating the lesions but there was increased noise in the surrounding normal brain which degraded image quality. 14 of 152 lesions demonstrated on the cumulative full dose images could not be seen on the synthetic images at these lower most doses.

Conclusions
Synthetic contrast enhancement is an effective tool using half, third and quarter gadolinium doses.
Purpose
To evaluate the performance of a convolutional neural network (CNN) in the CT diagnosis of cervical spine fractures.

Materials and Methods
We evaluated an FDA approved CNN model developed by Aidoc (Tel Aviv, Israel) for the detection of cervical spine fractures on CT. The model detects cervical spine linear bony lucencies in patterns consistent with acute or chronic fractures. The model was tested in a level I trauma center on all trauma cervical spine CTs acquired over four years that included a cervical spine MRI performed within 48 hours. Cervical spine MRIs were performed for two main reasons: 1) in patients with persistent clinical concern for occult cervical spine injury despite negative CT results and 2) to evaluate the spinal cord and ligaments in patients with a fracture on CT. A total of 690 cases were included in the analysis. To establish ground truth, the cervical spine CT and MR images, including their reports were retrospectively reviewed by one of three fellowship trained neuroradiologists who were blinded to the CNN results. The initial reports were considered "real-time" assessments. During retrospective review, cases were marked positive by the neuroradiologists if the fracture was detected on CT or evident in retrospect with the aid of follow-up MRI. The cervical spine CT dataset was evaluated retrospectively by the CNN model. The "real-time" radiologist assessment and the CNN model output were compared to ground truth.

Results
CNN algorithm accuracy in cervical spine fracture detection was 92%, with 79% sensitivity and 96% specificity. "Real-time" radiologist accuracy was 95%, with 89% sensitivity and 97% specificity. Fractures missed by the CNN mirrored those missed by radiologists by both level and location, including fractured anterior osteophytes, transverse and spinous processes, and those obscured by artifact in the lower cervical spine.

Conclusions
CNN performance accuracy and specificity was comparable to radiologist interpretations in the detection of cervical spine fractures on CT. This model holds promise for prioritizing exams and assisting clinicians in cervical spine fracture detection. Knowing the specifics of the algorithm is critical in successful incorporation into clinical practice. Further refinements in sensitivity will likely improve the results of the CNN.

Deep Learning Enables Accurate Quantitative Volumetric Brain MRI with 2x Faster Scan Times

L Wang¹, S Bash², S Dupont¹, S Magda³, C Airriess¹, E Gong¹, G Zaharchuk⁴, A Shankaranarayanan¹, T Zhang¹
¹Subtle Medical Inc, Menlo Park, CA, ²RadNet, Inc., Encino, CA, ³CorTechs Labs, San Diego, CA, ⁴Stanford University, Stanford, CA
Purpose
3D T1w MRI is valuable for providing high resolution structural information and is commonly used clinically despite long scan times. The recent development of deep learning (DL) has shown great potential for scan time reduction. However, the generalizability of DL methods is often of concern for actual clinical deployment. In this study, we apply FDA-cleared DL software to accelerate 3D T1w MRI scans by 2x and evaluate the quantification accuracy using FDA-cleared image analysis software. This study provides insight into the generalizability and accuracy of DL in clinical settings.

Materials and Methods
With IRB approval and patient consent, 32 subjects (age: 68+/−18 years; 19 male) undergoing clinical MRI exams were recruited. The study cohort includes cognitively normal, MCI, and AD subjects. Two 3D T1w scans were acquired for each subject: one from routine protocol and the other with half the phase encodes and scan time. The faster scans were enhanced post acquisition by FDA-cleared DL software SubtleMR. The paired datasets were collected on one of five different 3T scanners. Both the standard images and DL-processed images were processed and compared by FDA-cleared software NeuroQuant for quantitative analysis. Hippocampal occupancy score (HOC), a biomarker to predict the progression of neurodegenerative diseases, as well as the volumes of hippocampi, superior lateral ventricles (SLV), and inferior lateral ventricles (ILV), were analyzed.

Results
Excellent image quality (high perceived SNR and image resolution) was obtained by DL. Example morphometry results of the standard images and DL images are shown in Fig. 1. Matching segmentation can be visualized. The average HOCs did not differ: 0.68+/−0.17 and 0.68+/−0.17 for the standard scan and DL, respectively. The difference of the hippocampal volume, SLV and ILV is also negligible (less than 2%). The Bland-Altman analysis further suggested strong agreement between two measurements across wide range of neurodegenerative conditions (HOC ranging from 0.32 to 0.95).

Conclusions
This study has validated the high quantification accuracy of DL-accelerated scans with 2x faster scan times when compared with the standard longer scan. Consistent results from scans on diverse scanner types and clinical indications demonstrated good generalizability of the DL software, ready for clinical deployment.

Elevating Clinical Brain and Spine MR Image Quality with Deep Learning Reconstruction

L Tanenbaum¹, S Bash², M Thomas³, M Fung³, M Lebel⁴, S Banerjee³
¹RadNet, Inc., new york, NY, ²RadNet, Inc., Encino, CA, ³GE, Waukesha, WI, ⁴GE, alberta, Calgary

Purpose
In the quest for ever increasing image quality, MR throughput can suffer and maneuvers which create faster scans tend to trade off
quality. There is thus a tremendous need for improving images without prolonging scan time. Recently available deep learning-based reconstruction methods have shown promise to enhance image value. We evaluated the impact of a new deep learning image reconstruction (DLR) method which has shown potential for both noise reduction and improved image sharpness in clinical MR exams of the brain and spine.

Materials and Methods

The investigational DLR leverages a deep convolutional residual encoder network trained on a >10K image database to create images with enhanced SNR and spatial resolution. 28 patients were scanned using clinical 2D brain (3T-7, 1.5T-4) or spine (3T-12, 1.5T-5) protocols. K-space data was reconstructed with both conventional and DLR (tuned to 75% noise reduction). Two neuro-radiologists independently rated 93 pairs of conventional and DLR images side by side. Ratings were based on overall IQ, lesion conspicuity, perceived SNR & resolution, CNR, image texture and artifact using a 5-point Likert scale (5=Excellent, 1=Non-diagnostic). Wilcoxon signed-rank test was used to compare the ratings and inter-rater reliability between readers was assessed using Bennett S Score.

Results

DLR showed statistically significant improvement over conventional images in overall image quality (4.74±0.49 vs 3.27±0.70, p<0.05), lesion conspicuity (4.65±0.49 vs 3.24±0.52, p<0.05), contrast (4.59±0.61 vs 3.50±0.59, p<0.05), perceived resolution (4.66±0.61 vs 3.36±0.59, p<0.05), perceived SNR (4.72±0.60 vs 3.33±0.53, p<0.05), image texture (4.66±0.60 vs 3.13±0.38, p<0.05). There was substantial inter-rater agreement with an average S score of 0.66.

Conclusions

Overall IQ improved with deep learning reconstruction with higher perceived SNR, CNR and spatial resolution compared to the conventional method. Future work will assess whether this technique can accelerate acquisitions while preserving quality.
mistakes corrected. This data was split into 80% for training and 20% for validation. Labeled data was fed into the Bi-LSTM model with BioWordVec embeddings. Word embedding encodes the raw text into vectors that can be input into the model and BioWordVec is open source that has been pre-trained on PubMed to capture generic aspects of text structures and is able to compare sentence similarity. Model was tested on 2711 MRI brain orders obtained from the same hospital in years 2014 to 2017, 61% adhering to guidelines again manually labeled. LIME graphic user interface was tested by comparing results generated by model (research assistant cut and pasting MRI orders into the system) against 1 month of anonymised 89 MRI brain orders manually labelled by a radiologist, 64% adhering to guidelines.

Results
Model generated 1420 true positives, 817 true negatives, 233 false positives and 241 false negatives on the 2014 to 2017 dataset, giving 83% accuracy, area under curve 0.89, precision 0.86, recall 0.85, F1 score 0.86. LIME graphic user interface allowed an assistant to categorise MRI orders easily with no significant difference in model performance.

Conclusions
Bi-LSTM model and friendly LIME graphic user interface show potential to be incorporated into the daily workflow to triage MRI brain free-text orders for paediatric patients.

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Automatic detection of arterial occlusion on digital subtraction angiography: pilot study with convolutional neural network

Y Yu¹, J Ouyang², H Do³, G Zaharchuk²
¹STANFORD UNIVERSITY, Stanford, CA, ²Stanford University, Stanford, CA, ³Stanford Univ Medical Center, Stanford, CA

Purpose
digital subtraction angiography (DSA) reading requires specialized training and the interobserver agreement of the DSA readings can be low among multi-disciplinary teams. We aim to explore if convolutional neural network (CNN) can be used to detect artery occlusion.

Materials and Methods
we reviewed patients collected in from Imaging Collaterals in Acute Stroke study (NCT02225730) who had endovascular therapy and DSA. The arterial and parenchymal phase of DSA AP views were used in this pilot study. Visible occluded large arteries (ICA, M1, and M2 segment) on each frame of DSA AP views from multiple runs before and after each pull were annotated by experienced neurointerventional. The ICA bifurcation is also annotated. DSA images were pre-processed by inversion, median filter, and normalization (Fig A&B). Positive and negative samples were generated 1:1 as patches with size of 128px by 128px on 3 consecutive frames and the maximal intensity projection mage depend on whether the patch contains the occluded arteries (Fig C). Rotation, scaling, and mirroring were applied to augment the number of samples. The samples were fed into a CNN with 3 convolutional layers and 2 max-pooling layers. Coordinates of occluded artery and ICA bifurcation was fed into a fully connected neural network. The two networks were concatenated at the last layer, and the output was a binary classification of whether the input sample contains artery occlusion (Fig D). Six fold cross validation was performed with a ratio of training : validation : test as 4:1:1. The models were evaluated by area under curve (AUC) of Receiver operating characteristic, accuracy, sensitivity, and specificity.

Results
36 patients were included in this pilot study (18 male, age 70±18, 29 with TICI 2b-3 , 8 ICA occlusion, 21 M1 occlusion, and 7 M2 occlusion), from which 39405 samples were generate (with 20250 positive samples). Across all the 6 models, AUC is 0.868±0.04, accuracy is 0.79±0.03, sensitivity is 0.84±0.05, and specificity is 0.74±0.08. Examples of output are shown in Fig E.

Conclusions
This pilot study shows that it is feasible to detect large and medium artery occlusion on DSA using CNN. In the future, we will refine the network to facilitate the diagnosis of artery occlusion and TICI score during the intervention. This may enable more standardized assessments for clinical trials.
Fig A. Digital Subtraction Angiography (DSA) image before pre-processing. Fig B. DSA images after inversion, median filter, and normalization. Fig C. Annotations of occluded artery and internal carotid artery bifurcation made on DSA images by experienced neurointerventionalist. Positive and negative samples are extracted from the given coordinates of occluded artery. Fig D. Neural network used in this pilot study incorporating the image information and the coordinates of annotations. The output is a binary classification. Fig E. Examples of model output. Red dot indicates the occlusion and the white box indicates the sample location.
Automatic Quantification of White Hyperintensities in a Healthy Aging Cohort Using Convolutional Neural Networks

A Jimenez-Pastor, E Camacho-Ramos, A Alberich-Bayarri, C Biarnes, J Garre-Olmo, R Ramos-Blanes, J Vilanova, M Essig, S Pedraza, J Puig

1QUIBIM, Valencia, Valencia, 2IDI-IDIBGI, Girona, Girona, 3IDIBGI-IAS, Girona, Girona, 4IDIBGI, Girona, Girona, 5University of Lleida-IRBLleida, Lleida, Lleida, 6University of Manitoba, Winnipeg, Manitoba, 7IDI-IDIBGI, Girona, Spain

Purpose
Although brain white matter hyperintensities (WMH) are involved in the pathophysiology of several neurological disorders, they are also very common in healthy older adults. In damaged white matter, increased tissue water content and myelin degradation result in prolonged T2 relaxation time; fluid-attenuated inversion recovery (FLAIR) images depict these changes. Assessing the presence, location, shape, and severity of WMH might provide further insight into age-related changes in the brain. The gold standard for assessing WMH areas, manual segmentation, is cumbersome, time-consuming, and plagued by high intra- and inter-observer variabilities. Truly reliable fully automated methods to quantitatively assess WMH on magnetic resonance (MR) imaging are lacking. We used convolutional neural networks (CNN) on data from a large sample of healthy participants to develop a method to automatically segment WMH.

Materials and Methods
We recruited participants ≥50 years (mean, 66.67+/−7.96 years [range, 50-96 years]) for a population-based study. All imaging studies were obtained on a 1.5 T MRI system. We randomly selected 200 FLAIR studies (voxel size 1.5x1.5x5.8mm3 and image matrix size 464x384x24) for the development and validation of an ensemble of CNNs for the automatic segmentation of WMH. An experienced radiologist manually segmented WMH, using 180 studies to train the ensemble and the remaining 20 studies for testing. The ensemble was built of 4 architectures, all based on encoder-decoder networks, but differing in their use of the standard configuration, residual layers, dilated layers, or combinations of residual and dilated layers. From each network's output, we obtained each voxel's probability of being a WMH; we averaged and thresholded the output obtained with the 4 models to generate the final lesion mask used to compute the total WMH volume. We tested the system on 20 new unseen studies and compared the results by calculating the Dice coefficient (DC) and the average symmetric surface distance (ASSD).

Results
Each study was segmented in approximately 40 seconds. The mean WMH volume was 2.42+/−6.58 mL (median, 0.45 [0.12-1.69 mL]). The DC and ASSD were 83.28+/−10.91% and 3.46+/−1.42 mm, respectively. After applying the ensemble to the training dataset, the mean DC was 93.14+/−3.48 %, similar to that obtained in the testing dataset, proving the lack of overfitting in the ensemble.

Conclusions
In healthy older adults, WMH can be automatically and accurately segmented using an ensemble of deep CNN.
Using a Structured Scoring System, the Brain Tumor Reporting and Data System, to Predict Subsequent Imaging Outcomes in Glioblastoma Patients

S KIM¹, M Cooper¹, M Hoch², B WEINBERG¹
¹Emory University School of Medicine, Atlanta, GA, ²University of Pennsylvania School of Medicine, Philadelphia, PA

Purpose
Glioblastomas are the most common primary brain neoplasm with dismal prognosis. After treatment with surgical resection, radiation, and chemotherapy, follow-up decisions are guided by longitudinal MRI performed at routine intervals. Brain Tumor Reporting and Data System (BT-RADS) is a proposed structured system for reporting post-treatment brain MRIs. The purpose of this study is to establish a relationship between BT-RADS scores and subsequent imaging progression in glioblastoma patients. Ultimately, the goal is to predict the probability of further disease worsening, which can help guide management decisions.

Materials and Methods
Chart review of patients diagnosed with glioblastoma and given a BT-RADS score at a single institution from Nov 2018 to Nov 2019 was performed. BT-RADS scores, tumor features, and progression free and overall survival were recorded. When MRI reports did not have prospectively assigned BT-RADS scores, they were retrospectively graded using criteria previously published and publicly available on www.btrads.com (Fig 1A). Proportions were compared using Fisher exact test. Follow-up intervals were compared using one-way ANOVA test and post-hoc Tukey's multiple comparison test. A significance level of 0.05 was used.

Results
During the study period, 99 unique glioblastoma patients received a total of 582 MRIs. Mean age was 65.3 years old. IDH status was 18% mutated, 78% wild-type, and 4% unknown IDH status. MGMT was hypermethylated in 44%, unmethylated in 38%, and unknown in 18%. Among patients with improved imaging (score 1a, 1b), patients on medications such as bevacizumab or steroids (1b) were two times more likely to have image worsening on their subsequent MRI (p=0.02). 64% of patients with stable imaging (2) had improved or stable follow-up MRI. Of patients with worsening imaging, patients in the pseudoprogression window (90 days) were significantly less likely to have subsequent worsening than those outside the window (3b, 3c, and 4), (p=0.0005) (Fig 1B). BT-RADS scores had a statistically significant relationship with the follow-up interval, with significant differences between the mean follow-up interval of score 2 and those of scores 3c and 4 (F(6,249)=4.488, p=0.0002) (Fig 1C).

Conclusions
To conclude, initial BT-RADS scores can be used to anticipate whether patients' subsequent MRI will be improved, stable, or worsened. Patients with high risk of subsequent worsening should have close interval follow-up as they may benefit from earlier management changes.

J Lee¹, N Wang¹, S TURK², R Lobo¹, J Kim¹, E Liao¹, S Camelo-Piragua¹, M Kim¹, L Junck³, J Bapuraj¹, A Srinivasan⁶, A Rao¹
¹University of Michigan, Ann Arbor, MI, ²Sinop Ataturk State Hospital, Sinop, Turkey, ³University of Michigan, Ann Arbor, MI, ⁴Univ of Michigan, Ann Arbor, MI, ⁵University Of Michigan, Ann Arbor, MI, ⁶Univ. Of Michigan Health System, Ann Arbor, MI

Purpose
Glioblastoma (GBM) is the most aggressive primary brain tumor with the median survival of 15 months. During the treatment, the size of the tumor often increases or new inflammatory lesions appear in the absence of true tumor progressive disease (PD). Differentiating this pseudoprogression (PsP) from true tumor PD has become a major challenge in GBM follow-up. In this study, we proposed a set of multiparametric MRI data as a sequence input for the CNN-LSTM framework to classify PsP and true tumor PD and compared that with the most popular deep learning framework (VGG16).

Materials and Methods
46 patient data identified as high-grade glioma patients who underwent adjuvant chemoradiation therapy after total surgical tumor resection. We used 7 multi-parametric MRI datasets such as T1, T1 post-contrast, T2, FLAIR, and ADC map as well as two engineered modalities (T1post-T1 and T2-FLAIR). Next, we used two CNN-LSTM models with a different set of modalities, which are a set of 5 and 7 modalities, respectively, as input sequences to pass through CNN-LSTM layers. We performed 3-fold cross-validation in the training dataset and generated the boxplot, accuracy, and ROC curve from each trained model with the test dataset for each fold. Also, we estimated the AUC to evaluate the trained model in the test dataset.
Results
For VGG16 models, the mean accuracy for all modalities ranged from 0.45 to 0.58, and the mean accuracy is 0.50. The mean AUC for all modalities ranged from 0.42 to 0.61, and the mean AUC is 0.50. For the CNN-LSTM model, the mean accuracy for each sequence dataset is 0.67 and 0.71, respectively, and the mean AUC for each sequence dataset is 0.66 and 0.75, respectively. The mean values were computed from 3-fold cross-validation. A set of 7 multiparametric MRI sequence data for the CNN-LSTM model has a median AUC of 0.78. Fig.1 shows the boxplots of AUC for VGG16 and CNN-LSTM models.

Conclusions
In this study, we demonstrated the merits of a state-of-the-art CNN and RNN-based deep neural network, CNN-LSTM, with our proposed data frame, a set of multiparametric MRI sequence data. Our proposed method with a CNN-LSTM model outperformed a pretrained VGG16 and our study shows that a set of multiparametric sequence data with the CNN-RNN could be a promising method for identifying PsP and true tumor PD and could help in making decisions during follow-up. Further, our approach will potentially help the deep neural network model in clinical applications where the data are not sufficient for training a model.

![CNN-LSTM Architecture](TCT_2253_Fig1_Architecture.png)

![Boxplot for VGG16 and CNN-LSTM models](TCT_2253_Fig1_Boxplots.png)

**Fig. 1** (A) CNN-LSTM Architecture with a set of multiparametric MRI sequence data input. (B) Boxplots of AUC for VGG16 (T1, T1 Post, FLAIR, ADC, T1 Post – T1, and T2 – FLAIR) and CNN-LSTM models. Statistics were collected from 3-fold cross validation.

![Multi parameter MRI detection](TCT_2253_Fig1_MultiParameterMRIDetection.png)

2723
1:44PM - 1:50PM

Multi parameter MRI detection of infiltrative brain tumor validated with spatially-correlated brain tumor biopsies

M Prah\(^1\), R Wujek\(^1\), K Schmainda\(^1\)
Medical College of Wisconsin, Milwaukee, WI

Purpose
To differentiate glial tumor from non-tumor in non-enhancing hyperintense FLAIR regions.

Materials and Methods
Consented subjects were identified from a database of brain tumors that had pre-operative STEALTH imaging co-localized to surgical biopsy sites in addition to T1, T1+C, T2, FLAIR, DWI, & DSC. Only samples acquired in non-enhancing T1+C and hyperintense FLAIR regions were included. In total, "true biopsy" samples from 52 subjects with diagnoses of tumor (WHO grades I-IV glial tumor, n=116) or non-tumor (primary glial, metastasis, or meningioma) (n=20) were identified. To achieve a matched dataset, 96 non-tumor "virtual biopsies" were also included from subjects with meningioma or metastasis (n=6), as these tumor types are non-infiltrative [1]. ADC was derived from DWI (b-value=0.1000s/mm^2) and leakage-corrected normalized (to normal appearing white matter) rCBV was derived from DSC (IB Diffusion™ and IB Neuro™, Imaging Biometrics) [2]. Bias correction and white matter normalization was applied to T1, T1+C, T2, and FLAIR images [3]. All images were co-registered to the STEALTH exams and non-zero mean image values extracted using 3-mm spherical regions matched to the surgically recorded biopsy locations. 164 samples were used to develop a model and 68 samples were set aside for testing. All statistical analyses were performed using SPSS v22 (IBM Corp). To distinguish tumor from non-tumor Generalized Estimating Equations (GEE) analysis was used, which accounts for multiple samples from the same subject. A univariate GEE (P<0.2) was performed as an initial selection step to determine parameter inclusion for the multivariate GEE (P<0.05). From the predicted values, an ROC analysis was performed to determine sensitivity and specificity. The rate of false positives and negatives along with positive (PPV) and negative (NPV) predictive values were also calculated.

Results
Results are shown in Figure 1. ADC (P=.355) and T1 (P=.964) did not significantly contribute and were excluded. When including FLAIR (B=2.231), T2 (B=-5.355), T1+C (B=-13.775), and rCBV (B=-1.098) parameters, a threshold greater than or equal to -0.15521 predicted tumor with AUC=.885 (CI=.832-.938), sensitivity=.917 and specificity=.800. The false positive and false negative rates were .017 and .069, and the PPV and NPV were .933 and .789, respectively.

Conclusions
Tumor can be distinguished from non-tumor in non-enhancing FLAIR regions with a high level of accuracy using normalized FLAIR, T2, T1+C, and rCBV.

A precise comparison of T1-weighted contrast enhancement and pathological features of glioma at autopsy in nine patients

A Lowman^1, S Bobholz^1, J Connelly^1, E Cochran^1, W Mueller^1, S McGarry^1, M Brehler^1, A Banerjee^1, P LaViolette^1

Medical College of Wisconsin, Milwaukee, WI

Purpose
Gliomas have a uniquely heterogeneous nature that often result in difficulty delineating the active tumor region. T1 subtraction maps (T1S) are created by subtracting intensity normalized T1 weighted images from T1 post contrast images (T+C), and have been proposed as better method for calculating tumor volume and tumor location. This study compares T1S derived enhancement to annotated tissue samples acquired at autopsy in glioma patients.

Materials and Methods
Nine patients were recruited for this study. Of the nine patients, six were diagnosed with GBM at autopsy, two were diagnosed with grade III gliomas and one patient had no tumor but extensive treatment effect seen at autopsy. Within this patient cohort, time between
the last MRI and death ranged from 7-184 days (mean 66 days) with each patient having undergone a unique treatment course. Whole brain samples were sliced axially aligned to their final T1+C MRI scan taken prior to death. Large tissue samples were taken from regions of suspected tumor or treatment effect. All samples were processed, H&E stained, then digitized, for a total of 20 samples). Each slide was annotated to outline regions containing necrotic treatment effect, hypercellularity, and hypercellularity with pseudopalisading necrosis. The annotated histology was aligned and resampled into MRI space using control point registration and T1S were calculated. T1S values were compared based on the pathological annotation labels.

Results
A total of 13,019 annotated and 70,558 non-annotated voxels were analyzed within manually selected regions of interest from the MRI. Regions of hypercellularity with pseudopalisading necrosis corresponded with higher intensity values on the T1S. Areas with necrotic treatment effect and hypercellularity with pseudopalisading necrosis had similar T1S values and were subtly enhancing compared to regions unremarkable on histology.

Conclusions
Regions of infiltrative tumor and necrotic treatment effect had comparable T1S values to normal tissue while areas of pseudopalisading necrosis did enhance subtly. Additional research is necessary to examine how much the relationship between tissue and MRI values is affected when time of last MRI to death and treatment history is accounted for. This work begins to characterize the pathological profile of T1S in the presence of treatment.

Rate of change in [18F]-FDOPA PET uptake and non-enhancing tumor volume predicts malignant transformation and overall survival in low-grade gliomas

B Elingson¹, T Oughourlian¹, J Yao¹, J Schlossman¹, M Ji¹, H Tatekawa¹, N Salamon¹, W Pope¹, P Nghiemphu¹, A Lai², T Cloughesy³
¹University of California, Los Angeles, Los Angeles, CA, ²University of California Los Angeles, Los Angeles, CA, ³University of California, Los Angeles, 90095, CA

Purpose
Long-term prediction of survival in low grade gliomas (LGGs) can be difficult, as the average survival is approximately 7 years from initial diagnosis. Therefore, we aimed to test whether the rate of change in 18F-FDOPA PET uptake and the rate of change in non-enhancing tumor volume between two time points could be used to predict malignant transformation and residual overall survival (OS) in low grade glioma (LGG) patients who received serial 18F-FDOPA PET and MRI scans.

Materials and Methods
A total of 28 LGG patients with >2 18F-FDOPA PET scans and MRI scans were included in the study. The rate of change in FLAIR volume (uL/day) and the rate of change in maximum normalized 18F-FDOPA specific uptake value (nSUVmax/month), were compared between histological and molecular subtypes. A series of general linear models (GLMs) were used to integrate clinical information with MR-PET measurements to predict malignant transformation. Cox univariate and multivariable regression analyses were performed to identify imaging and clinical risk factors related to OS.

Results
A GLM using the rate of change in FLAIR volume and rate of change in 18F-FDOPA nSUVmax could predict malignant transformation with >70% sensitivity and specificity (AUC=0.7194,P=0.0482). Adding age and treatment to this model improved the prediction (AUC=0.7551,P=0.0216). Cox univariate regression analysis showed significant association between OS and age (HR=1.032,P=0.029), rate of change in FLAIR volume (HR=1.015,P=0.011), and rate of change in PET update (HR=3.401,P=0.021). Cox multivariable analysis confirmed that only rate of change in PET uptake was an independent predictor of OS (HR=3.805,P=0.044).
Conclusions
The change in maximum normalized 18F-FDOPA PET uptake, with or without clinical information and rate of change in tumor volume, may be useful for predicting the risk of malignant transformation and estimating residual survival in patients with LGG.

Pixel-wise comparison of the newly recommended low flip angle, single-dose versus moderate flip angle, double-dose DSC-MRI protocol

L Bell¹, L Hu², Y Zhou², K Schmainda³, J Boxerman⁴, C Quarles¹
¹Barrow Neurological Institute, Phoenix, AZ, ²Mayo Clinic, Scottsdale, AZ, ³Medical College of Wisconsin, Milwaukee, WI, ⁴Rhode Island Hospital / Brown University, Providence, RI

Purpose
ASFNR recommendations for brain tumor DSC-MRI include the use of a moderate flip angle (MFA) and a full standard preload dose [1]. Recently, simulations confirmed that a low flip angle (LFA) protocol without a preload is equally accurate, and has been validated in vivo by comparing mean tumor cerebral blood volume (rCBV) [2-3]. To further aid in standardization efforts, we systematically characterized the pixel-wise agreement in enhancing tumor, edema, white matter (WM), and gray matter (GM) regions.

Materials and Methods
Out of 48 subjects scanned at 3T (Siemens, Germany), 33 evaluable high-grade gliomas patients were analyzed. Two DSC-MRI scans were performed using gradient-recalled EPI: LFA sequence using no preload and flip angle = 30 deg and a MFA sequence using a full standard dose preload and flip angle = 60 deg. Both scans used a TR/TE = 1500/20 ms with a standard bolus dose of gadobutrol. Enhancing tumor, edema, WM, and GM were segmented from high resolution T1-weighted post-contrast and T2-weighted FLAIR scans. The percentage of voxels exhibiting T1- or T2*-related leakage effects was calculated across protocols for all subjects. Leakage
corrected rCBV was computed using conventional methods [4]. Lin's concordance correlation coefficients (LCCC) were evaluated in each subject to assess the agreement across all pixels.

Results
The LCCC across mean leakage-corrected rCBV in subjects between the two protocols was 0.973 and is comparable to a previously reported value of 0.952 [3]. More T1 related leakage effects are observed in the LFA protocol, whereas, more T2* related leakage effects are observed in the MFA protocol, due to the use of preload (Fig1a). After leakage correction, high pixel-wise agreement is observed within and across all 4 regions (Fig1b). The mean LCCC in each ROI is 0.834 (enhancing tumor), 0.834 (edema), 0.839 (WM), and 0.811 (GM). Figure 1c is an example of a subject with high agreement across protocols (LCCC = 0.919).

Conclusions
Building upon the prior study that highlighted mean tumor rCBV agreement, these results highlight that the LFA and MFA protocols also exhibit good pixel-wise rCBV agreement. This systematic comparison is clinically meaningful as interpretation of tumor status involves comparison to values observed in other brain regions and confirmation of peritumoral invasion into regions of edema as indicated by elevated rCBV. Results from this study further strengthen the recommendation that the single-dose LFA protocol may be used in the clinic.

(Filename: TCT_2641_Figure1.jpg)

1351
2:12PM - 2:18PM

Radiomics Risk Score of IDH-wild Type Lower-Grade Gliomas: A Potential Imaging Biomarker for Predicting Survival

C Park¹, K Han², H Kim², S Ahn³, Y CHOI³, Y Park⁴, S Lee²
¹Severance hospital, Seoul, Korea, Republic of, ²Severance hospital, Seoul, Korea, ³SEVERANCE HOSPITAL, YONSEI UNIVERSITY, SINGAPORE, SINGAPORE, ⁴Ewha Womans University College of Medicine, Seoul, Korea, Republic of

Purpose
Isocitrate dehydrogenase-wild type (IDHwt) lower-grade gliomas follow heterogenous clinical outcomes1-4, which necessitates preoperative risk stratification. We aimed to evaluate whether radiomics from preoperative MRI would allow prediction of survival in patients with IDHwt lower-grade gliomas and to investigate the added prognostic value of radiomics over clinical features.

Materials and Methods
Preoperative MRIs of 117 patients with IDHwt lower-grade gliomas (World Health Organization grade II or III) were retrospectively analyzed. The external validation cohort consisted of 33 patients from The Cancer Genome Atlas. A total of 182 radiomic features were extracted. Radiomics risk scores (RRSs) for overall survival were derived from the least absolute shrinkage and selection operator (LASSO) and elastic net. Multivariable Cox regression analyses, including clinical features – age, Karnofsky Performance Status, extent of resection, WHO grade – and RRSs, were performed. The time-dependent receiver operating characteristic curves
from models with and without RRSs were obtained and the integrated areas under the receiver operating characteristic curves (iAUC) were calculated for comparisons. The prognostic value of RRS was assessed in the validation cohort.

Results
The RRS derived from LASSO (RRS_LASSO) and elastic net (RRS_elasticnet) independently predicted survival with hazard ratio of 9.479 (95% CI, 3.220 – 27.847) and 6.148 (3.009 – 12.563), respectively. Those RRSs enhanced model performance for predicting overall survival (iAUC increased to 0.780 – 0.797 from 0.726, figure 1). The RRSs stratified IDHwt lower-grade gliomas in the validation cohort with significantly different survival (Figure 2).

Conclusions
Radiomics enables noninvasive risk stratification and can improve the prediction of survival in patients with IDHwt lower-grade gliomas when integrated with clinical features.

Figure 1.

![Graphs showing the comparison of AUCs for different models with and without RRSs over follow-up time.]

Figure 2.

![Graphs showing survival stratification based on RRS_LASSO and RRS_elasticnet.]

(Filename: TCT_1351_ASNR_figures.jpg)

1818
2:19PM - 2:25PM

Imaging and Histopathologic Correlates of Plasma Cell-Free DNA Concentration in Adult Patients with Newly Diagnosed Glioblastoma

S Nabavizadeh1, J Ware1, S Guiry1, M Nasrallah2, J Till1, J Hussain1, S Yee1, Z Binder1, S Brem1, D O'Rourke1, A Desai1, R Wolf3, E Carpenter1, S Bagley1
1University of Pennsylvania, Philadelphia, PA, 2Hospital of the University of Pennsylvania, Philadelphia, PA, 3Hospital Of the Univ. Of Pennsylvania, Philadelphia, PA

Purpose
Clinical use of plasma cell-free DNA (cfDNA), including for molecular profiling, assessment of treatment response, and prognostication, has recently increased in oncology. In glioblastoma (GBM), however, cfDNA concentration is lower compared to other solid tumors. Improved understanding of the factors that drive cfDNA concentration in GBM may lead to more efficient use of plasma-based liquid biopsy in this disease. In this study, we investigated the relationship between multimodality magnetic resonance imaging (MRI) features, histopathologic parameters, and plasma cfDNA concentration in patients with treatment-naive GBM.

Materials and Methods
We analyzed plasma cfDNA concentration, MRI scans, and tumor histopathology from 42 adult patients with newly diagnosed GBM. Plasma cfDNA concentration before surgery was correlated with tumor volume (defined as the combination of enhancing tumor, non-
enhancing core, and peritumoral T2 hyperintensity), dynamic susceptibility contrast (DSC), dynamic contrast-enhanced (DCE) MRI, diffusion-weighted imaging (DWI) metrics, and tumor histopathologic characteristics. A stepwise multivariable regression analysis was used to identify imaging metrics independently associated with plasma cfDNA.

**Results**

42 patients with GBM were included in this study (Median age=65, age range:20-81 years, 19 females, 23 males). Plasma cfDNA was not significantly correlated with total tumor volume (\(p=0.24, \ p>0.5\)). However, tumor volume with elevated (>1.5 times contralateral white matter) blood-brain barrier (BBB) permeability metric of rate transfer constant (\(K_{ep}\), \(p=0.002\)) was independently associated with plasma cfDNA concentration. Histopathologic characteristics independently associated with plasma cfDNA concentration included CD68+ macrophage density (\(p=0.01\)) and size of tumor vessels (\(p=0.01\)).

**Conclusions**

In patients with treatment-naïve GBM, tumor volume with elevated metrics of BBB disruption correlates with plasma cfDNA concentration. Tumor macrophage density and tumor vessel size are also associated with plasma cfDNA concentration. Future studies are warranted to investigate the clinical utility of these findings to predict which subset of patients may benefit from liquid biopsy.

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**Meningioma-Brain Adherence Assessment Using MRI Texture Analysis**

O Ahmed1, K Naser-Tavakolian2, M Clifton3, E van Staaldeninen1, O Hussaini1, A Khan1, H Li1, A Franceschi4, T Duong1, L Bangiyev1

1Stony Brook University Hospital, Stony Brook, NY, 2STONY BROOK UNIVERSITY HOSPITAL, Stony Brook, NY, 3Stony Brook University Hospital, Brooklyn, NY, 4Northwell, New York, NY

**Purpose**

Meningioma location is an easily identifiable major factor in the determination of tumor resectability. Evaluating for meningioma-pial adherence, however, is an important yet complex task which can complicate dissection. MR texture analysis (MRTA) is a technique that allows image analysis and detection of surface intensity and patterns that are indiscernible to the human eye. The purpose of this study is to assess whether MR texture analysis can detect the presence and degree of meningioma-brain adherence using intraoperative findings as the gold standard.

**Materials and Methods**

A retrospective review of 17 patients (10 females, 7 males, mean age 62.1) with pathology proven meningiomas, available pre-operative MRIs, and operative reports categorized by neurosurgeons into extrapial (no adhesion), subpial (adhesion) or mixed type surgical planes. The pre-operative MRI FLAIR sequences, T1 post-contrast sequences, and ADC maps were analyzed using LifeX software designed to characterize tumor heterogeneity based on histogram, textural, and shape indices. A radiologist placed regions of interest (ROI) at the tumor-brain interface and brain parenchyma adjacent to the tumor. 32 texture indices were identified using the T1 post-contrast sequence ROIs of the tumor-brain interface of the 32 texture indices were identified using the T1 post-contrast sequences, and ADC maps were analyzed using LifeX software designed to characterize tumor heterogeneity based on histogram, textural, and shape indices. A radiologist placed regions of interest (ROI) at the tumor-brain interface and brain parenchyma adjacent to the tumor. 32 texture indices were generated, and comparisons were made using analysis of variance (ANOVA) between extrapial, subpial, and mixed type meningiomas. Examples of texture indices that were generated include the grey level run length matrix (GLRLM), which evaluated the size of homogeneous runs for each grey level, and grey-level zone length matrix (GLZLM), which provides information on the size of homogeneous zones.

**Results**

Out of 17 patients, 10 demonstrated an extrapial surgical plane, 4 demonstrated a subpial, and 3 demonstrated mixed. Statistically significant differences (\(p < 0.05\)) in the tumor-brain interface of the 32 texture indices were identified using the T1 post-contrast sequences with GLRLM_GLNU, GLRLM_RLNU, GLZLM_GLNU, and GLZLM_ZLNU. T1 post-contrast sequence ROIs of adjacent brain parenchyma also demonstrated significance for the texture index GLZLM_LZLGE. FLAIR sequences and ADC map texture analysis of tumor-brain and tumor-bone interfaces had no significant difference in texture analysis.

**Conclusions**

MRTA of the tumor-brain interface and adjacent brain parenchyma using T1 post-contrast sequences demonstrated a statistically significant difference between extrapial, subpial, and mixed type surgical planes and therefore can provide a noninvasive method to prospectively predict meningioma-brain adhesion.

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**Pembrolizumab Checkpoint Immunotherapy Increases Apparent Diffusion Coefficient and may be an Early Biomarker of Survival in Patients with Primary Glioblastoma**

R Barajas1, D Schwartz1, L Szidonya1, C Varallyay1, B Hamilton1, J Nickerson1, J Starkey1, D Pettersson1, J Pollock1, S Han1, A Raslan1, A Dogan1, J Cetas1, C Ciporen1, R Roth-Carter1, C Diaz1, A Huddleston1, L Muldoon1, E Neuwehl1, P Ambady1

1Oregon Health & Science University, Portland, OR

**Purpose**

Determine the effect of pembrolizumab (pembro) checkpoint immunotherapy upon diffusion weighted imaging (DWI) apparent diffusion coefficient (ADC) metrics in patients with newly diagnosed glioblastoma (GBM).
Materials and Methods
21 patients with newly diagnosed GBM were enrolled in a clinical trial (NCT03347617) combining Stupp protocol temozolomide and irradiation (CRT) with pembro (200mg IV, q3Wks). Control group consisted of only CRT. Isocitrate dehydrogenase status and progression free survival (PFS) was recorded. Patients underwent baseline pre-treatment MRI with DWI 4 weeks following maximal safe resection and immediately before treatment. Follow-up MRI was performed 10 weeks after baseline. All scans were performed on a 3T Philips Ingenia system. DWI consisted of (TR, 5355 msec; TE, 81.37 msec; Directions, 3; b-value= 0 and 1,000 s/mm2). Region of interest analysis encompassing the T2 hyperintense or T1 contrast enhancing lesion was performed using Horos medical imaging viewer (v3.2.1) providing ADC metrics (mean, 25th, and 75th percentiles, mm2/s). Percent change assessed ADC difference between MRIs. Paired T-test assessed differences between groups. Univariate Cox regression assessed the effect of ADC on PFS. P< 0.05 was considered significant.

Results
Patients with IDH Wild type GBM demonstrated a significant elevation in the non-enhancing T2 hyperintense ADC metrics following the initiation of pembro with CRT (P< 0.05; Figure 1). This was not observed within the contrast enhancing lesion (P> 0.14). Pembro with CRT resulted in significantly increased percent change in ADC within the non-enhancing T2 hyperintense lesion when compared to CRT alone (P<0.05). This increase in ADC metrics predominated in the IDH wild type (mean= 10% +/- 14%) compared to IDH mutated GBM (-6% +/- 10%) (P< 0.03). Cox regression analysis suggested a trend toward significant PFS benefit with increasing percent change in ADC metrics in the pembro treated group (P= 0.053 to 0.057).

Conclusions
Pembro with CRT results in significantly increased ADC metrics in patients with primary GBM compared to controls. This may be due to disproportionate treatment induced interstitial edema. This is paradoxical to the hypothesized pembro mediated immune infiltrate and cytotoxic edema that would decrease ADC. Interestingly this effect is only observed in the T2 hyperintense region. Furthermore, the degree of ADC change 10 weeks after the initiation of therapy may be an early biomarker of effective therapy.

Scientific Abstract Session: Head & Neck Miscellaneous
1267

Proboscis Lateralis: A Rare Congenital Midface Abnormality

J ZHANG1, B Branstetter2
1UNIVERSITY OF PITTSBURGH (UPMC), PITTSBURGH, PA, 2UPMC, PITTSBURGH, PA

Purpose
To describe a rare case of proboscis lateralis, review the imaging findings, and describe optimal clinical management.
Materials and Methods
A normal birth weight male was born at full term via vaginal delivery to a 27-year-old G1P1 mother without known genetic risk factors. Prenatal ultrasound had noted an abnormal soft tissue lesion near the right eye, as well as a sacral tuft, so he was transferred to an academic children's hospital after birth. Clinical exam revealed abnormal right nostril, facial cleft with microform cleft lip and alveolus cleft, with involvement of the right lower eyelid. Maxillofacial CT was performed at 3 days of age. MRI was performed at one year of age and the patient underwent right lower eyelid repair and right nasolacrimal duct reconstruction at that time. Subsequently planned stage 1 proboscis lateralis repair was performed at 16 months, followed by stage 2 repair 6 months later. At age 5 years, the patient underwent fat grafting to the nose from the left thigh for improved cosmesis. Alveolar bone graft with autologous cancellous bone from the right hip was performed at age 7 for midline alveolar cleft. The patient is currently in elementary school and doing well in regular classes.

Results
Initial head and maxillofacial CT exams performed at 3 days of age, with 3-D volumetric surface rendering, confirmed right-sided proboscis lateralis and demonstrated associated right heminasal and maxillary dysplasia. MRI at age one year showed a right dacrocystocele with concern for superinfection. Right-sided proboscis lateralis and ipsilateral heminasal dysplasia were redemonstrated. The proboscis structure, lined with respiratory epithelium, enhanced similarly to nasal mucosa. CT following stage 1 repair demonstrated improved cosmesis after the initial procedure.

Conclusions
Proboscis lateralis is a very rare craniofacial congenital anomaly (reported incidence 1:100,000, 3:1 male to female predominance) with characteristic clinical and imaging findings, which can occur in isolation or with concurrent maxillofacial anomalies. It is described as a tubular, rudimentary nasal structure projecting off-midline in the midface, usually arising from the medial canthal region. Embryologically, it results from abnormal development of the nasal placode, usually with associated ipsilateral heminasal hypoplasia or aplasia, as well as ocular maldevelopment and cleft lip and/or palate. Unlike midline proboscis malformations, most patients do not have serious CNS anomalies. CT and MRI are useful in assessing the magnitude of underlying osseous and soft tissue abnormalities. Treatment options depend on extent of involvement and presence/absence of associated abnormalities. If surgically repaired, operations are generally staged.

Pulsatile CSF jet into a massive pseudomeningocele post-suboccipital decompression for Chiari I malformation: “Geyser sign” on MRI CSF flow study.

C Hsu1, S Bhuta1, K Kato1, M Lousick2
1Gold Coast University Hospital, Gold Coast, Australia, 2Gold Coast University Hospital, Gold Coast, Queensland
Purpose
To illustrate a rare complication of pulsatile cerebrospinal fluid (CSF) jet entering a pseudomeningocele post-suboccipital decompression surgery for Chiari I malformation.

Materials and Methods
A 42-year-old female patient with Chiari I malformation and upper cervical syringomyelia underwent elective suboccipital decompression surgery and duraplasty without tissue sealant. Although the immediate post operative period was uneventful, she represented four months post-operatively with acute onset of severe headache and a large pulsatile suboccipital mass. MRI of the brain and cervical spine revealed a massive suboccipital pseudomeningocele. CSF flow study demonstrated a small dural defect at the base of the pseudomeningocele with pulsatile jet of CSF entering the pseudomeningocele. Intraoperatively, there was a narrow flap valve defect in the dura mater, possibly resulting in the creation of a pressure gradient to generate the high velocity pulsatile CSF jet. Surgical repair was successful in sealing this defect. MRI scan performed at six months follow-up demonstrated interval reduction in size of the suboccipital pseudomeningocele.

Results
Pre-operative MRI scan revealed Chiari I malformation with upper cervical syringomyelia. Four months post-operatively patient represented with a massive pseudomeningocele. High resolution T2-weight (T2 SPACE) acquisition demonstrated a narrow defect in the dura mater at the base of the pseudomeningocele. Phase contrast CSF flow study showed pulsatile CSF jet entering the pseudomeningocele simulating the appearance of a Geyser. Axial FLAIR images of the pseudomeningocele showed pulsation motion artifacts along the phase encoding direction.

Conclusions
Phase contrast CSF flow study is a valuable addition in the assessment of complicated pseudomeningocele to differentiate a simple CSF leak from a pulsatile pressure-driven CSF leakage through a flap valve defect in the duraplasty.
positive despite negative PET scans. 1 patient had Fluoroclovine and FDG scans which revealed a possible primary with negative pathology. A higher Likert score correlated well with identifying site of primary. 5/5 patients with Likert score of 3 or greater on Fluoroclovine PET had positive pathology, while both patients with Likert score of 1 or 2 and both patients with no primary identified had negative pathology.

Conclusions
Fluciclovine PET demonstrated a nearly-equivalent ability to SOC FDG PET in identifying the site of primary tumor in patients with metastatic SCC of the head and neck but no apparent primary seen on CE-CT. Additional data is needed to confirm these initial observations.

Can Radiologist Assessment of the Tongue Inform Interpretation of Brain MRI Performed for Suspected Seizure?

J Erickson1, M Benayoun1, C Lack1, J Sachs1, P Bunch1
1Wake Forest School of Medicine, Winston-Salem, NC

Purpose
Suspected seizure is a common indication for emergency department (ED) imaging. Lateral tongue bites are described as a specific clinical finding of generalized seizure (1-5). We have observed tongue signal abnormality (TSA) suggesting bite injury on brain MRI among ED patients imaged for suspected seizure. We hypothesize a positive association between TSA and clinical diagnosis of generalized seizure. The purposes of this study are: 1) to determine the prevalence of TSA among ED patients imaged for suspected seizure 2) to assess for associations between TSA and clinical seizure diagnosis.

Materials and Methods
For this HIPAA-compliant, IRB-approved retrospective study, the T2-weighted and FLAIR images from 46 consecutive brain MRI examinations meeting inclusion criteria were independently evaluated by 2 readers (1 radiology resident, 1 attending neuroradiologist) for TSA. Readers were blinded to clinical information during initial image review. Discrepancies were resolved by unblinded consensus review. Imaging data were recorded, and clinical information was obtained from the electronic medical record. Statistical tests were performed.

Results
The prevalence of TSA was 26% (12/46). Inter-rater reliability was 'substantial' (0.777, Cohen kappa). When present, TSA was more commonly unilateral (8/12; 67%) than bilateral (4/12; 33%). When unilateral, a left-sided predilection was observed (7/8; 88%). Tongue injuries were documented by clinical exam in 9/12 (75%) patients with TSA and 3/34 (9%) patients without TSA (p<0.0001, Fisher exact). The final clinical diagnosis was 'generalized seizure' among 11/12 (92%) patients with TSA and 26/34 (76%) patients without TSA (p=0.41, Fisher exact). With clinical diagnosis as gold standard, TSA conveyed 30% sensitivity, 89% specificity, 92% PPV, and 24% NPV for generalized seizure among this patient population (80% disease prevalence).

Conclusions
Prevalence of TSA suggesting bite injury among ED patients imaged for suspected seizure is 26%, and a significant association between TSA and documented tongue injuries was observed. In this high generalized seizure prevalence cohort, there was no significant association between TSA and final clinical diagnosis. Nonetheless, radiologist awareness of, assessment for, and reporting of TSA as a potentially high specificity finding for generalized seizure may have clinical utility in high patient-throughput EDs, where some tongue bite injuries may be unrecognized clinically.
Radiology Errors and Misses on CT and MRI Imaging

S Culleton¹, J Lysack¹
¹Foothills Medical Centre, Calgary, Alberta

Purpose
To review head and neck cancer cases from a tertiary referral centre tumour boards and evaluate available prior earlier imaging to see if the mass was evident To categorise any masses not mentioned on prior imaging in a structured approach according to a classification system to gain insight into radiology common errors and misses Classify missed tumours by location to discover the commonest radiology head and neck "blind spots" on imaging

Materials and Methods
Previous imaging for each patient was reviewed by two reviewers a Neuroradiologist and a Neuroradiology fellow to determine if the subsequently diagnosed head and neck malignancy were present on the earlier imaging study. Documented the following; type of

Figure: Axial T2-weighted images with fat suppression (A, B) and coronal FLAIR images with fat suppression (C, D) obtained in four different patients demonstrate the typical appearance of tongue signal abnormality (red arrows) suggesting seizure-related bite injuries.

(Filename: TCT_2139_Abstract_Figure.jpg)
study and date of exam, clinical history on examination request, type of tumour, delay to diagnosis. Each case was then categorised into a type of error or miss based on a classification system previously described for categorising errors in diagnostic radiology (1).

Results
In total 1196 patients, over 5 year period were reviewed and 43 cancers were deemed missed cancers on prior imaging giving a 3.6 % error rate. Thirteen cases (30.23%) were categorised as faulty reasoning, findings described but attributed to wrong cause these are true-positives findings misclassified. Thirty (69.77 %) cases were deemed as under-reading (missed findings) the finding was present and not mentioned. The location of the cancers was as follows; oropharynx 11 cases, sinuses 9, nasopharynx 7, salivary gland 5, larynx 4, oral cavity 3, hypo pharynx 3, unknown ca lymphadenopathy 1 case. Delay in diagnosis ranged from 1 – 2800 days.

Conclusions
The commonest cause for radiology errors in head and neck imaging was under-reading and missing the findings completely. As many studies are often performed for other reasons, there is a missed opportunity to discover a patient's malignancy at an earlier stage and improve a patient's outcome. The commonest missed areas which warrant particular review are the oropharynx, sinuses and nasopharynx.

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The Shifting Infrahyoid Carotid Artery: An Entity Clinicians Should Know

A Nayate¹, S ANWARULISLAM²
¹University Hospitals of Cleveland, Cleveland, OH, ²CASE WESTERN UNIVERSITY, Cleveland, OH

Purpose
We describe a case in which the carotid arteries changed positions in the infrahyoid neck.

Materials and Methods
An elderly obese female patient with history of essential hypertension was referred to undergo an aortic valve replacement for aortic stenosis. A preop chest CT with IV contrast revealed retropharyngeal (RP) course of the infrahyoid common carotid arteries (CCA), defined as located medial to the lateral border of the thyroid cartilage at the level of the hypopharynx and thyroid and cricoid cartilages. After aortic valve replacement, the patient had 2 CT angiogram of the neck studies due to concern for stroke 4 and 9 months after surgery. These studies demonstrated tortuous carotid arteries and the carotid arteries changed positions in the infrahyoid neck.

Results
Figure A. Infrahyoid RP CCAs Figure B. Infrahyoid CCAs are no longer in a RP position 4 months after surgery Figure C. Infrahyoid CCAs are more medial in location 9 months after surgery Figure D. Tortuous carotid arteries

Conclusions
Movement of the carotid arteries on imaging at different time points has been described in 6 cases at the level of the hyoid bone. Incomplete fascial ring enveloping the carotid and jugular vessels in the suprathyroid neck and variance in anatomic position of the carotid arteries during swallowing have been proposed as 2 explanations for this phenomenon. These explanations would not account for the change in position of the carotid arteries in the infrahyoid neck. This case demonstrates that carotid arteries can also change positions in the infrahyoid neck. The etiology remains unclear but could be related to reduced axial tension on carotid arteries and increased body mass index (BMI). Reduced axial tension occurs due to elastin degradation in the arterial walls and is linked to multiple processes including hypertension and elderly age. Reduced axial tension can lead to tortuous arteries and 2 prior studies demonstrated that tortuous arteries can move due to change in head position. Another study demonstrated a direct relationship between tortuosity of the cervical carotid artery and BMI which was partly attributed to intraabdominal hypertension causing elevation of the diaphragm and mediastinum. This elevation causes the CCA to rise and the distance from the cervical carotid artery origin to its termination at the skull base is reduced. The artery then becomes tortuous to maintain the same length and can change position since the carotid arteries are surrounded by loose connective tissue.
Clinico-Radiological Features of a 'TIPIC'al Case of Unilateral Neck Pain

R Purushothaman¹, G Vilanilam¹, R Ramakrishnaiah¹, M Kumar¹, R Samant¹
¹University of Arkansas for Medical Sciences, Little Rock, AR

Purpose
Transient Perivascular Inflammation of the Carotid Artery (TIPIC) syndrome is diagnosed in less than 3% of patients with acute-onset neck pain. The clinico-radiological description of TIPIC syndrome is sparse in literature, with about 47 reported patients so far. The purpose of our excerpta is to elucidate this uncommon entity further.

Materials and Methods
A 55-year-old woman with no significant past history presented with right-sided neck pain for four days. She had a two-week history of non-productive cough and shortness of breath without fever, trauma, headache, or neurological symptoms. On examination, she was febrile and hemodynamically stable. There was fullness on the right side of the neck without neurological deficit. Labs were significant only for raised WBC count of 19.74K/uL. She was evaluated with CT angiogram (CTA) head and neck which showed inflammatory changes around the right carotid artery suggestive of TIPIC syndrome. She was managed conservatively with non-steroidal anti-inflammatory agents, with resolution of symptoms and lymphadenopathy at two-week follow-up.

Results
CTA of the head and neck revealed circumferential wall thickening surrounding the proximal portion of the right internal carotid artery (ICA) and carotid bulb, with a trace collection in the lateral wall of the proximal ICA. Additionally, right-sided lymphadenopathy and fluid extending to the right retropharyngeal space was noted.

Conclusions
TIPIC syndrome has evolved over time from an obscure entity of idiopathic carotid bifurcation pain, to the incorporation of specific imaging features. Even so, this entity affects only 0.002% of the population. The most commonly reported symptom is unilateral neck pain with palpable swelling, as seen in our patient. Only about 1 in 5 patients have neurological symptoms. Current literature also suggests an association with autoimmune diseases or acute inflammatory conditions, such as upper respiratory tract infection seen in our patient. Perivascular inflammatory soft tissue with enhancement, fat stranding, and lumen caliber narrowing without flow limitation are invariably seen in most patients. Less frequently, unilateral lymph node enlargement, soft intimal plaque, laryngeal, and pharyngeal inflammation were reported. Carotid artery dissection is the top differential, and CTA remains the investigation of choice as it also helps in the diagnosis of other differentials of neck pain. Patients are treated conservatively with complete resolution of symptoms within two weeks.
Duo-Invasion of the Brachial Plexus and Cavernous Sinus in a Singular Case of Waldenstrom Macroglobulinemia.

M Nguyen¹, T Vanderjagt¹, J Witt¹, V Phalke¹
¹Oregon Health & Science University, Portland, OR

Purpose
Waldenstrom's macroglobulinemia (WM) is a distinct type of non-Hodgkin's lymphoma characterized by lymphoplasmacytic infiltration in the bone marrow, lymph nodes and spleen. Central nervous system (CNS) involvement defines Bing Neel Syndrome (BNS), a rare complication of WM described only in case reports and small case series. Unlike neurolymphomatosis related to non-Hodgkin's lymphoma, which historically carries a poor prognosis, BNS is relatively responsive to standard chemotherapy and radiotherapy. However, diagnosis of BNS is challenged by its rarity in addition to the characteristically long time interval between onset of WM and CNS involvement, with median delay in time reportedly up to 9 years. BNS can present focally or diffusely. To our knowledge, there are no prior reports of both forms presenting simultaneously, as demonstrated in our case of diffuse brachial plexus involvement and tumoral cavernous sinus invasion. This case highlights the varied imaging presentations of BNS that further undermine its diagnosis.

Materials and Methods
71 year-old female presents with progressive left upper extremity pain and weakness. She was diagnosed with Waldenstrom's macroglobulinemia 8 years prior to presentation without history of CNS involvement, and had been in complete remission for 2 years following rituximab maintenance therapy. Left upper extremity symptoms were initially associated with cervical degenerative disc disease, but progressed despite analgesic trials, nerve blocks and ultimately surgical decompression with left C6-7 foraminotomies. Neurolymphomatosis was suspected on further work-up with MRI of the brain/brachial plexus, and serum laboratory tests showing elevated monoclonal IgM; diagnosis was confirmed on CSF analysis. The patient achieved symptomatic relief after resuming chemotherapy.
Results
Post-gadolinium T1-weighted MRI Brain shows right nasopharyngeal soft tissue mass extending into the fossa of Rosenmueller (A) with abnormal enhancement of the V3 segment of the trigeminal nerves at the level of the foramen ovale bilaterally (B). MRI of the brachial plexus shows fusiform thickening and enhancement of the left C6-C8 and T1 nerve roots and trunks (C). PET/CT shows corresponding increased radiotracer uptake in the nasopharyngeal mass and brachial plexus (D).

Conclusions
BNS should be considered in any patient with neurologic symptoms and history of hematologic malignancy. Both symptoms and imaging findings may resolve following treatment with chemotherapy.

Eye tracking for cervical lymph node localization, longitudinal follow-up and for deep learning data labeling: a proof of concept

J STEMBER1, A Holodny2, N Swinburne1, D Gutman1, R Young1, E Krupinski3
1Memorial Sloan Kettering Cancer Center, New York, NY, 2MEMORIAL SLOAN KETTERING CANCER CENTER, NEW YORK, NY, 3Emory University School of Medicine, Atlanta, GA

Purpose
Cervical lymphadenopathy is a key prognostic and treatment-directing feature for primary head and neck malignancies as well as non-solid tumor types such as lymphoma (1). Generally, larger nodes are followed due to higher likelihood of containing tumor spread. Following such nodes can be challenging and tedious, especially when a large number is present. Additionally, inadequate annotated data hampers progress in deep learning to localize, measure and classify lymph nodes. We have recently demonstrated feasibility of
Eye Tracking (ET) to label lesions for deep learning (2). Extracting labeled diseased cervical lymph nodes automatically from ET, in the routine clinical setting, could vastly improve the convolutional neural networks. In this proof-of-principle work, we hypothesize that ET can accurately localize and annotate cervical lymph nodes.

Materials and Methods
Nine publicly available (3) image slices of neck CTs containing a total of 14 lymph nodes highlighted by arrows were viewed by a radiology researcher with eye tracking software and hardware (Tobii T60XL). The arrows were mostly embedded in the public images, but this did not detract from the study, because our initial goal is to analyze larger, more obvious lymph nodes, which typically is the main focus of clinical interpretation and follow-up. Gaze plot heat maps (Fig 1B) were generated, with red regions corresponding to longer gaze times. The user was instructed to look longer (~2 seconds) at the highlighted nodes than other structures. All nodes were traced with hand annotated (HA) regions of interest (ROIs) in Matlab v2016b, with the remaining image processing employing Python v3.7. Regions of prolonged gaze were extracted by color selection for the red areas (Fig 1B) yielding ET ROIs.

Results
100% (14/14) of nodes were correctly predicted (i.e. nonzero overlap) by ET. Fig 1 displays one sample image with a large centrally necrotic labeled node (1A), its gaze plot (1B), the HA ROIs (1C) and the ET ROIs (1D).

Conclusions
We have demonstrated as proof-of-principle that ET can accurately localize cervical nodes. They can thus generate "seed points" to easily tag nodes for longitudinal follow-up and deep learning applications of automated detection and measurement. Future work will extend the modest sample size, employ three-dimensional image sets and use the seed points for longitudinal image tracking and convolutional neural network training.

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Is my scanner broken? "Pseudo fat-saturated” MRI images in Cachexia

Y Chen¹, M Chan¹
¹Trillium Health Partners/ University of Toronto, Mississauga, Ontario

Purpose
Cancer cachexia is a wasting syndrome characterized by anorexia with progressive loss of adipose tissue and muscle mass. It is driven by tumor-induced metabolic and hormonal dysregulation. MRI images of cachexic patients have a "pseudo fat-saturated" appearance secondary to disappearance of subcutaneous fat tissue, as well as fat atrophy of the bone marrow. Interestingly, orbital fat is usually preserved. We present a case with classic, but often misdiagnosed, imaging findings of cancer cachexia.

Materials and Methods
A 74-year-old male presented to the emergency department with episodes of falls and 30-pound weight loss over 6 months. MRI of the head revealed a large infiltrative nasopharyngeal mass with extensive skull base invasion. In addition, it was noted that the T1-weighted images resembled fat-saturated sequences with hypointense signal in the scalp, neck tissue, and marrow. However, bilateral orbital fat remained hyperintense. The scan parameters were doublechecked to ensure correct TR and TE times (492ms/11ms). Prior CT scans confirmed absence of subcutaneous fat in the scalp and body wall, but preserved orbital fat. Low bone marrow T1 signal is attributed to marrow fat lipolysis with replacement by extracellular mucopolysaccharide, a process named "gelatinous transformation" or "serous atrophy".

Results
Sagittal (A) and coronal (B) non-fat saturated T1-weighted MRI images through the head demonstrate diffuse hypointensity of the scalp, neck soft tissue, and bone marrow leading to a "pseudo fat-saturated" appearance. Bilateral orbital fat remained hyperintense (B). A large nasopharyngeal tumor infiltrating the skull base (yellow arrows) is seen in (A). Axial CT image through the head (C) and neck (D) corroborate the preservation of orbital fat but complete absence of subcutaneous fat.

Conclusions
This case illustrates the often confusing imaging findings of long-term cachexia. When faced with prolonged negative energy balance, the body mobilizes atypical energy stores causing disappearance of subcutaneous and marrow fat leading to a "pseudo fat-saturated" appearance on MRI. Orbital fat is usually the last to undergo lipolysis, but is involved in extreme cases. Radiologists should be aware of this phenomenon in order not to mistake this for erroneous scan parameters or incorrectly diagnose orbital fat inflammation or marrow tumoral infiltration.
Scientific Abstract Session: Health Policy

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Value of Emergent CT Angiogram for "Seat belt Injury"

F Ghazi Sherbaf\(^1\), E Beheshtian\(^1\), D YOUSEM\(^1\)
\(^1\)JOHNS HOPKINS MEDICAL INSTITUTION, Baltimore, MD

Purpose
The presence of seat belt injury sign is debated as an independent indicator of blunt cerebrovascular injury (BCVI) in the literature without consensus. In many trauma centers and emergency departments (ED), CT angiography (CTA) is frequently ordered to exclude BCVI in patients demonstrating this sign after motor vehicle collision (MVC). In this study, we aimed to assess the value of emergent CTA in MVC patients who presented with a seat belt sign in our institution.

Materials and Methods
We retrospectively searched our electronic medical record for patients who underwent CTA or MRA screening for BCVI after MVC who also had a "seat belt" injury of the neck. Patients' imaging studies' results, demographics, medical history, and physical examination were retrieved from the Epic system.
Results
206 adult (70.4% female, mean age 41.5 years) and 21 pediatric (57.1% female, mean age: 13.9) ED patients with the seat belt sign from May 2011 until July 2019 were identified. Five patients had a GCS of 14; all others had a GCS of 15. 18 patients had lost consciousness (LOC) at the time of accident. Others had denied LOC. None of the patients were reported to have a focal neurological deficit on physical examination. Neck CTAs were negative for all patients regarding the presence of BCVI in the setting of acute trauma. One 52 year old female patient with a left neck abrasion from the seat belt injury showed a dissection and a focal pseudoaneurysm of the right vertebral artery with a beaded appearance of both cervical internal carotid arteries compatible with fibromuscular dysplasia rather than acute traumatic injury. In the course of hospitalization, this patient did not show any neurological symptoms. Other trauma-related findings were fractures of the ribs (n=4), clavicle (n=1), facial bones (n=3), and cervical vertebrae (n=3), cervical spine ligamentous injuries (n=2), and hematoma in the scalp or neck (n=9).

Conclusions
We found that the risk of injury to the neck vessels in the presence of the seat belt sign is negligible. Therefore CTAs performed solely based on the seat belt sign have limited value. We suggest that this CTA indication be eliminated in the absence of other findings.

Benefits of MRI Acceleration Techniques in Increasing Productivity and Urgent Patient Access to MRI at a Large Academic Medical Center

M Keiper1, S Kelly2, C Byers3
1UNMC, Omaha, NE, 2UNMC, Papillion, NE, 3University of Nebraska Medical Center, Omaha, NE

Purpose
To determine the utility of MRI acceleration techniques in increasing productivity and urgent add-on patient access to MRI at a large academic medical center.

Materials and Methods
An MRI acceleration technique (compressed sensing) was applied to all existing MRI protocols at a large academic radiology department. No additional modifications were made to the protocols. Imaging was performed on four MR systems, two 1.5 T and two 3.0 T scanners. Mean scan times for each MRI exam were recorded before and after application of the acceleration techniques. Mean number of studies and percent increase in studies completed in a daytime shift before and after applying the acceleration techniques were also evaluated. Centralized scheduling time slots remained at 45 minutes, and time savings were utilized to accommodate urgent add-on scan requests. Changes in add-on scan requests accommodated before and after the intervention were recorded.

Results
All existing MRI protocols were successfully converted without change in image parameters. Mean imaging time prior to conversion was 25.5 minutes. Mean imaging time after application of acceleration techniques was 17.6 minutes. The vast majority of new MR imaging time times were between 15 and 30 minutes as opposed to 30-45 minutes prior to application of acceleration techniques. Mean increase in studies performed on each scanner per daytime shift was 2.5 exams for a total increase of 10 scans per day across all four scanners. This constituted an overall 18% increase in total scans across all four systems per day shift. Time savings allowed for the accommodation of urgent add-on requests. The number of urgent add-on requests accommodated per daytime shift on all four scanners increased from a mean of 4 to a mean of 14 after application of acceleration techniques.

Conclusions
The use of MR acceleration techniques is effective in increasing the overall productivity of MR scanners and may also be utilized to improve patient care through significant increase in accommodation of urgent or emergent add-on requests. These innovative techniques may also ultimately translate to increased radiology department revenues and overall patient access to coveted daytime imaging time slots.

Utilization Trends of CT Angiography of the Head and Neck: A Dramatic Rise in ED Imaging

A Gandhi1, G Bober1, R Gorniak1, A Flanders1
1Thomas Jefferson University Hospital, Philadelphia, PA

Purpose
Neurovascular imaging volume has been increasing, in part due to recent changes in stroke management guidelines. The aim of this study is to analyze utilization trends of CT angiography of the head and neck among the Medicare population from 2001-2018.

Materials and Methods
Medicare Part B Physician/Supplier Procedure Summary master files from 2010-2018 and Part B National Summary Data Files from 2001-2018 were analyzed for all Current Procedural Terminology, version 4 (CPT-4) codes related to CT angiography of the head and neck (70496 and 70498). The files provided total procedure volume and Medicare payments, from which utilization rate could be
calculated. Medicare place-of-service codes were used to identify locations where services were provided. Medicare specialty codes were used to determine provider specialty.

Results
Utilization rate per 1,000 Medicare beneficiaries of CT angiography of the head and neck has increased every year since 2001 with 8941% increase from 2001 to 2018 and 109% increase from 2014 to 2018. Medicare payments have seen similar increases with a doubling of payments from $32.9 million in 2014 to $65.9 million in 2018. While overall utilization rate has increased, the growth of emergency department imaging has outpaced inpatient and outpatient imaging within the past 2 years. Emergency department imaging accounted for 12% of overall CTA imaging in 2010 versus 39% in 2018 and now constitutes the largest contributor to CTA head and neck imaging volume. Lastly, radiologists consistently hold greater than 90% share and interventional radiologists hold a 3-4% share of CTA head and neck Medicare claims. All other providers' share of CTA head and neck claims have decreased from 6.3% in 2010 to 1.6% in 2018.

Conclusions
Rising utilization rates of CTA head and neck imaging, especially in the emergency department, has placed incredible workload demands on radiologists. The exponential growth in emergency department imaging coincides with the implementation of new stroke guidelines.

Facilitating MRIs in Patients with Non-Conditional Cardiac Devices: What the Neuroradiologist Should Know

M Antonucci¹

¹MEDICAL UNIVERSITY OF SOUTH CAROLINA, CHARLESTON, SC

Purpose
Recent large clinical trials evaluating MR safety profiles of non-conditional ("legacy") cardiac devices demonstrated a strikingly low complication rate in carefully monitored patients. This motivated the Centers for Medicare & Medicaid Services to permit reimbursement for MRIs in these patients. Collectively, the scientific evidence and regulatory change allow radiologists to offer expanded services to a vulnerable patient population. Unfortunately, there is lagging awareness of these changes, leading to a slow incorporation of new policies. Evidence of this includes: -The largest trials originating outside the radiological literature. -Advocates of MRIs in device patients simultaneously unaware of CMS policies.(ref4) -A global inertia, with British reports of only 2% of needed MRIs performed in this group.(ref5) In this setting, neuroradiologists must proactively bridge science/policy advances and clinical care. The purpose herein is to review the literature and federal regulatory change, offer suggestions for local protocol incorporation, and discuss real-world experience imaging this patient population.

Materials and Methods
-Review the critical literature and evidence regarding MRIs in legacy device patients. -Suggest techniques for CMS-compliant protocol design/implementation, and facilitation of service expansion to these vulnerable patients. -Identify challenges to local policy change implementation and discuss potential solutions.

Results
The MagnaSafe Registry & Nazarian's study report extraordinarily low complication rates. Along with cumulative data from smaller
studies & solicited public comments, this compelled the CMS to revise coverage determinations. Reviewing the associated published guidelines can facilitate protocol implementation. Altering conceptions of MRI safety policies (ingrained in the mandate to "do no harm") can be challenging. This can be remedied through multidisciplinary teamwork, standardized patient screening/monitoring, and an institutional commitment to facilitating MR access (as modeled in our institution).

Conclusions
The scientific & regulatory progress in MRI safely for device patients represent the culmination of evidence gathering, extensive effort revising protocols, & tireless work toward policy change. However, ensuring radiologist/clinician awareness, promoting ground-level policy implementation, and preemptively addressing understandable hesitation represent critical steps in translating excellent science into improved patient access.

Analysis of BPCI Stroke Clinical Episode and Ramifications for Participation in BPCI Advanced

O Schoeck1, M Chen2, L Golding3, K Wang4, J Hirsch5, G Nicola6, R Lee1
1Albert Einstein Medical Center, Philadelphia, PA, 2MD Anderson Cancer Center, Houston, TX, 3N/A, N/A, 4Baylor College of Medicine, Houston, TX, 5Massachusetts General Hospital, Boston, MA, 6Hackensack Radiology Group, Hackensack, NJ

Purpose
The Bundled Payments for Care Improvement Initiative (BPCI) created by the Center for Medicare & Medicaid Innovation (CMMI) was a demonstration project to see if linking physician payments to an episode of care would improve quality and/or reduce cost. We now have performance information from providers participating in this initiative. The purpose of this project is to evaluate the performance of providers in BPCI specifically in the Stroke Clinical Episode and to compare this with other clinical episodes. We will also analyze these findings with respect to how providers in the newer BPCI Advanced Model may perform.

Materials and Methods
Data for the Stroke Clinical Episode and all other BPCI clinical episodes from 2013-2016 is available from CMS and will be presented. The effect of the BPCI initiatives on CMS payments, quality of care, and length of stay are analyzed.

Results
Medicare fee-for-service (FFS) payments decreased for the stroke clinical episode, and across all clinical episodes, models, and participant types in BPCI. However, there were no net savings to the Medicare program nor were there significant changes in the quality of care.

Conclusions
Although BPCI did not ultimately decrease cost or quality, lessons learned from its implementation have ramifications for both CMS and providers for those choosing to participate in BPCI Advanced. As CMS has adjusted the payment methodology in this initiative, it is imperative that interventional neuroradiologists participating in the Stroke Clinical Episode be cognizant of factors that may improve or hamper their performance.

Team Science and Interdisciplinarity in Radiology and Implications for Radiology Resident Training: a Retrospective Review of 1.0 Million Citations

M Petterson1, C Longhurst2, J Yu3
1University of Wisconsin Hospital and Clinics, Madison, WI, 2University of Wisconsin - Madison School of Medicine and Public Health, Madison, WI, 3University of Wisconsin School of Medicine and Public Health, Madison, WI

Purpose
The need for inter- and cross-disciplinary research has never been greater, in radiology no less than other biomedical fields. However, little is known about interdisciplinary research output in radiology. To understand the effect of collaborative research in radiology, comparison was made between interdisciplinarity and journal impact factor, which is frequently used as a surrogate marker for overall reach and quality of published research.

Materials and Methods
The top 125 journals as measured by journal impact factor in the year 2014 from the Web of Science category "Radiology, Nuclear Medicine, and Medical Imaging" were identified. Articles published within each journal during the years 2012-2014 were then analyzed to create a categorized report of all subsequent citing publications, utilizing an approach with yielded DIV*, a statistical metric of interdisciplinarity. The data were then pooled, and impact factor and interdisciplinarity were compared.

Results
When examining more than one million article citations from the aggregated data, a significant correlation was found between journal impact factor and interdisciplinarity (t = 0.26, p-value < 0.001).

Conclusions
Radiology research with implications for multiple specialties tends to be associated with to increased number of future citations,
evidencing greater influence on future inquiry. Given that interdisciplinary research is particularly impactful, efforts should be made to engage radiology residents in team science during training to help provide them with the tools to engage in such interdisciplinary research in the future.

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Neuroradiology Fellow Remediation: a National Survey

T Ouyang¹, V Agarwal², M Mullins³, B Policeni⁴
¹Penn State Health Hershey Medical Center, Hershey, PA, ²University of Pittsburgh Medical Center, Pittsburgh, PA, ³Emory University, Atlanta, GA, ⁴N/A, N/A

Purpose
It is estimated that approximately 7-10% of trainees across all medical specialties fall into category of "under-performing" or "problematic" trainee. The identification and remediation of under-performing fellows in one year radiology subspecialty fellowships (which most are) is particularly difficult and urgent because of the short duration of training. The purpose of our study was to identify the scope of the problem in one year neuroradiology fellowships and gather information on evaluation and remediation strategies as well as barriers to remediation.

Materials and Methods
Program directors of 91 ACGME accredited neuroradiology fellowship programs were sent an electronic survey. We collected information on demographics of the program, identification of problematic fellows, and decision making regarding remediation and remediation strategies/outcomes.

Results
The response rate was 30% (27 of 91). 30% (8 of 27) fellowship programs has had to remediate in the last 10 years. The most frequently reported deficiencies of under-performing fellows were: insufficient medical knowledge (71%), poor clinical judgment (46%), unsatisfactory behavior with faculty/staff (33%), and poor interventional skills (25%). Approximately half (48%) of programs reported having a structured remediation program in practice. Remediation included: frequent feedback sessions (82%), general counseling (55%), targeted mentorship (36%), remedial didactic and educational activity (27%), and psychiatric/psychological counseling (18%). 18% of fellows were placed on probation. Remediation failed to improve 9% (1 of 11) of fellows who did not
graduate. Interestingly, 35% (8 of 23) responders had under-performing trainees who were not remediated (approximately 12 in past 10 years). Reasons listed for not remediating included delay in recognizing need for remediation, insufficient time to remediate, and possible stigma for trainee future employment chances.

Conclusions
Despite the relatively low response rate, 30% of neuroradiology fellowship programs have had to remediate in the last 10 years and another 35% of respondents had under-performing fellows who were not officially remediated. Our data indicate that under-performance is not an uncommon problem in one year neuroradiology fellowships, and while deficiencies may exist in multiple domains requiring individualized learning plans, remediation is possible and usually successful.
Neuroradiology Fellowship Remediation: Questionnaire

Demographics:

Location of institution:
- Midwest
- Northeast
- Pacific
- South
- West

Number of one year fellows per year (1-3, 4-5, 6-10, >10)

Approx. number of graduating fellows in last 10 years (10-30, 30-50, >50)

Number of fellows who failed to graduate in last 10 years (0-3, 4-5, 6-10)

What % of fellows completed DR residency at same institution (0-25%, 25-50%, 50-75%, 75-100%)

What percent of fellows graduated from a non-ACGME accredited/ international DR residency (0-25%, 25-50%, 50-75%, 75-100%)

Number of full time neuroradiology faculty (1-5, 6-10, >10)

Number of part time neuroradiology faculty (1-5, 6-10, >10)

Years of experience as fellowship PD (0-3, 4-5, 6-10, >10)

Identification of Problem Trainee
- Is there a written policy regarding unsatisfactory performance of trainees? (Y/N)
- Do fellows have formal advisors outside of the PD? (Y/N, other/please specify)
- How often does PD meet with the fellows? (monthly, quarterly, twice yearly, other/please specify)
- How often does your CCC meet? (monthly, quarterly, twice yearly, other/please specify)
- How are fellows evaluated in your program? (choose all that apply: faculty evaluations, tech evaluations, self-evaluations, perception of faculty, perception of PD, other/please specify)
- How often are one year fellows evaluated (twice yearly, quarterly, monthly, other/please specify)
- How were the problematic fellows identified? (choose all that apply: formal evaluations, private communication, CCC meetings, general sense of PD, other/please specify)
- What were the apparent deficiencies? (please check all that apply)
  - Insufficient medical knowledge
  - Poor clinical judgment
  - Poor interventional skills
  - Poor patient care
  - Unsatisfactory behavior with colleagues/staff
  - Unsatisfactory behavior with patients
  - Excessive tardiness/absences
  - Unacceptable ethical behaviors
  - Other/please specify

Scope/Solution:
- Is there a structured remediation program in practice? (Y/N)
- Have you ever had to re-mediate a fellow (Y/N)
- If yes, how many times in the last 10 years (free text)
- How did you remediate? (check all that apply)
  - General counseling
  - Frequent feedback sessions
  - Special mentor assigned (to deal with the problem)
  - Remedial didactic and educational activity
  - Psychiatric/psychological counseling
  - Formal psychomotor/learning assessment
  - Substance abuse rehabilitation program
  - Probation
  - Leave of absence
  - Other/please specify
- How long was the remediation process? (free text)
- What was the outcome of remediation, ie did s/he then complete fellowship? (Y/N, free text)
- Have you ever felt that a trainee was problematic but did not seek to remediate? (Y/N)
- If yes, how many times in the last 10 years (free text)
- Why did you not choose to remediate? (free text)
- Did s/he then complete fellowship? (Y/N, free text)
- Does your program do any systematic follow up of fellows after graduation? (Y/N)
- If yes, how? (free text)
Restructuring and Revaluation of Evaluation and Management Codes and Implications for the Neuroradiology Profession

K Wang¹, R Lee², L Golding³, O Schoeck², J Hirsch⁴, G Nicola⁵, M Chen⁶
¹Baylor College of Medicine, Houston, TX, ²Albert Einstein Medical Center, Philadelphia, PA, ³Triad Radiology Associates, Winston-Salem, NC, ⁴Massachusetts General Hospital, Boston, MA, ⁵Hackensack Radiology Group, Hackensack, NJ, ⁶MD Anderson Cancer Center, Houston, TX

Purpose
Overall payments for diagnostic imaging services have decreased by 12% from 2006 to 2017. The 2020 Proposed Rule released by the Center for Medicare & Medicaid Services (CMS) has the potential to significantly impact reimbursement for neuroradiology studies. Specifically, our aim is to inform neuroradiologists of the impact of the proposed changes to Evaluation and Management (E/M) reimbursement on the Medicare Physician Fee Schedule (MPFS) and its implications to the neuroradiology profession.

Materials and Methods
A historical background of office E/M codes and the rationale for the recently proposed revisions will be provided. Estimates and projections on the consequent impact on the budget neutral MPFS and conversion factor (CF) will be reviewed. The impact of the proposed E/M policy specifically on neuroradiologists will then be discussed.

Results
E/M codes are a category of CPT codes frequently utilized for billing purposes by physicians who see patients in the office/outpatient setting. The increasingly burdensome documentation requirements for E/M codes led CMS to propose changes to the structure and valuation in its 2019 Proposed Rule. Physicians and specialty societies disagreed with the proposal. The AMA worked with its CPT Editorial Panel to restructure the E/M codes and the AMA Specialty RBRVS Update Committee subsequently made recommendations for valuation. In the 2020 Proposed Rule, CMS adopted this new coding structure and accepted the substantial increase in valuation for E/M codes set to begin in 2021. Given the budget neutrality requirements of the MPFS, the projected increase in E/M reimbursement will require a reduction in the CF to offset such increases. Consequently, estimates suggest medical specialties such as radiology that do not typically bill E/M codes may experience as much as an 8% decrease in payment. This escalates under some very

Routine Coagulation Testing Prior to Image Guided Lumbar Puncture May Not Have Value in Patients Without Risk Factors

J Mei¹, A Vijayashankar², J Gans¹, S Benitez¹, B Chulpayev¹, A Erdfarb¹, R Zampolin¹, A Brook¹, S Lee¹
¹Montefiore Medical Center, Bronx, NY, ²Albert Einstein College of Medicine, Bronx, NY

Purpose
Evaluation of recent coagulation parameters is generally considered a prerequisite for image guided lumbar puncture (IG-LP) to avoid hemorrhagic complications. This requirement may delay patient care and increase cost. Our purpose was to evaluate whether patients without clinical history of hemorrhagic risk factors undergoing IG-LP develop procedure related hemorrhagic complications or demonstrate laboratory findings of bleeding diathesis.

Materials and Methods
Retrospective review of patients who received IG-LP from 2018 to 2019 at a single tertiary referral center was conducted. All IG-LP were performed with either 20G or 22G needle with 3 ½, 5 or 7 inches in length, in prone position under either fluoroscopic or CT guidance. Hemorrhagic risk factors were defined as having history of cancer, bleeding disorder, liver disease, or peri-operative antiplatelet/anti-coagulant medications. Demographic data reviewed include patient age, sex, height, and weight. Clinical history of hypertension, diabetes, hyperlipidemia, cancer, bleeding disorder, or liver disease were included. Pre-procedure INR, PT, PTT, platelet counts, and CSF analysis results were also reviewed. The procedural information collected include intra-procedural blood pressure, opening pressure, number of prior LPs, and history of a post procedure blood patch.

Results
One hundred and twenty four patients (M:F=43:81) undergoing 137 IG-LP under either fluoroscopic (n=121) or CT (n=16) guidance from 2018 to 2019 were reviewed (mean age = 55.8 years, mean body weight = 178.8lbs, mean BMI=30.2 kg/m2). Of these, 58 patients (46.8%) who had no hemorrhagic risk factors underwent 66 IG-LPs (M:F=18:40, mean age = 49.7 years, mean body weight = 182.0 lbs., mean BMI = 30.9 kg/m2, fluoro: CT guidance = 58:8). The percent of patients with hypertension, diabetes, and hyperlipidemia was 43.1%, 22.4%, and 25.9% respectively. The average opening pressure was 23.2 cm H2O. There was no post-procedure hemorrhagic complication. None of the patients had abnormal PT/INR or PTT or low platelet counts on pre-IG-LP tests. Three patients (3/59, 5%) had post-IG-LP headache, one of which then received epidural blood patch. One patient had post-IG-LP back pain controlled with NSAIDs.

Conclusions
Coagulation testing prior to IG-LP in patients without risk factors did not result in abnormal laboratory values or identify patients with hemorrhagic complications. Therefore, Pre-IG-LP routine coagulation test may not be necessary in patients without hemorrhagic risk factors.

Restructuring and Revaluation of Evaluation and Management Codes and Implications for the Neuroradiology Profession
realistic scenarios such as the inclusion of the E/M reimbursement increases into global surgical period codes, which may trigger a further reduction in the CF easily moving into double digit percentage diminution of neuroradiology professional fees.

Conclusions
The purposeful commitment to reducing the office documentation burden by the proposed restructuring and revaluing E/M codes has the potential to improve patient care. However, the reduction in the CF and consequent cuts imposed on medical specialties such as radiology who infrequently bill for E/M services will impact beneficiary access to radiology services.

1858 2:33PM - 2:39PM
Attending the 2019 Annual Meeting of the American Society of Neuroradiology Results in Improvement in the Stanford Professional Fulfillment Index in a ‘Dose-Dependent’ Fashion

E Schwartz1, A Simon2, T Roberts3, T Shanafelt4

Purpose
Burnout and professional fulfillment are critical issues for medical professionals with implications for quality of care as well as personal health. We set out to determine the effect of attending the 2019 Annual Meeting/Symposium (AM) of the ASNR on burnout and professional fulfillment using a standardized assessment.

Materials and Methods
The Stanford Professional Fulfillment Index (SPFI) is a validated instrument which can be administered to assess burnout and professional fulfillment at two week intervals. 16 questions are rated on a five point scale (0-4) and divided into professional fulfillment (PF - higher number is better) and two domains of burnout subscales: work exhaustion (WE - lower number is better), and interpersonal disengagement (IPD - lower number is better). The SPFI was administered electronically to the ASNR mailing list on three occasions around the AM; two weeks prior to the AM (528 responses), immediately following (409 responses) and one month following (251 responses). Statistical analysis was performed with SPSS via a linear mixed model with fixed effects of practice (academic, private), number of days attending AM (shorter: <=3 days, longer: 4-6 days) and subscale components.

Results
At the first post-meeting follow up, improvement in PF and IPD subscale means correlated with longer duration attendance at the AM (PF non-attendee: 2.39, shorter: 2.51, longer: 2.82, p=0.017; IPD non-attendee: 1.01, shorter: 1.05, longer: 0.79, p=0.009). WE subscale mean improved but did not reach statistical significance (non-attendee: 1.63, shorter: 1.53, longer: 1.36, p=0.168). The benefits were not sustained at the second post-meeting follow up. There were no significant differences in results based on practice setting. Pre- and post-meeting scores of non-attendees did not change significantly.

Conclusions
Attending the 2019 ASNR Annual Meeting/Symposium improved short-term physician professional fulfillment and the interpersonal disengagement domain of burnout in a 'dose-dependent' fashion. Providing physicians the time and financial support to attend this meeting appear to be valuable investments for both academic and community-based radiology practices, with the potential to improve not only medical knowledge but also physician well-being.

SNIS Programming: Hemorrhagic Stroke
2037 2:40PM - 2:45PM
Hemorrhagic Transformation Rates and the use of ISO and low OS Contrast Media in Patients Hospitalized with Ischemic Stroke

f moser1, M Ryan2, c Gunnarson3, T Todoran4, j Kellum5
1cedars-sinai medical center, los angeles, CA, 2CTI Clinical Trial & Consulting Services, covington, KY, 3CTI Clinical Trial & Consulting Services, covington , KY, 4Medical University of South Carolina, Mount Pleasant, SC, 5University of pittsburgh, Pittsburgh, PA

Purpose
Hemorrhagic transformation (HT) is a critical complication associated with ischemic stroke. Several studies have reported the effects of iodinated contrast media on the intravascular cellular components including the coagulation pathway. The objective of our study is to use real world data to evaluate the effect of contrast media osmolarity on the rate of transformation from ischemic to hemorrhagic stroke.

Materials and Methods
Data were obtained from the Premier hospital database between 9/2012 and 6/2018 to include inpatient visits with a diagnosis of stroke upon admission and a record of having received contrast media (CM) – either iso-osmolar (IOCM) or low osmolar (LOCM),
Feasibility, Safety, and Outcome of Endovascular Recanalization in Childhood Stroke: The Save ChildS Study.

P Sporns1, A Kemmling2, M Wildgruber1
1Muenster University Hospital, Muenster, North Rhine-Westphalia, 2University Hospital Kaiserslautern, Kaiserslautern, AK

Purpose
To evaluate the use of endovascular recanalization in pediatric patients with arterial ischemic stroke.

Materials and Methods
This retrospective, multicenter cohort study, conducted from January 1, 2000, to December 31, 2018, analyzed the databases from 27 stroke centers in Europe and the United States. Included were all pediatric patients (<18 years) with ischemic stroke who underwent
endovascular recanalization. Median follow-up time was 16 months. The decrease of the Pediatric National Institutes of Health Stroke Scale (PedNIHSS) score from admission to day 7 was the primary outcome (score range: 0 [no deficit] to 34 [maximum deficit]). Secondary clinical outcomes included the modified Rankin scale (mRS) (score range: 0 [no deficit] to 6 [death]) at 6 and 24 months and rate of complications.

**Results**

Seventy-three children from 27 participating stroke centers were included. Median age was 11.3 years (interquartile range [IQR], 7.0-15.0); 37 patients (51%) were boys, and 36 patients (49%) were girls. Sixty-three children (86%) received treatment for anterior circulation occlusion and 10 patients (14%) received treatment for posterior circulation occlusion; 16 patients (22%) received concomitant intravenous thrombolsis. Neurologic outcome improved from a median PedNIHSS score of 14.0 (IQR, 9.2-20.0) at admission to 4.0 (IQR, 2.0-7.3) at day 7. Median mRS score was 1.0 (IQR, 0-1.6) at 6 months and 1.0 (IQR, 0-1.0) at 24 months. One patient (1%) developed a postinterventional bleeding complication and 4 patients (5%) developed transient peri-interventional vasospasm. The proportion of symptomatic intracerebral hemorrhage events in the HERMES meta-analysis of trials with adults was 2.79 (95% CI, 0.42-6.66) and in Save ChildS was 1.37 (95% CI, 0.03-7.40).

**Conclusions**

The results of this study suggest that the safety profile of thrombectomy in childhood stroke does not differ from the safety profile in randomized clinical trials for adults; most of the treated children had favorable neurologic outcomes. This study may support clinicians' practice of off-label thrombectomy in childhood stroke in the absence of high-level evidence.

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**ASPNR Programming: A Royal Flush of Epilepsy Imaging**

**1893**

**4:45PM - 5:00PM**

**Morphometric Analysis of Double Inversion-Recovery Magnetic Resonance Imaging in Evaluation of Focal Cortical Dysplasia**

A Panda1, R Witte1, R WATSON2, S Messina3, L Wong-Kisiel1, J Britton1, B Brinkmann1

1Mayo Clinic, Rochester, MN, 2MAYO CLINIC, ROCHESTER, MN, 3N/A, N/A

**Purpose**

Focal cortical dysplasia (FCD) is a common pathology in epilepsy. Double Inversion Recovery (DIR) MRI improves detection of FCD due to dual suppression of normal white matter and CSF. Voxel-based morphometric analysis of T1w sequences has been shown to be useful in identifying epileptogenic lesions in intractable focal epilepsy. However the utility of voxel based morphometric analysis program (MAP) on DIR images is not known. The purpose was to evaluate the utility of MAP on DIR in epilepsy with pathology proven FCD.

**Materials and Methods**

We retrospectively identified 29 patients with pathologically proven FCD who had DIR as part of their presurgical MRI exam. We excluded patients with gliosis (n=2), prior surgeries (n=2) and those with noisy DIR images (n=6). Final cohort included 19 patients. The automated MAP program generated z-score maps referenced to healthy adult or pediatric patients for each of the FCD cases. MAP-extension (MAP-E) and MAP-junction (MAP-J) were overlaid on DIR images using rainbow color display, and reviewed in consensus by two epilepsy neuroradiologists blinded to seizure semiology, EEG, SISCOM, FDG-PET, initial MRI reads and resection site. Predetermined thresholds were used for the MAP overlays, but color intensity could be adjusted during the review. DIR-MAP was considered positive if either MAP-E or MAP-J localized to the resected site.

**Results**

Of 19 patients, 4 had FCD type IIB, 4 had FCD type IIA, and one patient's FCD was not categorized. Median patient age was 15.5 years (range 2-70). Presurgical MRI was read as positive in 9/19(47%), equivocal in 2/19(10.5%) and negative in 8/19(42%). In 10 patients with initial equivocal/negative MRI reads, MAP-DIR identified FCD in 9/10(90%) and failed to identify in one. Of 9 patients with initial positive MRI reads, MAP-DIR confirmed/co-localized to resected FCD in 7/9(89%) and failed to identify in the remaining two. Overall, DIR-MAP was positive in 16/19(84%) patients. In these 16 patients, abnormality was seen on MAP-E only in 5/16(31%), on MAP-J only in 3/16(19%) and on both in 8/16(50%). In 8 patients where both MAP-J and MAP-E were localizing, findings were more conspicuous on MAP-E in 6/8(75%). MAP-E performed better when FCD was associated with cortical thickening; MAP-J performed better when FCD was associated with underlying white matter signal abnormality.

**Conclusions**

Morphometric analysis program applied to dual inversion recovery MR images improves detection of subtle FCDs in MRIs originally interpreted as negative.
Associations between H-MR Spectroscopy results, MRI-based Semi-automated segmentation of Hippocampal Volume and Clinical Outcomes of Pediatric Patients with Mesial Temporal Sclerosis.

D Timaran¹, Y Mateo Camacho², K Fuentes¹, L Morales¹, C Bartolo M¹, G Feria¹, J Aguirre², J Orozco V², B Navarro E²

¹Centro Médico Nacional 20 de Noviembre- ISSSTE-UNAM, Mexico City, Mexico City, ²Centro Médico Nacional 20 de Noviembre-ISSSTE-UNAM, Mexico City, TX

Purpose
The aim of the study was to assess the impact of Hydrogen MR-spectroscopy (H-MRS) and hippocampal volume using semi-automated segmentation on clinical outcomes of pediatric patients with mesial temporal sclerosis.

Materials and Methods
A retrospective, single center study was performed over a 36-month period. Mesial temporal sclerosis was defined according to clinical findings, electroencephalogram criteria and morphologic hippocampal MRI findings. Magnetom® 3T-MRI scanner was used in all cases. All patients underwent routine cerebral MRI including H-MRS scanning using a multi-voxel technique to quantify N-acetyl aspartate (NAA), choline, creatine and NAA/choline + creatine ratio. Semi-automated segmentation of the hippocampus was performed based on 3D-phase sensitive-inversion-recovery imaging using the Alma medical imaging software. Refractory epilepsy and cognitive impairment were the primary end-points of the study.

Results
A total of 65 patients (34 men [52%] and 31 women [48%]) with a mean age of 11.5 years (+/- 6.1) were included in the study. Among patients with unilateral disease (15 [21%]), the mean hippocampal volume on the affected side was 1.3 cc (+/- 0.4 cc) and 1.5 cc (+/- 0.4 cc) on the contralateral side. Median NAA/choline+creatine ratio on the affected side was 0.48 (interquartile range [IQR], 0.33-0.66) versus 0.78 (IQR, 0.71-0.98) on the contralateral side. In these patients, 7 (47%) were diagnosed with cognitive impairment and 2 (13%) were classified as refractory epilepsy. Patients with cognitive impairment demonstrated a lower hippocampal volume on the contralateral side (1.12 cc +/-0.14cc) versus 1.55 cc [0.5 cc], p=0.05) compared to patients with preserved cognitive function. The hippocampal volume of the affected side, however, did not demonstrate significant differences between patients in both groups (p=0.6). In patients with refractory epilepsy, the hippocampal volume on the affected side was lower compared to patients with controlled epilepsy (1.0 cc +/-0.13cc versus 1.56 cc +/0.17cc [p=0.06]). MRS did not demonstrate significant differences on the NAA/choline+creatine ratio for cognitive impairment and refractory epilepsy (p=0.9).

Conclusions
H-MRS and hippocampal volume are two effective MRI techniques to assess pediatric patients with mesial temporal sclerosis. Furthermore, lower ipsilateral and contralateral hippocampal volumes were found to be associated with refractory epilepsy and cognitive impairment, respectively.
Cortico-striatal-thalamo-cerebellar network for differential diagnosis of genetic and focal epilepsies with generalized tonic-clonic seizures using fMRI

Z ZHANG

1Massachusetts General Hospital, Harvard University, Boston, MA

Purpose

Generalized tonic-clonic seizures (GTCS) is one of the common, and the severest phenotype of human epilepsy, it can either be presented in genetic epilepsy (GE-GTCS), and or be secondary to partial seizures onset in focal epilepsy, as secondary GTCS (FE-GTCS). Differentiation of them is significant, and often hard for the sake of establishing clinical pharmacotherapeutic schemes in clinic. Functional connectivity technique based on resting-state fMRI provides feasible way for mapping the epilepsy network and may be used for classification of epilepsy types.

Materials and Methods

A total of 220 cases of epilepsy patients (110 with GE-GTCS and 110 focal epilepsy with FE-GTCS) and 110 healthy controls were involved in the study. Resting-state fMRI data were acquired on a 3T MR scanner. Using 5 cortical parcellations of frontal, motor/premotor, somatosensory, parietal/occipital and temporal cortex, we constructed cortico-striatal-thalamo-cerebellar networks of in each subject group using Winner-take-all strategy. Networks were calculated using static and dynamic functional connectivity (sliding window) analyses. Group comparisons between two patient groups were performed voxel-wisely and edge-wisely to detect the features of static and dynamic functional connectivity of cortico-striatal-thalamo-cerebellar networks. Metrics of static and dynamic functional connectivity were also correlated with duration of epilepsy in each patient group. Multivariate Support-vector-machine was used for classification among subject groups, and a cross-validation of leave-one-out was performed.

Results

Compared with healthy controls, both patient groups showed increased static and dynamic functional connectivity in the edges of frontal lobe-thalamus and thalamus-cerebellum, and decreased functional connectivity in the edges of striatum-cerebellum. SVM classification revealed that the accuracy, sensitivity, specificity, and AUC values between GE-GTCS were 87.5%, 85%, 90% and 0.95 by combining static and dynamic functional connectivity metrics.

Conclusions

The connectivity between the frontal lobe and thalamus and between the thalamus and the cerebellum played important roles in the
pathological processing of epilepsies with GTCS. Functional MRI connectivity of cortico-striatal-thalamo-cerebellar network can be used as a feasible imaging biomarker for differential diagnosis between GE-GTCS and FE-GTCS.

Scientific Abstract Session: Brain Dementia

Network Mediation of Pathology Pattern in Sporadic Creutzfeldt-Jakob Disease

B Freeze1, P Maia2, S Pandya3, A Raj2
1Massachusetts General Hospital/Harvard Medical School, Boston, MA, 2University of California, San Francisco, San Francisco, CA, 3Weill Cornell Medicine, New York, NY

Purpose
Sporadic Creutzfeldt-Jakob disease (sCJD) is a rapidly progressive dementia caused by the accumulation and spread of pathologically misfolded prions. Evidence from animal models and in vitro experiments suggests that prion pathology propagates along neural connectivity pathways, with transmission of misfolded prions initiating a corruptive templating process in newly encountered brain regions. Although regional patterns of disease have been recognized in humans, the mechanistic basis of these patterns remains poorly understood. To address this question we test whether regional diffusion-weighted MRI (dMRI) abnormalities in two different published patient cohorts can be predicted by a quantitative model of transneuronal prion transmission.

Materials and Methods
Average dMRI abnormalities were extracted from datasets published in Eisenmenger et al. (2016; n=37 subjects) and Vitali et al. (2011; n=48 subjects), and mapped to 66 corresponding areas of the Desikan-Killiany atlas. The normative connectome for this study was derived from HARDI tractograms from 73 healthy young adults. Graph theoretical analysis was performed using the Brain Connectivity Toolbox. sCJD disease progression is considered as a network diffusion process on the connectivity matrix C (Raj et al. 2012). The regional pathology vector x at timepoint t is given by the equation x(t)=e^(-βHt)*x_0 where x_0 is the initial state of the model at t=0 (e.g. initial pathologic insult), H is the graph Laplacian and β is a global diffusivity constant. The model (NDM) was initialized at each possible seed region such that x_0 is 1 at the seed region and 0 at all other regions. The maximum correlation coefficient (r) between the NDM-predicted regional dMRI vector and empirical dMRI vector was determined and is considered a measure of seed region likelihood (SR).

Results
Regional dMRI abnormalities are predicted by graph theoretical measures of centrality and distance, with highly affected regions such as cingulate gyrus demonstrating increased connectivity to other brain regions (Fig. 1). Regional diffusion restriction is positively correlated with degree centrality (r = 0.42, p = 5.0 x 10^-4) and betweenness centrality (r = 0.34, p = 5.6 x 10^-3); and negatively correlated with mean distance to other brain regions (r = -0.40, p = 9.3 x 10^-4). The spatial pattern of disease can be best predicted by a network diffusion process originating from the right posterior cingulate gyrus and operating on the structural connectome (r = 0.53, p = 5.4 x 10^-6; Fig. 2).

Conclusions
We show here for the first time that regional patterns of sCJD pathology observed on dMRI can be predicted by a transneuronal spread process. These findings are concordant with a mechanism in which small numbers of misfolded prions originating in a single brain region can initiate a cascade of pathology throughout the brain via neural connectivity pathways. Further investigation of this process may provide insight into potential therapeutic strategies.
MR Guided Focused Ultrasound Blood Brain Barrier Opening for Alzheimer Disease

E Lustbader\(^1\), J Chazen\(^2\)

\(^1\)NewYork Presbyterian/Weill Cornell Medicine, New York, NY, \(^2\)WEILL CORNELL MEDICINE, NEW YORK, NY

Purpose
The blood brain barrier (BBB) has long been an obstacle in administering pharmaceutical therapy to the central nervous system. Currently, therapeutics have to employ transport mechanisms to enter the brain parenchyma, requiring modifications to drug structure in order to take advantage of active or passive transport mechanisms. In the presence of microbubbles, low frequency ultrasound leads to cavitation, which is thought to cause stress on the vessel walls and lead to temporary disruption of the blood brain barrier. Temporarily opening the blood brain barrier to allow entry of pharmaceutical agents eliminates the need for costly and time intensive redesigning of therapeutic agents. Additionally, temporary opening of the blood brain barrier has been shown in animal models to reduce amyloid-beta plaque buildup, which is thought to be responsible for dementia in Alzheimer disease.
Materials and Methods
A 71 year old woman with mild cognitive impairment secondary to Alzheimer disease. Brain F18 Florbetaben PET-CT showed characteristic distribution of cerebral amyloid plaque deposition. The right hippocampus was chosen as a target for low frequency MR guided focused ultrasound (MRgFUS) blood brain barrier (BBB) opening. Definity microbubbles were injected intravenously and four sites of BBB opening were prescribed. As part of the clinical trial, she received three treatments of MRgFUS separated by approximately two weeks for each session.

Results
Pre-procedural imaging demonstrates no contrast uptake in the right hippocampus (figure A). Post-procedural MR following MRgFUS blood brain barrier disruption, demonstrates focal contrast uptake in the right hippocampus (figure B), representing focal disruption of the BBB. This area of enhancement resolves at 24-hour follow up MRI (figure C), representing reconstitution of the blood brain barrier.

Conclusions
Contrast enhancement and subsequent non-enhancement of the right hippocampus demonstrates transient and targeted disruption of the blood brain barrier. This is anticipated to have a myriad of research and clinical applications for therapeutics and drug delivery.

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Metabolic PET/MRI in Primary Progressive Aphasia and FTD Subtypes: Reassessment of Expected FDG Uptake Patterns

A Franceschi1, K Naser-Tavakolian2, M Clifton3, G Cruciat4, L Bangiyev4, S Clouston5, D Franceschi4

1Northwell, New York, NY, 2STONY BROOK UNIVERSITY HOSPITAL, Stony Brook, NY, 3Stony Brook University Hospital, Brooklyn, NY, 4Stony Brook University Hospital, Stony Brook, NY, 5Stonybrook, Stonybrook Univ, NY
Purpose

Our study reevaluates the expected FDG uptake patterns in patients with underlying neurodegenerative disease meeting imaging and clinical criteria for the diagnosis of frontotemporal dementia (FTD), with a special emphasis on patients with primary progressive aphasia. While traditional teaching emphasizes left-side predominant hypometabolism, this is not always the case in clinical practice.

Materials and Methods

99 subjects underwent FDG PET/MRI as part of their routine clinical workup for underlying neurodegenerative disease. Images were obtained using Siemens Biograph mMR integrated 3T PET-MRI scanner. PET surface maps, fusion T1-MPRAGE and axial FLAIR/PET images were generated utilizing MIM software. Volumetric based semi-quantitative analysis was performed with NeuroQuant software. Two board-certified neuroradiologists and a nuclear medicine physician were blinded to patient history and evaluated for a pattern of neurodegenerative disease, classified patients according to FTD subtype and assessed for left versus right predominant hypometabolism.

Results

Qualitative assessment of PET cortical surface maps demonstrated 39 subjects meeting imaging criteria for underlying FTD: 18 primary progressive aphasia, 16 behavioral variant FTD and 5 with progressive supranuclear palsy (PSP). Of the 18 PPA patients, 11 demonstrated temporal pole hypometabolism consistent with semantic dementia; 5 had lateral parieto-temporal hypometabolism compatible with logopenic PPA; and 2 had peri-insular hypometabolism suggesting underlying agrammatic PPA. Among PPA subjects; 12 (67%) demonstrated left predominant and 6 (33%) right predominant pattern of decreased FDG uptake. Of the 16 bvFTD patients, 12 (75%) had left, 3 (19%) right predominant and 1 subject had symmetric bilateral frontal hypometabolism pattern. Among 5 PSP subjects, 3 (60%) demonstrated left predominant, 1 right predominant and 1 bilateral posterior frontal region, anterior cingulate and basal ganglia pattern of decreased FDG uptake.

Conclusions

Clinical evaluation of patients with frontotemporal neurodegeneration and particularly aphasic patients with underlying PPA is challenging because most instruments of cognitive assessment rely extensively on language. A reliable and accurate metabolic PET/MR diagnosis is therefore of importance, since it can affect the prognosis, emerging treatments and patient management. While the literature stresses left side predominant hypometabolism as a key imaging feature in these patients, over a third of our subjects demonstrated right side predominant patterns, therefore suggesting emphasis should be placed on specific brain regions affected, rather than sidedness.

Cerebral Amyloid may Influence White Matter Burden in MTHFR Gene Carriers

P Rajagopalan1, S Risacher2, K Nho3, A Saykin2
1UCSF, San Francisco, CA, 2Indiana University, Indianapolis, IN

Purpose

Hyperintense signal abnormalities on T2-weighted and fluid-attenuated inversion recovery (FLAIR) MRI sequences of the brain are referred to as white matter hyperintensities (WMH). These are commonly associated with senescence. However, neurovascular inflammatory markers such as homocysteine can increase the risk for WMH. Beta-amyloid deposition in the brain is also implicated with WMH, albeit inconsistently (1). Homocysteine mediates brain atrophy (2) particularly in the presence of beta-amyloid deposition (3). MTHFR is a candidate risk gene for elevated homocysteine and is implicated in brain atrophy (4) and WMH (5). However, prior studies, including ours, studying WMH have found it to be inconsistently associated with MTHFR (4,5). In order to understand the underlying pathways determining the association between WMH and MTHFR and explore potential novel pathways, we postulated that cognitively normal elderly who carry MTHFR gene mutation are at risk for increased WMH burden.

Materials and Methods

MTHFR gene risk alleles (rs1801133) were genotyped in 294 cognitively normal elderly subjects (72.2 +/- 0.3 yrs) enrolled in the Alzheimer's Disease Neuroimaging Initiative GO/2 study. WMH volumes were computed from 2D FLAIR images at University of California (UC), Davis and downloaded for further analysis. Beta-amyloid positivity was estimated using cerebral amyloid deposition demonstrated on [18F] Florbetapir PET scans processed at UC, Berkeley (Landau et al. 2013) and Beta-amyloid measured in cerebrospinal fluid (http://adni.loni.usc.edu).

Results

Increased WMH volume was noted in healthy cognitively normal elderly who carried the T allele of the MTHFR gene and also had cerebral beta-amyloid deposition (p=0.006*, b=4.0). Risk gene carriers without beta-amyloid deposition did not show significant association with WMH. An interaction term denoting carrying MTHFR gene polymorphism and having cerebral beta-amyloid deposition further increased WMH burden (p=0.003*, b=4.7). All associations were controlled for age, sex and ApoE4 status.

Conclusions

We have shown that cognitively normal elderly who carry MTHFR gene mutation are at risk for increased WMH, if they have concurrent beta-amyloid deposition in their brain. This suggests potential synergistic interactions between MTHFR-homocysteine and beta-amyloid increasing WMH burden by multiplied neuropathogenic cascades. Future neuroimaging studies mapping amyloid and WMH, in relation to MTHFR, may offer new insights into novel AD-related pathways.
The association between microvascular changes, and PET measures of amyloid, perfusion and metabolism in Alzheimer's disease

N Sheikh-Bahaei\textsuperscript{1}, S Sajjadi\textsuperscript{2}, R Manavaki\textsuperscript{3}, J Gillard\textsuperscript{4}
\textsuperscript{1}Keck School of Medicine of USC, LA, CA, \textsuperscript{2}University of California, Irvine, Irvine, CA, \textsuperscript{3}University of Cambridge, Cambrige, Cambridgeshire, \textsuperscript{4}Christ's College, Cambridge, United Kingdom

Purpose
Several studies have shown cerebral microvascular diseases can increase risk of developing AD. Cerebral microvascular disease may contribute to dementia by accelerating AD pathology by increasing the rate of amyloid deposition due to ischemic changes, or possibly by an independent process, which occurs in parallel to AD pathology. We investigated the regional associations between microvascular changes and PET measures of amyloid, perfusion and metabolism in early stages of AD to understand the role of these vascular changes in AD.

Materials and Methods
Participants with mild dementia, Mild cognitive impairment (MCI) and age-matched healthy controls were recruited through well-established memory services. All participants were imaged with Pittsburg-Compound B (PiB)-, Fludeoxyglucose (FDG)-PET followed by 3T MRI. Early frames of PiB-PET (e-PiB) (1-8 min) were utilized to estimate perfusion and late frames (1-PiB) (40-70 min) to measure amyloid burden. FDG emission data was acquired from 60-90 minutes after injection. PET uptake was presented as standardized uptake value ratio (SUVR) using cerebellum as reference. The number and grade of perivascular spaces (PVS) in centrum semiovale (CS) and basal ganglia (BG), severity of deep and periventricular white matter changes (DWM and PVWM) and presence of lobar cerebral micro bleeds (LCMB) were recorded according to 5-point visual-scale (0-4), Fazekas scoring (0-3), and MARS grading system respectively and compared between groups.

Results
We found regional associations between 1-PiB-SUVR and CS-PVS (p=0.006) and also LCMB (P<0.001). e-PiB-SUVR however, was associated with BG-PVS (p=0.01) and PVWM changes (p= 0.02). These associations remained significant even after adjusting for age and history of stroke as possible cofounding factors (p=0.002, p=0.06). Regional FDG-SUVR was not significantly associated with
any of these microvascular changes. In multiple regression models adjusting for different microvascular changes, only LCMB was significantly associated with mini-mental state examination (p=0.02) and Addenbrookes-Cognition Examination Revised (p=0.04).

Conclusions
Regional association between CS-PVS and amyloid and between BG-PVS and perfusion reveals that they contribute to the AD pathology through different pathways. Our data also confirmed that PVWM changes are related to AD process while DWM lesions are not. More importantly among microvascular changes LCMB has the most effect on cognitive function.

Fig-1: PiB-PET (a): high cortical uptake in frontal lobes and posterior cingulate gyrus; FDG-PET (b): low uptake in right parietal lobe; SWI (c): LCMB (yellow arrow heads); T2W (d): CS-PVS (yellow arrows) in a case with AD.

Quantitative Susceptibility Mapping Detects Increased Iron Deposition Associated with Temporoparietal Hypometabolism in Cognitively Impaired Elderly

G Chiang¹, Q Zhang¹, M Tokov¹, T Nguyen¹, J Dyke¹
¹Weill Cornell Medical College, New York, NY
Purpose
Studies have shown evidence for increased cerebral iron deposition in patients with Alzheimer's disease (AD) compared to normal controls. The purpose of this study was to evaluate whether regional iron deposition differs in patients with clinical and metabolic evidence of AD compared to patients with cognitive impairment from other etiologies.

Materials and Methods
Thirty-four patients who presented with cognitive impairment to our Memory Disorders Clinic underwent an integrated PET-MR study, which included quantitative susceptibility mapping (QSM) and 18FDG-PET. QSM maps were processed using the total field inversion method, co-registered to the 3D T1-MPRAGE sequence, and parcellated using the automated anatomical labeling (AAL) atlas to obtain regional tissue iron concentrations. FDG-PET images were likewise parcellated using the AAL and Z-scores were obtained by comparing mean regional standardized uptake values with a normative database. An FDG-PET scan was considered abnormal if the average Z-score of regions typically involved in AD (temporal and parietal lobes, including the posterior cingulate and precuneus) was more than 1.5 standard deviations below the normative mean.

Results
Twenty-five (74%) patients had clinically diagnosed AD, confirmed by an abnormal FDG-PET scan. Patients with an abnormal FDG-PET scan had higher iron deposition in the inferior parietal lobes (coefficient=6.2, p=0.03, Figure) and precentral gyri (coefficient=6.7, p=0.01). An abnormal FDG-PET scan was not associated with levels of iron deposition in the posterior cingulate gyri, precuneus, or temporal lobes (p>0.05).

Conclusions
Regional iron deposition was higher in patients with clinical and metabolic evidence of AD, compared to patients with non-AD cognitive impairment. Future directions will include validating these findings in a larger cohort and investigating the pathophysiology of increased iron in the motor cortex, which is typically considered a late finding in the clinical course of AD.

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A Potential Biomarker for Early Onset Alzheimer Disease Phenotypes: Deep Learning Derived Brain Age Determination

M Gautherot¹, G Kuchcinski¹, C Bordier¹, J Pruvo¹, X LECLERC², L Hacein-Bey³, R Lopes¹
¹Lille University Medical Center, Lille, France, Lille, Other, ²Lille University Hospital, LILLE, Hauts-de-France, ³UC Davis School of Medicine, SACRAMENTO, CA

Purpose
Early-onset Alzheimer disease (EOAD) is characterized by a high prevalence of non-amnestic variants as opposed to late onset disease. However, clinical identification of EOAD remains challenging as cognitive changes are more pronounced in those patients. The aim of this study was to define new phenotypic biomarkers of EOAD through deep learning estimation of brain age on T1 weighted MRI. Our working hypothesis was that patients with non-amnestic forms of AD undergo significantly more severe brain aging compared to patients with the amnestic form of the disease.

Materials and Methods
3345 T1 weighted MRI studies of healthy subjects were obtained from 4 free access databases. Images were corrected for field
inhomogeneity, scanner variations between white (WM) and gray matter (GM) and segmentation between brain tissue and CSF. The database was divided in 3 components: "training" (n=2945 images), testing (n=200) and validation (n=200). A deep learning algorithm was trained, tested and validated so as to predict brain age in healthy subjects [Ref 1]. The trained model was then used to predict brain age in 40 patients with EOAD, 20 amnestic, 20 non-amnestic. Lastly, the difference between predicted and actual age was calculated and compared statistically between both patient groups.

Results
Our best model resulted in a median absolute error of 3 years in the validation database. The difference between predicted and actual age was significantly more pronounced (p<0.05) in patients with the non-amnestic compared to those with the amnestic form of AD. Such difference reflects cumulative age-related changes within the brain.

Conclusions
Deep learning methodology permits reliable age prediction in healthy subjects. Brain age estimation in patients with dementia may allow to differentiate between amnestic and non-amnestic forms of EOAD. Such scores may become standard measurements which could become part of neuroimaging reports.

1982

Diagnostic Utility of Volumetric Brain MRI Quantification for Distinguishing Frontotemporal Dementia from Alzheimer’s Disease

C Raji1, S Meysami2, M Mendez2
1Mallinckrodt Institute of Radiology, St. Louis, MO, 2David Geffen School of Medicine at UCLA, Los Angeles, CA

Purpose
The purpose of this work was to determine the extent to which automated quantitative volumetric MR neuroimaging can distinguish persons with behavioral variant frontotemporal dementia (bvFTD) from the more common Alzheimer’s diseases (AD). The ability of volumetric brain MRI to be utilized clinically would be better realized if objective data could demonstrate its ability to distinguish common forms of dementia from one another. As bvFTD must often be distinguished from AD, the most common neurodegenerative dementia, applying this question to these disorders has a high potential to affect future clinical practice.

Materials and Methods
A total of 95 cognitive neurology patients were evaluated by a behavioral neurologist of which 16 met Consensus Criteria for bvFTD and 79 met established criteria for clinically probable AD. All participants received a sagittal T1 weighted volumetric acquisition on a 3T MR scanner and were analyzed by the Neuroreader software (1) to compute brain volumes. Volumes for lobar structures and limbic areas were inputted into a discriminant analysis in SPSS with leave one out cross validation. This analysis produced an ROC and feature selection was also done separately.

Results
Persons with bvFTD were younger (mean age = 60.6 ± 10.3 years) compared to those with AD (mean age = 67.2 ± 11.8 years) (t = 2.1, p = .04). There were no statistically significant differences in gender. The Neuroreader volumes distinguished bvFTD from AD with an AUC of 94%, a sensitivity of 99%, and a specificity of 98%. The three most predictive features from the volumetric analysis were i) Right frontal lobe ii) Right temporal lobe iii) left parietal lobe.

Conclusions
Clinically available, quantitative volumetric MR neuroimaging combined with a predictive analytic approach can distinguish bvFTD from AD with a high level of accuracy, sensitivity and specificity. Future work will evaluate such features in distinguishing other possible etiologies of dementia.

2766

Associations between NeuroQuant-Defined Brain Structures and PET Amyloid Scans

A Rodriguez1, R Dela Paz2, C Marder2, C Vanier3, A Asturias3, T Knoblauch4, T Snyder2, J Uglietta2
1IMGEN LLC., Las Vegas, NV, 2SimonMed, Scottsdale, AZ, 3Touro University Nevada, Henderson, NV, 4University of Nevada, Las Vegas, Las Vegas, NV, 5SimonMed, Las Vegas, NV

Purpose
To examine MRI brain volumetric trends in patients testing positive or negative for Amyloid plaques on PET Imaging and assess for volumetric predictors of amyloid presence.

Materials and Methods
Amyvid or Vizamyl amyloid binding tracers were administered using PET CT and separately 3T MRI NeuroQuant v3.0 (NQ) study, were obtained from 174 patients (F:93; mean age:74.4 and M:81; mean age:75.4) with clinical concern for mild cognitive impairment and/or Alzheimers dementia. PET imaging classified patients as positive or negative for amyloid by neuroradiologists trained in amyloid PET interpretation. Fifty-one of the features identified by NQ were normalized for intracranial volume (ICV) and gender by using percentiles derived from the NQ database with respect to size and asymmetry. A training data set (130; 75% of patients)
consisting of 54% females, with average age of 75 and 53% amyloid positive, was used to train a random forests (RF) model. A validation data set of 44 (25%) randomly selected patients consisting of 52% females, with an average age of 74 and 55% amyloid positive, was used to determine the classification error. For the RF model, the classification variable was amyloid positive or negative, and variables included size and asymmetry for each volumetric location in addition to age. Importance of brain structures for predicting amyloid presence was based on the decrease in prediction accuracy for positive cases or the Gini index.

**Results**

The accuracy for predicting amyloid positive or negative values in the validation set was less than 70%. The sensitivity for the overall RF model predictions relative to amyloid status was 87.5%, but specificity was 35%. The attributes of the brain which contributed the most to predicting a patient would be amyloid positive included Asymmetry in the frontal lobe, premotor, primary motor, and superior parietal regions (changes in accuracy between 2.2 and 3.5). Overall the strongest predictors for amyloid presence or absence were the size of the amygdala and hippocampus, as well as asymmetry in the premotor and frontal lobe.

**Conclusions**

There are brain regions which have asymmetry or relative size that correlate with amyloid status, but there appears to be a high rate of false positives. More work is needed to understand possible heterogeneity within the amyloid-free group to improve understanding and diagnostic power of the reported observations. To our knowledge this is the first study to compared PET plaque burden to whole MRI brain volumetric analysis.

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**2031**

**Changes in Ventricular and Gray Matter Volumes Following Shunt Placement in Patients with Normal Pressure Hydrocephalus**

**P COGSWELL, M Murphy, M Senjem, J Gunter, C Schwarz, B Elder, C Jack, J Huston**

*Mayo Clinic, Rochester, MN*

**Purpose**

Normal pressure hydrocephalus (NPH) is a clinical syndrome of gait ataxia, dementia, and urinary incontinence for which the etiology is not well understood. A subtype of NPH, disproportionately enlarged subarachnoid space hydrocephalus (DESH) characterized by ventriculomegaly, tight high convexity sulci, and enlarged sylvian fissures has been increasingly recognized and thought to represent morphologic changes related to disordered CSF dynamics. Prior work has shown a decrease in ventricular size and increase in size of suprasylvian CSF spaces but no change in cerebral volume following shunt placement. The purpose of this work is to investigate changes in gray matter and ventricular volumes in patients with NPH following shunt placement.

**Materials and Methods**

Patients with a diagnosis of NPH were imaged before and after shunt placement under an IRB-approved protocol, following informed written consent. Imaging included a 3D T1w sequence that was analyzed using tensor based morphometry with symmetric normalization (TBM-SyN) to determine percentage change in ventricular and regional cortical gray matter volumes. Ventricular volumes changes were assessed using the Wilcoxon signed rank test, p<0.05. A mixed-effects model was used to test for a significant change in gray matter volume in a set of ROIs spanning the cerebral cortex, p<0.05. Gait was included in pre- and post-shunt assessments.

**Results**

Thirteen patients (age 74±6 years, 10M/3F) were included in the study. Gait improved in all patients following shunt placement. Time between imaging exams was median 14 months, range 4-15 months. Ventricular volume decreased after shunt placement median change -17.3% (p<0.001) (Figure 1A,B). Gray matter volume across all subjects and ROIs showed a statistically significant mean percentage increase of 1.3% (p=0.005), though changes varied by ROI (Figure 1C). ROIs near the vertex showed the greatest increase in volume, while ROIs in the temporal lobes showed the greatest decrease in volume.

**Conclusions**

Ventricular volumes in NPH patients were shown to overall decrease following shunt placement, which corresponds with results of prior work. Overall gray matter volume mildly increased. The greatest regional increases in volumes were in the gray matter ROIs near the vertex, which may reflect decrease in mass effect on the gyri (e.g. less crowing of the sulci at the vertex) following shunt placement and would correspond with increase in suprasylvian CSF spaces found on prior studies.
Scientific Abstract Session: Brain Tumor 2

2544

Role of Myeloperoxidase in Glioblastoma Progression after Radiotherapy

M Ali¹, G Fulci², A Li², G Wojtkiewicz², K Hsieh², C Wang², J Linnoila², J Chen³

¹Center for Systems Biology, Massachusetts General Hospital, Boston, MA, and Oslo University Hospital, Oslo, Norway; ²Center for Systems Biology, Massachusetts General Hospital and Harvard Medical School, Boston, MA; ³Center for Systems Biology and Institute for Innovation in Imaging, Massachusetts General Hospital, Boston, MA

Purpose

Radiation therapy is widely used to treat glioblastoma (GBM) but can also result in an inflammatory immune response. Using molecular MRI (1), we aimed to evaluate the effects of modulating a highly oxidizing inflammatory enzyme, myeloperoxidase (MPO), on tumor progression and outcome after radiotherapy.

Materials and Methods

The protocol for animal experiments was approved by the institutional animal care committee. GBM stem cells (005) were implanted intracranially in either immunocompetent male C57BL/6J (n=49, 8-10 weeks of age) mice or MPO-knockout mice (n=5). After two weeks, animals received unfractionated radiation (10 Gy, n=41) to the head. Irradiated animals were randomly assigned to either a group receiving saline as vehicle control (n=24), or a group receiving the specific MPO inhibitor 4-aminobenzoic acid hydrazide (ABAH, 50mg/kg IP bid, n=17). The mice were evaluated by MRI using an agent targeting MPO (MPO-Gd). After imaging, the brains were harvested for flow cytometry. We quantified and compared inflammation, tumor size progression and survival between the groups. P<0.05 was considered statistically significant.
Results
Irradiation increased both MPO enzymatic activity (Fig. A, P=0.03) and number of MPO-secreting inflammatory Ly6Chigh monocytes and neutrophils within the tumor parenchyma (2.4 and 2.2 times compared to those of non-irradiated mice, P=0.03). MPO inhibition with ABAH decreased MPO-specific contrast enhancement on molecular MRI (Fig. B, MPO-MRI, P=0.01), and attenuated neutrophils and inflammatory monocytes recruitment (3.8 and 2.3 times less than those of saline-treated mice, P=0.03). Surprisingly, compared to saline-treated mice, both ABAH-treated and MPO-knockout mice exhibited accelerated tumor growth (Figs. B, C, P=0.01 & 0.003) and worsened survival (Fig. D, P=0.02 & 0.005 respectively).

Conclusions
MPO inhibition or absence after radiation markedly increased tumor growth and decreased survival. These results reveal that MPO has an important role in host defense against GBM and suggest a role for pro-inflammatory therapies in conjunction with radiation.

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1218 3:37PM - 3:43PM

Remodeling Tumor Vascular Microenvironment by Inhibition of Glycolytic Activator PFKFB3 to Synergize with Antiangiogenic Therapy in Glioblastoma: Insights from Multiparametric MRI and Proteome Profiling

J Zhang

1Daping Hospital, Army Medical University, Chongqing, China

Purpose
To investigate whether targeting tumor glycolysis by PFKFB3 blockade is a novel potential strategy to enhance antiangiogenic therapy in glioblastoma (GBM), and to evaluate treatment-related molecular characterization and clinically translatable MR imaging biomarkers of tumor response.

Materials and Methods
Patient-derived orthotopic GBM xenografts in mice were established and imaged before and at different time points(day2,day5,day8,day12,day20) after treatment with bevacizumab(BEV), 3PO(PFKFB3 inhibitor), BEV and 3PO, and saline. Tumor volume, cellularity, neovascularization, and metabolites were monitored by T2WI, IVIM, DCE-MRI, and MRS, respectively. Pathology, proteome microarray and western blotting were analyzed to correlate with imaging parameters and evaluate post-treatment molecular profiling.

Results
BEV treatment induced remarkable PFKFB3 expression with a time-dependent manner compared with control (P<0.05), and reduced reversely after the addition of 3PO. 3PO treatment enhanced BEV therapeutic efficacy with significant tumor growth inhibition,
concomitant with a decrease of cell proliferation and increased of cell apoptosis. Multiparametric MRI and histology analyses revealed that compared with BEV monotherapy, BEV+3PO dual therapy prolonged and sustained vascular normalization with reduced vascular permeability and perfusion recovery, improving tumor oxygenate status and reduced lactate production (P<0.05). Mechanism, BEV monotherapy upregulated angiogenic cytokines (IL-4, IL-6, CXCL-16, and TIE-1) and activated alternative pathways (cytokine-cytokine receptor interaction, IL-17, and PI3K-Akt). These molecules were downregulated after dual therapy (P<0.05). Imaging-histology correlation analysis shown that IVIM outperformed DCE-MRI for monitoring tumor therapeutic response. Perfusion fraction f was positively correlated with microvascular density (r=0.9177) and hypoxia (r=0.5681), and D* was correlated with vascular maturation (r=0.5884).

Conclusions
Targeting PFKFB3 has much potential to synergize with antiangiogenic therapy by abating tumor glycolysis and remodeling tumor vascular microenvironment. IVIM parameters are much better than DCE-MRI as alternative translatable imaging biomarkers for evaluating tumor response and monitoring vascular normalization without exogenous contrast media.

1872
3:44PM - 3:50PM

Tumor-to-Brain Interface Radiomics to Predict Brain Invasion in Meningioma

L Joo1, M Kim2, J Park3, H Kim4
1Asan medical center, Seoul, Korea, Republic of, 2Asan medical center, Seoul, Songpa-gu, Seoul, 3Asan medical center, Seoul, Seoul, 4Asan Medical Center, Seoul, Seoul

Purpose
To date no radiologically detectable parameter was shown to be sufficient to predict brain invasion preoperatively. We therefore developed and validated a tumor-to-brain interface radiomics model using MRI to predict brain invasion in meningioma.

Materials and Methods
The model was developed from 521 patients (365 training [brain invasion = 75 patients] and 156 validation set [brain invasion = 32 patients]) with preoperative MRI between March 2015 and February 2019. Total 3236 radiomics features were obtained from circumferential 1cm-thickness region-of-interest (ROI) at tumor-to-brain interface from contrast-enhanced T1-weighted (CE-T1w) and T2-weighted (T2w) imaging. After radiomics feature selection using least absolute shrinkage and selection operator (LASSO) penalization, top 5 features were ranked using random forest among combined radiomics, clinical, and pathologic parameters of age, gender, tumor volume, peritumoral edema volume, tumor grade, and Ki-67 index. The performance of predicting brain invasion using the composite model was evaluated by using the area under the receiver-operating-characteristic curve (AUC).

Results
Fifteen significant interface radiomic features (2 from CE-T1w and 13 from T2w imaging) were selected for model construction. Top 5 features in the composite model include tumor grade and radiomics features from T2w imaging (1 gray-level run length matrix, 2 entropy, and 1 maximum probability feature). The composite model showed high performance in the training (AUC 0.98) and validation set (AUC 0.99), which was better than a model developed from top 5 ranked clinical/pathologic parameters of tumor grade, tumor volume, peritumoral edema volume, age, and Ki-67 index in both training (AUC 0.74, P <.001) and validation set (AUC 0.78, P <.001).

Conclusions
Radiomics at tumor-to-brain interface on T2-weighted imaging can help predict brain invasion in meningiomas and improve diagnostic performance from known clinical and pathologic parameters.
SMART Syndrome, an Uncommon Complication of Radiation Therapy

T Tragon, K Traylor
University of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
Stroke-like migraine attacks after radiation therapy (SMART) syndrome is a rare, delayed complication of radiation therapy versus the more common postradiation necrosis and leukencephalopathy. Average symptom onset is 20 years after radiation treatment. Patients typically present with symptoms of migraine-like headaches, seizures, and/or neurologic deficits. Although rare, early recognition and prompt communication of this suspected diagnosis is crucial to prevent further morbidity and unnecessary invasive testing. We report a case where the patient acutely presented with episodic speech difficulty and seizures 18 years following resection and radiation therapy. The clinical and radiologic manifestations of SMART syndrome will be reviewed.

Materials and Methods
58-year-old man presents to the ER with acute onset speech fluctuation with seizures. Prior history included a left frontal lobe anaplastic oligodendroglioma status post resection and standard chemoradiation 18 years prior. MRI revealed new areas of gyriform thickening in the operative bed with T2/FLAIR hyperintensity with adjacent cortical enhancement. SMART syndrome was suggested, and anti-epileptic therapy were initiated. In 3 months, the patient's symptoms markedly improved and a follow-up MRI demonstrated resolution of the masslike FLAIR and enhancement.

Results
1. Axial T2 FLAIR (top left) and T1-weighted post contrast (top right), one year prior to presentation showing unchanged posttreatment related changes in the left frontal lobe superior to the surgical bed without mass effect or abnormal enhancement. 2. Axial T2 FLAIR (bottom left) and T1-weighted post contrast (bottom right), upon admission for acute symptom onset, shows gyral thickening and FLAIR hyperintense signal with sulcal effacement. Post contrast images demonstrate heterogeneous areas of linear cortical enhancement.

Conclusions
SMART syndrome is a rare, delayed complication of brain radiotherapy, often occurring many years following completion of radiation. The clinical presentation and debilitating symptoms could suggest tumor recurrence to the inexperienced clinician, potentially leading to unnecessary invasive testing. Due to the characteristic time course of symptom onset and the imaging features the radiologist can suggest this in the differential diagnosis, helping to ensure rapid initiation of appropriate therapy for this potentially reversible syndrome.
Symptomatic Fibrous Dysplasia in a Pregnant Woman

W Mallon¹, J Lee²
¹Montefiore Medical Center, New York, NY, ²N/A, N/A

Purpose
To discuss a symptomatic exacerbation of Fibrous Dysplasia in pregnancy.

Materials and Methods
A 23 year old female who was 22 weeks pregnant with no PMH presented to an outside institution with severe headaches, left sided forehead swelling, and periorbital edema. A CT and MRI of the brain was performed revealing a lytic lesion abutting the left coronal suture with bony erosion of the inner table. The patient was treated symptomatically and continued the pregnancy to term without complication and was referred to our institution for further evaluation. The patient had no neurological deficits but had continued intermittent headaches that were treated with Fioricet. MRI 5 months later showed the lesion was decreasing in size. A decision was made to undergo excisional biopsy with one of our neurosurgeons 7 months after the initial presentation. The morning of the procedure the patient had a CT for operative guidance and the lesion had reossified and had a ground-glass appearance. The procedure was aborted with the plan to do follow-up imaging as the patient's symptoms had largely subsided.
Results
On the initial CT a lytic soft tissue lesion was seen along the inner table of the skull abutting the left coronal suture with local mass effect upon the adjacent left frontal lobe, erosion of the inner table and the lesion had nearly eroded through the outer table. The subsequent MRI demonstrated the lesion as a heterogeneously iso to low T1, heterogeneously iso to high T2, with peripheral enhancement measuring 2.7 x 1.5 cm. The lesion abuts the underlying dura with mild dural enhancement, An interval MRI 5 months later demonstrated the lesion had decreased in size slightly but the decision to excise was made. On the date of the procedure the lesion had reossified and now had a central ground glass appearance without any mass effect on the frontal lobe.

Conclusions
There have been several case reports of patient's with monostotic fibrous dysplasia and McCune-Albright syndrome who have experienced increased symptoms of bone-pain during pregnancy(1,2). Osteogenic cells in these tumors express elevated levels of estrogen and progesterone receptors(3). Elevated levels of this hormone during pregnancy provides a possible mechanism of exacerbation of fibrous dysplasia in pregnancy (3,4,5). Symptomatic exacerbations of fibrous dysplasia may have an aggressive appearance on imaging and it is important to recognize this possibility in pregnant patients and help guide appropriate counseling and follow-up imaging.

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1095
4:05PM - 4:11PM

Laser Interstitial Thermal Therapy In Brain Tumors: Immediate, Short And Long-Term Appearance On DWI With Apparent Diffusion Coefficient Maps.

A mahammedi1, S Bachir2, E Escott3, G Barnett,4, A Mohammadi4, M LARVIE5

1University of Cincinnati Medical Center, Cincinnati, OH, 2Cincinnati Children's Hospital Medical Center, Cincinnati, OH, 3University of Kentucky, Lexington, KY, 4Cleveland Clinic, Cleveland, OH, 5Cleveland Clinic, CAMBRIDGE, MA

Purpose
The purpose of our study was to investigate the MRI appearance on diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC) maps following MRI-Guided Laser Interstitial Thermal Therapy (LITT), immediately and up to 50 months after LITT.

Materials and Methods
One-hundred-two patients with brain tumors treated with LITT entered the study: Thirty-nine GBM, thirteen anaplastic astrocytoma, eight anaplastic oligodendroglioma, and forty-two metastases.
Results

24-hour after LITT, all patients demonstrated a rim of restricted diffusion at the edge of the treatment zone that marks the border of the peripheral rim of enhancement. A complete undisputed ring of restricted diffusion at day one post LITT that shrinks exponentially and resolves after 8 months demonstrates high correlation with median progression-free survival which was 6.4 months (range 2.1-70 months) (P < 0.01).

Conclusions

A complete ring of restricted diffusion at day one post-LITT that shrinks exponentially within eight months signifies a favorable prognosis. Future randomized studies are needed to evaluate the role of DWI with ADC maps to characterize evolution of post LITT lesions.

Conclusions

The ability to detect at an early stage the true aggressiveness of GBM is key in directing management. The current study suggests that presurgical enhancing tumor growth may predict survival to an even greater degree than presurgical enhancing tumor volume alone.

Presurgical enhancing tumor growth serves a prognostic survival indicator in patients with glioblastoma, above tumor volume alone.

H Bagce¹, A Lignelli²

1Columbia University Medical Center, New York, NY, 2Columbia University Irving Medical Center, New York, NY

Purpose

Recent studies have demonstrated a significant correlation between prognosis and pretreatment tumor volume (Ellingson et al 2017) as well as a correlation between prognosis and post-surgical changes in tumor volume (Smedley et al 2018) in patients with glioblastoma (GBM). Little is known about how the presurgical dynamic nature of GBM affects prognosis. In the current study, we retrospectively investigate how pretreatment changes in contrast-enhancing tumor volume affect survival.

Materials and Methods

IRB-approved retrospective search of the PACS report database and electronic medical record yielded 13 patients with inclusion criteria of a pathologic GBM diagnosis and two prior contrast-enhanced MRIs in the PACS, one within two weeks prior to resection and a second prior MRI within two months preceding resection. Enhancing tumor volume in cubic centimeter was approximated for each scan utilizing a standard ellipsoid estimation algorithm (V = AP x TV x CC / 2). Outcome data included tumor volume immediately prior to resection, tumor growth, calculated as a change in tumor volume per day prior to resection (ΔV = (Vol2-Vol1)/#days between scans), and survival time (days) following tumor resection. Anatomic and survival data were correlated utilizing Pearson r correlation coefficients in MATLAB's Statistics and Machine Learning Toolbox.

Results

Average patient age at the time of resection was 67 ± 12 (SD) years old. As expected, there is a negative correlation between survival time and tumor size immediately prior to surgery, however, the correlation is not statistically significant (r = -0.43, p = 0.17), likely secondary to the limited number of patients available for inclusion in the current study. Rather, there is a statistically significant negative correlation between survival time and enhancing tumor growth prior to surgery (r = -0.61, p = 0.03; see Figure).

Conclusions

The ability to detect at an early stage the true aggressiveness of GBM is key in directing management. The current study suggests that presurgical enhancing tumor growth may predict survival to an even greater degree than presurgical enhancing tumor volume alone.
The results have significant implications, suggesting that short-term tracking of tumor volume prior to pathological diagnosis may help guide clinicians/surgeons in their management decision.

Is there added value of arterial spin labeling compared to MR dynamic susceptibility contrast perfusion weighted imaging in the evaluation of tumor hemodynamic abnormality in patients with malignant brain tumors

X LIU\textsuperscript{1}, W Tian\textsuperscript{2}, A Hussain\textsuperscript{2}
\textsuperscript{1}UNIV OF ROCHESTER MEDICAL CENTER, PITTSFORD, NY, \textsuperscript{2}university of rochester medical center, Rochester, NY

Purpose
MR dynamic susceptibility contrast perfusion weighted imaging (DSC-PWI) is the most commonly used perfusion imaging technique in the brain tumors. MR arterial spin labeling (ASL) is a novel noninvasive MR sequence to quantify tissue blood flow. The purpose of this study is to compare the quantitative measurement of the relative cerebral blood volume (rCBV) derived from DSC-PWI and cerebral blood flow (CBF) of ASL, and evaluate whether there is added value of ASL in patients with malignant brain tumors.

Materials and Methods
65 patients with high grade gliomas, lymphoma and brain metastasis were enrolled in this study. The MR DSC-PWI and pCASL (Pseudo-Continuous ASL) were acquired in the MR examination of these patients. The rCBV maps without and with contrast leakage correction were generated using FDA-approved NordicICE program, and the CBF images were generated using GE ASL program. The maximal rCBV ratio and CBF ratio in the "hot" ROIs were measured. The paired t-test, Spearman Rank correlation analysis, and the Mann Whitney test was used to compare ASL-CBF and rCBV derived from DSC-PWI in the evaluation of malignant brain tumors.

Results
The CBF map detected perfusion change of 72 lesions, in contrast rCBV map could show 63 lesions. The other 9 lesions had susceptibility artifact subsequent to the location closed to the skull base or due to hemorrhage. There was no significant difference between the mean rCBV ratio and CBF ratio in the 63 lesions (p>0.05), both rCBV ratios of rCBV without and with contrast leakage correction had correlation with CBF ratio (p<0.05). However, in 23 new or enlarged enhancing lesions after chemoradiation or radiation treatment, the mean maximal rCBV ratio of rCBV with contrast leakage correction (1.78±2.11) were higher than rCBV without contrast leakage correction (1.23 ± 0.69, p<0.05). The rCBV with contrast leakage correction has better correlation with CBF ratio ( p<0.001) than rCBV without contrast leakage. There was no significant difference between CBF of ASL and rCBV from DSC-PWI in the detection perfusion change in the malignant brain tumors (p>0.05).

Conclusions
Combing rCBV without and with contrast leakage correction and CBF of ASL can demonstrate more characteristics of perfusion change in such brain tumor patients after chemoradiation or radiation treatment. In addition, ASL can provide added value than DSC-PWI in the evaluation of tumor hemodynamic abnormality for the brain tumors contaminated with susceptibility artifact.

Pituitary Adenomas and Patterns of Invasion

K SEIFERT\textsuperscript{1}, A Malhotra\textsuperscript{2}
\textsuperscript{1}YALE NEW HAVEN HOSPITAL, MILFORD, CT, \textsuperscript{2}Yale University School of Medicine, New Canaan, CT

Purpose
Pituitary lesions are common in the general population, with pituitary adenomas making up the largest percentage, at approximately 30% of all pituitary lesions. In the most recent WHO update for pituitary adenomas, the term "atypical adenoma" is no longer
recommended, which was previously used for tumors that demonstrated aggressive features, both on histology and imaging. In the latest update, it was recommended that patients who demonstrate clinical aggressive features should be imaged and followed up for tumor invasion. The pituitary adenoma literature localizing tumor invasion has been relatively sparse, with several articles focusing on the cavernous sinus, and few studies evaluating other locations of invasion. This study was performed to assess pituitary adenomas and evaluating invasion to all adjacent spaces.

Materials and Methods

We performed a retrospective search over a 7 year period. We chose a search term of pituitary macroadenoma to optimize our search for pituitary tumors that may cause clinical aggressive symptoms. Each study was reviewed for route and extent of tumor invasion to the adjacent spaces, including suprasellar, parasellar/cavernous sinus, inferior/sphenoid/clivus, prepontine, skull base foramen.

Results

In our preliminary search, we initially had 429 patients. 36 patients were excluded as they had no evidence of a pituitary mass; 2 additional patients were excluded with a separate diagnosis. Of the remaining 391 patients with pituitary adenomas, 249 (67%) had suprasellar extension, 157 (40%) had cavernous invasion, 52 (13%) had inferior extension, 8 (3%) had prepontine involvement, and 15 (5%) had evidence of extension into the skull base foramen.

Conclusions

This study was performed to evaluate aggressive pituitary adenomas and tumor invasion. To our knowledge, this is the first paper to assess the location and prevalence of particular parasellar routes of infiltration. Given changes in recommendations for imaging and follow up when a patient demonstrates clinically aggressive symptoms associated with their adenoma, it is important to keep in mind the expected routes and prevalence of invasion.

Prediction of Recurrent Glioblastoma after Laser Interstitial Thermal Therapy: The Role of Early Changes in the Pattern of DWI and Apparent Diffusion Coefficient Maps.

A mahammedi1, S Bachir2, E Escott3, G Barnett4, A Mohammadi4, M LARVIE5

1University of Cincinnati Medical Center, Cincinnati, OH, 2Cincinnati Children's Hospital Medical Center, Cincinnati, OH, 3N/A, Lexington, KY, 4Cleveland Clinic, Cleveland, OH, 5CLEVELAND CLINIC, CAMBRIDGE, MA

Purpose

To evaluate the incremental value of diffusion-weighted imaging (DWI) with apparent diffusion coefficient (ADC) maps for predicting locally recurrent GBM immediately following MRI-Guided Laser Interstitial Thermal Therapy (LITT). We hypothesize that microscopic peritumoral infiltration cause early subtle variations in the DWI images and ADC maps.

Materials and Methods

Out of sixty-four patients with GBM treated with LITT, thirty-nine were studied 24 hours after undergoing LITT. Post LITT patterns on DWI and ADC maps obtained on day one following LITT were correlated to areas of future GBM recurrence identified through coregistration of follow-up MRI examinations. Multivariable logistic regression models were created.

Results

Thirty-nine GBM patients. For predicting recurrent cancer, areas of decreased DWI signal and increased signal on ADC maps along the expected peritumoral ring of true restricted diffusion identified 24-hour after LITT showed a high sensitivity (91%) and correlation with future areas of GBM recurrence (P < 0.001). A significantly greater area under the receiver operating characteristics curve was determined for DWI with ADC maps (P < 0.01). The results suggest that location and direction of future recurrence after LITT can be predicted as a function of signal intensity on ADC maps and DWI images.

Conclusions

DWI images and ADC maps obtained on day 1 after LITT can predict location and direction of future GBM recurrence months before the development of abnormal enhancement occurs. A multiparametric logistic model calibrated to these changes can be used to predict the location of recurrent disease after LITT.
Interesting Clinical Dilemma after a Boxing Punch

S Wagle, J Verdoorn, J Morris
1Mayo Clinic, Rochester, MN, 2N/A, N/A

Purpose
To describe the emergent clinical presentation and imaging findings of proliferative fasciitis involving the neck.

Materials and Methods
A 24-year-old previously healthy male developed a golf ball sized neck mass over a few days after being punched in the right side of the neck during a boxing class. Initial CTA showed a hematoma without active arterial or venous extravasation. Over the next few weeks, the mass enlarged (figure A) and the patient developed dysphagia, voice changes, and neck pain. Repeat CT angiogram showed an 8.3 cm presumed hematoma (figure B) with a small amount of suspected contrast extravasation on venous phase imaging (arrow on figure C). The patient underwent a right neck exploration which showed a large pale lobulated mass (figure D). Intraoperative frozen sections showed a high grade epithelioid malignancy with multiple mitoses. All immunostains were negative. Final pathology revealed pediatric-type proliferative fasciitis. The patient subsequently underwent surgical debulking, with a small residual retrosternal mass. 1 cc Kenalog 40mg/ml was injected into the remaining mass. Proliferative fasciitis is a rare benign soft tissue lesion that can be mistaken for a sarcoma both radiologically and pathologically. This lesion occurs as a result of a reparative process with reactive fibroblastic proliferation involving the fascia. It mainly affects the upper and lower extremities in adults older than 40 years old without gender predilection. It typically presents as a solitary painful mass which rapidly grows for a few weeks and achieves a final size between 1-7 cm. Lesions rarely self-involute and are almost always excised. Proliferative fasciitis is a pseudosarcoma which is a benign non-neoplastic mass that can be misdiagnosed as sarcoma due to its rapid growth and histological appearance. Most pseudosarcomas rarely recur following simple excision.

Results
Initial CTA done 4 days after the injury showed a hematoma within the right supraclavicular space without active arterial or venous extravasation. Subsequent CTA done 4 weeks after the injury showed substantial enlargement of the presumed hematoma with small amount of suspected active contrast extravasation on venous phase imaging.

Conclusions
The neuroradiologist should be aware of proliferative fasciitis. This is a rare benign lesion that typically presents as a fast growing mass and can be mistaken for a sarcoma both radiographically and pathologically.
An Unusual Case of Diffuse Nodal Recurrence From an Arytenoid Chondrosarcoma

S Culleton¹, R Wiggins²
¹Foothills Medical Centre, Calgary, N/A, ²University of Utah, Salt Lake City, UT

Purpose
To describe an unusual case of nodal recurrence from an arytenoid chondrosarcoma. This is an important reminder for the reporting radiologist that these rare cases very occasionally extend to nodes causing diffuse nodal involvement.

Materials and Methods
Primary chondrosarcoma of the larynx is rare, accounting for approximately 0.2 % of all malignancies (1). These tumours represent a minority of malignancies involving the larynx and can be mistaken for benign entities (1). An 83 year-old man presents with bilateral neck fullness with discrete nodules on both sides of his stoma. He had with a history of grade 2 right arytenoid chondrosarcoma with a total laryngectomy performed in 2008. His medical history also included T2DM, HTN and metastatic hormone sensitive prostate cancer. A CT of the patient's neck demonstrated bilateral SCM cystic foci and initially interpreted as bilateral myositis from possible blood bourne infectious spread.

Results
Figure 1: axial CT image from 2008 shows a mass arising from and replacing the right arytenoid, with a normal cricoid, thyroïd, and left arytenoid cartilage. Middle image from 2012 shows expected postoperative changes from a total laryngectomy. Right image from 2019 demonstrates an unusual appearance of bilateral SCM cystic changes that were initially thought to be arising from the muscles themselves, but found to be chondrosarcoma recurrence on FNA.
Conclusions
Chondrosarcomas of the larynx are rare lesions and it is very rare for these lesions to arise from the arytenoid cartilage. This rare highlights an unusual and unexpected recurrence of nodal disease found to be chondrosarcoma nodal recurrence.

Volumetric Analysis of Vocal Folds in the Healthy Population using Computed Tomography

N Alexander¹, K Wang¹, K Jiang¹, J Ongkasuwan¹, C MALAYIL LINCOLN¹

¹Baylor College of Medicine, Houston, TX

Purpose
Age-related atrophy of the thyroarytenoid muscles has been described by direct visualization and pathological examination [1,2], but has not been confirmed on subsequent studies with magnetic resonance imaging (MRI) [3,4]. Given the lack of data on imaging, the purpose of this study is to perform computed tomography (CT) volumetric analysis to assess for associations of vocal fold volume with age, height, and sex in a cohort of patients with normal larynges.

Materials and Methods
A total of 140 patients (age range: 21-93 years old, mean age: 59.1 years old) with no history of laryngeal pathology and with available thin-section (1 mm) soft tissue neck CTs were retrospectively reviewed. Patients with motion artifact, plane obliquity to the vocal folds, and vocal fold adduction were excluded. Bilateral true cords were measured by a board-certified radiologist blinded to the clinical history. Anteroposterior measurements were made from the anterior commissure to the vocal process of the arytenoid cartilage, and transverse measurements were made at the mid-aspect of the vocal fold. Craniocaudal measurements were made from superior to inferior edge of the vocal fold. The product of the three was used to calculate the vocal fold volume. Simple and multiple linear regression was used to evaluate the ability of age, sex, and height to predict vocal fold volume.

Results
Neither left nor right vocal fold volumes were significantly associated with age (p=0.42-0.98). Both left and right vocal fold volumes were significantly associated with patient height (p<0.001) and sex (p<0.001) on univariate regression. After adjusting for height, sex was no longer associated with vocal fold volume (p=0.070 to 0.080) on multivariate regression. However, after adjusting for sex, height remained a significant predictor of vocal fold volume (p=0.001 to 0.002).

Conclusions
Limited descriptions on vocal fold volumetric analysis exist within the literature. To our knowledge, this is the first study establishing a relationship between height and vocal fold volume. As with prior MRI studies [3,4], no significant association between vocal fold volume and age was found, supporting the argument that the assumption of age-related vocal fold atrophy should be re-examined. Prior studies demonstrated sex-related differences in vocal fold volume [3,5], although this may be confounded by height as suggested in our study.
The Diagnostic Performance of CT and MRI for Detection of Extranodal Extension in Patients with Head and Neck Squamous Cell Carcinoma: A Systematic Review and Diagnostic Meta-analysis

S Park¹, C Suh²
¹Mokpo National Hospital, Mokpo-si, Jeollanam-do, ²Asan Medical Center, Seoul, Seoul

Purpose
To review the diagnostic performance of CT and MRI for detection of extranodal extension (ENE) in head and neck squamous cell carcinoma (HNSCC) patients.

Materials and Methods
MEDLINE and EMBASE databases were searched up to October 7, 2019. Studies that evaluated the diagnostic performance of CT and/or MRI for detection of ENE in HNSCC patients with pathological ENE as a reference standard were included. The quality of the included studies was assessed using the Quality Assessment of Diagnostic Accuracy Studies-2 tool. A 2x2 table was reconstructed for each study. Pooled sensitivity and specificity were calculated using the bivariate model and hierarchical summary receiver operating characteristic (HSROC) model. Subgroup analyses were performed according to imaging findings of ENE. Pooled correlation coefficient for interobserver agreement was calculated.

Results
Twenty-two studies including a total of 2478 patients were included. The quality of the included studies was moderate. The pooled sensitivity and specificity for detection of ENE were 73% (95% CI, 62%-82%) and 83% (95% CI, 75%-89%), respectively, for CT, and 60% (95% CI, 49%-70%) and 96% (95% CI, 85%-99%), respectively, for MRI. There was substantial heterogeneity in terms of sensitivity and specificity for both CT and MRI. A threshold effect was present for MRI. In subgroup analysis, central node necrosis showed significantly higher, pooled sensitivity (81% vs. 51%; p = 0.02), while infiltration of adjacent planes showed significantly higher, pooled specificity (94% vs. 65%; p = 0.03). The pooled correlation coefficient was 0.719 by a random-effects model.

Conclusions
Both CT and MRI show good diagnostic performance for detection of ENE in HNSCC patients and interobserver agreement was substantial.
Rheumatoid Arthritis of the Larynx, an Uncommon Alternative to Squamous Cell Carcinoma

T Tragon1, B Branstetter1
1University of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
Although laryngeal mass lesions may have many potential etiologies, by far the most common cause is malignancy, with up to 95% of cases being squamous cell carcinoma1. Laryngeal involvement in rheumatoid arthritis (RA) is common, but clinical manifestations involving the cricoarytenoid joint are rare, and often difficult to diagnose on laryngoscopy2. Due to its location in the upper respiratory tract, prompt establishment of the diagnosis is critical as cricoarytenoiditis harbors significant morbidity and may precipitate respiratory arrest3. Here we discuss a patient with advanced RA who presented with an obstructive mass of the larynx and hypopharynx.

Materials and Methods
The patient is a 61 year old female who initially presented with symptoms of increased work of breathing and stridor. A CT scan was performed demonstrating a heterogeneously enhancing mass centered in the supraglottic larynx with extension into the hypopharynx resulting in narrowing of the supraglottic airway. Due to difficulty with intubation, she was scheduled for tracheostomy and laryngoscopic biopsy of the mass. No mucosal lesion was evident on endoscopy, so an intraoperative radiologic consultation was requested, and the diagnosis of cricoarytenoiditis was suggested. Intraoperative biopsies revealed inflammatory mucosa without malignant cells. She underwent MRI of the neck, which revealed an enhancing mass in the left cricoarytenoid joint with involvement of the hypopharynx and post-cricoid space, favoring inflammatory pannus formation. Final pathology returned as edematous, inflamed squamous mucosa. The patient was started on a steroid taper and discharged.

Results
1. Axial (top left) and Sagittal (top right) Contrast Enhanced CT – a heterogeneously enhancing mass centered in the supraglottic larynx and hypopharynx causes significant narrowing of the supraglottic airway and effacement of the left piriform sinus. 2. Axial (bottom left) and Coronal (bottom right) T1 Post Contrast with Fat Suppression – At the level of the glottic larynx, the enhancing mass involves both true vocal folds and the post cricoid region without subglottic extension

Conclusions
Although rheumatoid involvement of the larynx is common, establishing the diagnosis is often difficult clinically and radiologically.
In a patient with rheumatoid arthritis who presents with a laryngeal mass lesion, cricoarytenoiditis should be strongly considered, as early recognition and prompt communication may prevent further morbidity and unnecessary surgery.

**Improved Diagnostic Accuracy in Optimized Head and Neck Diffusion Weighted Imaging Utilizing RESOLVE and MultiBand Versus Conventional Diffusion Weighted Imaging**

G Guzman Perez-Carrillo¹, S Han¹, R Khan², N Chen¹
¹University of Arizona, Tucson, AZ, ²Dartmouth Hitchcock Medical Center, Lebanon, NH

**Purpose**
To evaluate diagnostic accuracy of conventional DWI sequences versus our optimized DWI sequences combining readout-segmented, multi-shot EPI RESOLVE (iShim, Siemens Medical Solutions, Erlangen, Germany) and multiband echo planar imaging (MultiBand, Siemens Medical Solutions, Erlangen, Germany) in post-treatment head and neck squamous cell carcinoma (SCC) patients.

**Materials and Methods**
A cohort of 18 adult patients with biopsy-proven diagnosis of head and neck tumor that presented with suspicion of tumor recurrence after completion of either surgical and/or chemoradiation treatment was evaluated. We have a full data set in 16 patients to compare conventional (DWI-EPI) ADC versus optimized (RESOLVE/SMS) ADC values utilizing the Siemens WIP 1051 C. In 16 patients, 3 were female and 13 were male, with an average age of 58 ± 12 years. For biopsy results, 10 patients had histologically-proven SCC recurrence and the other 6 did not. In total 16 subjects, 2 subjects' data were excluded in the analysis, as the conventional DWI images were non-diagnostic, and quantitative comparison with the optimized DWI sequence could not be performed, as seen in Figure 1. We utilized the suggested average ADC value cut-off to identify squamous cell carcinoma in the head and neck is <1.1 × 10⁻³ mm²
reported in QIBA (1). We performed a 2-sample t-test to calculate p-values of the ADC values for both the conventional and optimized DWI, using biopsy results as the gold-standard.

Results
Figure 2 shows the individual ADC values, with subject 1-10 corresponding to SCC recurrence subjects. The p-value for diagnostic accuracy including 16 subjects was 0.0656 for optimized sequence. It was statistically insignificant due to a low ADC value from two cases with bad image quality. With exclusion of these two cases, the p-value for diagnostic accuracy for our optimized sequence was 0.0356 as compared to the conventional DWI sequence p-value of 0.1427. It is statistically significant to use optimized sequence for diagnostic accuracy (p-value = 0.0356 < 0.05) We again saw our reported phenomena of elevated ADC values in the optimized DWI sequence (2).

Conclusions
Our optimized DWI sequence for the head and neck has increased diagnostic accuracy as compared to the conventional DWI sequence. This is a promising result, as an optimized DWI sequence can then be compared to PET-CT imaging in a comparative effectiveness study.

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1202

Metastatic Supraglottic Carcinoma with Perineural Spread Along a Spinal Nerve

R Jordan¹, K LEARNED², L Ginsberg³
¹University of Texas-Houston, HOUSTON, TX, ²MD ANDERSON CANCER CENTER, HOUSTON, TX, ³M.D. Anderson Cancer Ctr., Houston, TX

Purpose
To illustrate a rare example of a mucosal carcinoma nodal metastasis spreading perineurally along the C3 nerve root into the neural foramen.

Materials and Methods
A 64-year-old man, previously treated for recurrent epiglottic carcinoma, was undergoing systemic therapy for persistent tumor and was re-imaged with PET/CT. In addition to extensive FDG-avid left neck disease, PET/CT showed evidence of perineural extension along the left C3 nerve root.
Results
The PET/CT showed mixed activity associated with the known left cervical adenopathy, and an FDG avid left C3 nerve root within the C2-3 neural foramen which could be followed laterally to the site of the nodal metastasis. Retrospective review of the CT obtained 1 month prior, demonstrated a thickened, enhancing linear structure in the same location that was not described.

Conclusions
While perineural tumor spread is most recognized to occur along cranial nerve branches, it has also been described in several branches of the superficial cervical plexus (spinal nerves), including the great auricular and supraclavicular nerves, in both cases associated with recurrent cutaneous cancer. We describe an unusual case of perineural spread arising from nodal metastases associated with a mucosal cancer.

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2344 4:19PM - 4:25PM

To assess the safety and efficacy of bleomycin/pingyangmycin sclerotherapy for orbital and peri-orbital veno-lymphatic malformations-a systematic review

K Faiz¹, J Shankar², S Finitsis³, J Linton¹
¹University Of Manitoba, Winnipeg, Manitoba, ²university of Manitoba, Winnipeg, MB, MB, ³Aristotle University of Thessaloniki, Thessaloniki, Thessaloniki

Purpose
The purpose of this systematic review is to investigate the safety and efficacy of bleomycin/pingyangmycin sclerotherapy for the treatment of orbital and peri-orbital veno-lymphatic malformation (VLM).

Materials and Methods
Methods: The authors performed Medline, Embase, Scopus and Cochrane central register of controlled trials search for the period between 1974 to April 5th, 2019, reporting outcomes of bleomycin/pingyangmycin sclerotherapy for orbital and peri-orbital veno-lymphatic malformations. Two reviewers independently screened and extracted data from these studies and assessed the risk of bias. Predefined outcome measures of interest were subjective and objective reduction of the lesion in addition to symptomatic relief and minor and major complications of the treatment.

Results
Results: Nine studies enrolling 132 patients were included. Subjective reduction of the lesions was seen in 96.2 % of the studies. Objective reduction of the lesion and symptomatic improvement were reported in 91.6 and 95% of the studies respectively. Minor adverse events were reported in 18.25 % of the studies. Major complications like pulmonary toxicity or pulmonary fibrosis was not encountered in any of the included studies. Quality of evidence was generally low.

Conclusions
Bleomycin/pingyangmycin is a very effective and safe drug for the treatment of orbital and periorbital veno lymphatic malformations and is not associated with any major side effects including pulmonary fibrosis.
IgG4-Related Hypophysitis With Invasion of the Clivus

N Naro1, A Weyer2
1University of Pittsburgh Medical Center, Pittsburgh, PA, 2University of Pittsburgh, Pittsburgh, PA

Purpose
Isolated IgG4-related hypophysitis is a rare manifestation of a rare disease. Although adjacent bone involvement in cases of IgG4-related disease has been reported at other anatomic sites, this tends to manifest as osseous remodeling without marrow invasion or cortical destruction. We present a case of IgG4-related hypophysitis with rapid progression and clival invasion in the absence of systemic features of IgG4-related disease.

Materials and Methods
A 63-year-old female without significant past medical history presented to her physician for evaluation of new-onset daily headaches. She noted a 3-week history of headaches with associated polydipsia and polyuria. Initial workup included an MRI, which revealed a sellar/suprasellar mass concerning for macroadenoma. Upon presentation for resection 5 weeks later, new onset diplopia and 6th nerve palsy were noted. Preoperative MRI at this time revealed marked enlargement of the mass and new involvement of the clivus. Given the rapid progression and new bone involvement, findings were concerning for an aggressive neoplasm. The patient underwent transsphenoidal biopsy rather than primary resection. Pathology revealed lymphocytic hypophysitis with a large population of IgG4 positive plasmacytes. Rituximab therapy was initiated, and the patient continues on oral prednisone without new endocrinopathies.

Results
Initial brain MRI demonstrated an enhancing sellar/suprasellar mass with central hypoenhancement. Subtle T1 hypointense signal was noted in the tip of the clivus on retrospective review. It was difficult to assess whether findings represented enlargement of the pituitary gland and infundibulum or a separate mass. Preoperative MRI 5 weeks later displayed marked enlargement of the mass with loss of the central hypoenhancement. New circumferential enhancement and thickening developed in the sphenoid sinus. T1 hypointensity and enhancement in the clivus progressed. Preoperative stereotactic localization CT confirmed cortical destruction of the dorsum sella and clivus, as well as bony dehiscence of the hypophyseal fossa.

Conclusions
IgG4-related hypophysitis may have an aggressive appearance and should be included in the differential for sellar masses with osseous invasion.
Unusual Sellar Atypical Teratoid/Rhabdoid Tumor Presenting in an Adult

T Ouyang
Penn State Health Hershey Medical Center, Hershey, PA

Purpose
To report a rare case of sellar-suprasellar AT/RT presenting in a 69 year old female patient and review the literature and the imaging characteristics.

Materials and Methods
A 69 year old female presented to our institution with right CN3 palsy. MRI revealed a sellar-suprasellar mass. Surgical debulking was performed. Tumor cells were completely negative for INI-1. Final pathologic diagnosis was WHO grade IV AT/RT. Post-operative course was complicated by development of DI, seizures, and hydrocephalus requiring a shunt. CSF was shown to be positive for malignant cells. Patient's mental and functional status continued to decline and only one cycle of chemotherapy was given before she was readmitted to this institution with large subdural hematoma necessitating decompression, DVT and PE. Repeat imaging showed continued progression of intracranial disease. Family elected for hospice care given her rapidly worsening quality of life. The patient expired approximately 5 months after diagnosis.

Results
MRI on presentation showed a T1 hypointense, T2 hyperintense sellar-suprasellar mass which enhanced solidly after gadolinium
contrast. Interestingly there was restricted diffusion in the mass without hemorrhage on CT. No clear cavernous sinus invasion. The radiological differential diagnoses were lymphoma, metastasis, or atypical/infarcting adenoma. Repeat MRIs 2 weeks after presentation and again 10 days after surgery showed continued rapid increase in size. MRI obtained during patient's final hospitalization showed a new dural based metastatic deposit in the left parietal convexity.

Conclusions
To the best of my knowledge, this is the 18th case of a sellar/suprasellar AT/RT in an adult, all of the reported cases have been in females. AT/RT can be indistinguishable on imaging from other sellar-suprasellar masses and has been reported to present with apoplexy. Clinically, it is characterized by rapid progression in size, cranial neuropathies, propensity for leptomeningeal spread and poor prognosis. Neuro-radiologists should consider this diagnosis in adults, especially female patients, presenting with atypical sellar/suprasellar masses.

Magnetic resonance imaging of sellar AT/RT before and after surgery. A. Post contrast sagittal T1W shows a sellar suprasellar mass which is hypointense on T1 and solidly enhancing. It appears separate from and superior to normal pituitary tissue. B. Post contrast T1W 2 weeks after initial presentation shows growth of the mass. C. Axial DWI image shows restricted diffusion in the mass. D. Post operative imaging 10 days after surgical debulking shows that the enhancing mass has increased in size, now with mass effect on the brain stem.

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Modified Seldinger Technique for Placement of Lumbar Drain: Case Report, Literature Review, and Future Treatment Implications

M Taon
Kaiser Permanente Los Angeles, Glendale, CA

Purpose
Discuss the use of modified Seldinger technique to obtain intrathecal access for lumbar drain placement. Review anatomy associated with intrathecal access including skin, subcutaneous tissue, bones, ligaments, epidural space, dural space, dorsal and ventral spinal cord, and vasculature. Discuss possible future treatment implications including "endothecal" intervention and neural-machine interface.

Materials and Methods
58 year old man 7 months status post L3 to L5 laminectomy complicated by cerebrospinal fluid leak. Request was made for lumbar drain placement prior to repeat surgical intervention. A 14 Gauge spinal access needle was advanced under fluoroscopic guidance in the desired trajectory but was unable to reach the spinal canal due to patient anatomy and excessive soft tissue. A 17 Gauge needle was used with fluoroscopy to access the thecal sac at the L5-S1 level. After an egress of CSF was obtained, a 0.035 inch Bentson wire was advanced through the epidural needle into the thecal sac. The needle was removed over the Bentson wire and a 4 French x 12.5 cm sheath was used to dilate the tract. The Bentson wire was then exchanged for a 0.035 inch Amplatz wire. The 4 French sheath was removed and a 5 French x 25 cm sheath was then advanced into the thecal sac. The wire and inner dilator of the 5 French sheath were removed and the 1.5 mm diameter lumbar drain was advanced through the sheath with confirmation of placement on fluoroscopic guidance and egress of clear CSF. The lumbar drain was connected to the drainage bag, patient was admitted, and underwent surgical revision without complication.

Results
Fluoroscopy demonstrates a 14 gauge needle at the L5-S1 level. This was replaced by a 17 Gauge needle. An .035 inch wire is seen within the thecal sac. After dilation with a 4 French sheath, a 5 French sheath was placed. A lumbar drain was placed co-axially through the 5 French sheath.

Conclusions
We report a case of intrathecal lumbar drain placement using wire, sheath, and dilation in a modified Seldinger technique. The success of this case highlights the importance and need for further tools that would aid in access to the thecal sac. The anatomy and risks associated with intrathecal access were reviewed. Current and future indications for intrathecal access with an intrathecal platform were discussed including "endothecal" intervention and neural-machine interface.

Spinal osseous, non-osseous exclusive epidural AV malformations and Metameric syndrome with symptomatic epidural component- Clinical, imaging, angiographic characteristics and its endovascular treatment outcomes- An institutional experience.

J Nadarajah, L Sebastian, S GAIKWAD
All India Institute of Medical Sciences, New Delhi, NH, All India Institute of Medical Sciences, NEW DELHI, Delhi, ALL INDIA INSTITUTE OF MEDICAL SCIENCES, new delhi, delhi

Purpose
Spinal epidural arterio venous malformations (SEAVM) are uncommon, complex spinal vascular lesions with varying clinical presentations and include osseous and non osseous epidural fistulae and more complex metametric lesions with epidural components. Although difficult to cure completely, these can be managed by endovascular means with reasonable functional outcome. Objective of this study is to review the consecutive cases of spinal epidural fistulae in a single center and analyze their clinical presentation, imaging findings, angioarchitecture, endovascular management and outcome.

Materials and Methods
From our institutional data base, we retrospectively reviewed all cases of spinal vascular malformation from January 2005 to May 2019 and identified 23 cases of SEAVM (18 were isolated SEAVMs and 5 were Spinal Metameric Malformations with symptomatic epidural component). Demographic details, clinical presentation, imaging findings, digital subtraction angiographic pattern, immediate and long-term functional outcome following endovascular treatment were analyzed.

Results
Of the 23 cases, 15 were male. Mean age was 30.08 years (12-68 years). Out of these 23 patients 3 had neurofibromatosis and 2 had coarctation of aorta. Isolated cord compression by epidural sac was noted in 14 (60.8%), congestive myelopathy in 2 patients (8%), cord compression with congestion in remaining 7 patients (30.04%). All 5 patients with SAMS showed cord AVM with intramedullary nidus. In remaining 18 patients only three (16%) showed intradural reflux. Of these three patients, two were dorsal SEDAVFs and one
was lumbar SEDAVF. Out of 23 patients, endovascular embolization was done in 18 patients. Glue was preferred embolic agent and used in 13 out of 18 patients. In remaining 5 patients, all were cervical SEDAFs, treated with stent graft in two and Detachable balloons in two and coils in remaining one patient. No major periprocedural complication was noted. Mean duration of follow up was 8±9.2 months (2-36 months). Out of 18 treated patients, complete clinical improvement was noted in 5 patients (28%), partial improvement in 9 (50%) and no improvement in remaining 4 patients (22%).

Conclusions
Understanding angioarchitecture is the key in the management of these complex lesions and avoiding complications. Though these lesions are difficult to cure completely, targeted embolization of large extradural venous pouches can yield dramatic clinical improvement by relieving compressive myelopathy.
and the left lateral sacral artery visualized the two shunts in the CE, the one visualized from the Th9 injection and the other lower shunt (not uploaded).

Conclusions
Fusion images of 3DRA and volumetric T2 MRI was useful in understanding complex anatomy of the multiple AVFs. Particular attention was required in embolization due to the varix on the shared drainer. This case may be a manifestation of spinal arteriovenous metameric syndrome.

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1643

Adjacent level fracture after vertebroplasty: does the stress riser phenomenon exist?

M Werndle¹, A Thorpe², R Flood², S Morgan²
¹North Bristol NHS Trust, Bristol, United Kingdom, ²North Bristol NHS Trust, Bristol, Bristol

Purpose
Adjacent level fractures from the stress riser phenomenon after vertebroplasty, in the treatment of acute osteoporotic vertebral compression fractures, remains the subject of debate. A post hoc analysis of the VERTOS IV trial,(1) which compared vertebroplasty versus sham intervention, revealed a higher incidence of further vertebral collapse after the sham procedure. Furthermore, in the patients with vertebroplasty, there was no further height loss or cardiovascular compromise, suggesting a protective effect of the procedure. The aim of our study was to identify the rate of adjacent level fracture after vertebroplasty in our consecutive cohort of patients.

Materials and Methods
We performed a retrospective study on 70 consecutive procedures in 65 patients undergoing vertebroplasty for compression fractures secondary to tumour or osteoporosis between 2016 and 2019. We recorded patient age, gender, underlying diagnosis (i.e. osteoporosis or malignant, and if the latter, the type of malignancy), date of death (if applicable), the level targeted, the number of levels performed per procedure, any previous treatment (e.g. radiotherapy or chemotherapy), the vertebroplasty approach (uni or bipedicular), and the presence of a new vertebral fracture on follow up. We defined an adjacent level fracture as within two levels from the target. Groups were compared with Fisher's Exact test for non parametric data.

Results
70 vertebroplasties were performed in 65 patients, with an average age of 70 years old. The indication was osteoporosis in 19 (27%), haematological malignancy in 20 (29%), haemangioma in 2 (3%) and metastatic disease in 29 (41%). A single level was target in 43 cases (61%) and multiple in 27 (39%). 20 patients had died at the time of follow up. The average length of follow up was 15 months, minimum 0 months, maximum 35 months. 5 patients went on to develop an adjacent level fracture, and 1 developed a fracture three levels away from the vertebroplasty. Of these 6 patients with fractures, the underlying diagnosis was osteoporosis in 4, myeloma in 1 and lymphoma in 1. There is no significant difference between developing a new fracture in our patient group versus the natural history of developing further fractures (p=0.83).(2)

Conclusions
There is a low incidence of new vertebral body fracture following vertebroplasty in our patient cohort. The risk of new vertebral body fractures is not increased following vertebroplasty in comparison to the natural history.
Validation of a Non-Contrast Two Needle Technique in the Diagnostic Differentiation and Potential Treatment of Symptomatic Tarlov Cysts

J Ziegler¹, C Zhou¹, M Kumar¹
¹University of California, Davis, Sacramento, CA

Purpose
Tarlov cysts are fluid-filled structures usually involving the sacral spinal nerve roots. Larger lesions can cause function-limiting symptoms. MR is helpful in diagnosing expansile cysts, and refinements in interpretation can stratify patients. Tarlov cysts are most commonly treated with aspiration. Single-needle aspiration has a high recurrence rate, often with significant intra-procedural pain. A two-needle technique has been recently described which allows for equilibration of intra-cyst pressure during suction, greatly reducing procedural pain. We have further refined this method with concurrent needle placement, administration of bupivacaine, and removal of contrast administration.

Materials and Methods
Tarlov cysts with narrow necks can be identified by discordant T2 signal (10%+ variance in ROI) relative to the CSF in the spinal canal. Qualifying patients were selected and treated with our modified technique. For each patient, the skin over the lower midline back was steriley prepped, draped, and infiltrated with lidocaine. Image guidance was obtained via CT fluoroscopy. One 18-gauge and one 21-gauge needle were advanced into the Tarlov cyst at various depths. Slow aspiration was then initiated through the larger deeper needle. The resulting air-fluid level was monitored under intermittent CT fluoroscopy for speed of refill. The aspirated fluid was replaced with a 0.75-1 ratio of 0.5% bupivacaine in slow refill cases. Both needles were then withdrawn, and sterile dressings applied.

Results
MR imaging demonstrates the presence of a Tarlov cyst, with discordant T2 signal relative to the spinal cord CSF. Procedural images illustrate dual needle placement, with sequential imaging to monitor the air-fluid level.

Conclusions
Tarlov cysts are common, but expansile lesions can cause significant functional disability. Patients with narrow-necked cysts on MR imaging, as reflected by discordant T2 signal, are more likely to benefit from intervention. Recently, a two-needle technique for aspiration and fibrin sealant injection has been described, which improved procedure-related pain. However, this required contrast. With our revised methodology of intra-cyst bupivacaine, we are able to avoid a temporary paresis after anesthetic block and prevent the potentially devastating consequence of arachnoiditis. This adjustment further allows us to provide diagnostic surety and staged relief, while providing an alternative treatment for patients with an allergy or aversion to contrast.
Coccygeoplasty: A New Alternative For Treatment Of Refractory Coccygodinia In Patients With Coccyx Fracture, Hypermobility Or Luxation: Our Experience On 12 Patients

A De Vivo¹, I Gil², H Alqatami³, F Ventura¹, L Manfre¹

¹IOM, Catania, Italy, ²Centro Hospitalar Lisboa Ocidental, Lisbon, Portugal, ³Institute of Hamad Medical Corporation, Doha, Qatar

Purpose
Multiple factors can be responsible for chronic coccyx pain (coccydynia) being fracture, sub-luxation and hypermobility of sacrococcygeal segments the most frequent etiology. In the past, several techniques had been proposed for coccydynia resolution, as coccydiectomy, RF ablation of the coccyx, coccyx screw fixation: however, complications can occur with all surgical treatments. Coccygeoplasty is a new minimally invasive treatment, without severe complications documented. We present clinical results at 3 months’ follow-up of the largest series of patients with coccygodinia for fracture, hypermobility or luxation treated by coccygeoplasty and try to find any relation between the technical and clinical results. To our knowledge, only a case report exists in the literature about.

Materials and Methods
We retrospectively selected all consecutive patients treated for chronic coccydynia with coccygeoplasty between January 2010 and October 2018. All the patients underwent dynamic radiograms in standard and sitting position, hi-res CT study and MRI study, for diagnosis of sub-luxation, fractures and to exclude other pathologies that could contribute for the symptoms.

Results
Twelve patients were treated in our center. All the patients showed coccyx subluxation and/or hypermobility in high resolution CT.
study and dynamic radiograms. There was significant improvement of clinical symptoms in 75% (n=9) of the patients and 25% persist with pain. No symptomatic complications were noticed. FU CT control images showed optimal results in 75% patients with fusion of the sacrococcygeal bone segments. No correlation was found between final imaging results and clinical outcome at 3 months.

Conclusions
75% of patients with coccyx fractures and/or sub-luxation submitted to coccygeoplasty showed a satisfactory pain relief at 3 months' follow-up. We failed to find a statistic relation between the final imaging results and clinical results, probably for the low numbers. More studies are needed to validate these technic and find best indications for coccygeoplasty success.

1586
Detection of CSF Venous Fistula with Intrathecal Gadolinium MR Myelography

D Edasery, J Chazen
Weill Cornell Medicine, New York, NY

Purpose
Spontaneous intracranial hypotension (SIH) is an uncommon cause of headache and can have a protean clinical presentation which can lead to misdiagnosis or a prolonged period from symptom onset to diagnosis. Unlike CSF leak from lumbar puncture or ventral dural tears associated with disc herniations, a CSF venous fistula represents a communication between the subarachnoid space and an adjacent spinal epidural vein which results in decreased CSF pressure, often without evidence of epidural CSF leak on conventional myelography. Although dynamic CT and digital subtraction myelography have been used to diagnose CSF venous fistulas, our experience in the following case series highlights the value of off-label intrathecal gadolinium MR myelography.

Materials and Methods
A retrospective review was performed of 5 patients who had undergone preoperative imaging including off-label intrathecal gadolinium MR myelography with CSF venous fistula identified by paraspinal venous enhancement communicating with a spinal meningeal diverticulum.

Results
The included representative patient is a 25-year-old female who had CT myelography and multiple epidural blood patches. She eventually developed upper extremity paresthesia with tonsillar herniation and cervical cord syrinx which persisted despite posterior decompression. Initial CT myelogram demonstrated a large nerve root sleeve cyst (Figure 1, A). Follow up intrathecal gadolinium MR myelogram at the same level demonstrated a CSF venous fistula (Figure 1, B) which was targeted for surgical clipping and ligation. Pre- and post-operative brain imaging (Figure 1, C and D) demonstrates marked interval improvement in findings of intracranial hypotension and resolution of the syrinx.

Conclusions
CSF venous fistulas are a treatable cause of SIH which can often be occult on conventional myelography. When the standard workup is unrevealing, off-label intrathecal gadolinium MR myelography can have a role in accurately identifying CSF venous fistulas without the radiation exposure associated with dynamic CT or digital subtraction myelography.
Does relative renal contrast accumulation on ipsilateral compared to contralateral side down CT myelography predict laterality of CSF venous fistulae?

S Wagle\textsuperscript{1}, D Kim\textsuperscript{1}, C Carr\textsuperscript{1}, P Morris\textsuperscript{1}, J Benson\textsuperscript{1}, G Liebo\textsuperscript{1}, J Verdoorn\textsuperscript{1}, J Morris\textsuperscript{1}, W Brinjikji\textsuperscript{1}, F Diehn\textsuperscript{1}

\textsuperscript{1}Mayo Clinic, Rochester, MN

Purpose
Digital subtraction myelography (DSM) is increasingly used to diagnose CSF venous fistula (CVF). At our institution, this exam is typically performed sequentially in the lateral decubitus position on one day followed by the opposite side on the next, with each DSM followed immediately by same side down CT myelography (CTM). Renal collecting system contrast may be seen on CTM in patients with CSF leaks, particularly in those with CVFs. We assessed the potential correlation with the laterality of a CSF venous fistula and the laterality of which decubitus CTM demonstrated more renal contrast excretion.

Materials and Methods
All patients who underwent sequential lateral decubitus DSM followed by CTM on which a CVF was diagnosed during a 1-year period were studied. Two neuroradiologists evaluated the DSM and CTM images. DSM exams were reviewed for presence and laterality of CVF. CTM exams were reviewed by readers blinded to the DSM results for presence of renal contrast. If renal contrast was present on both right and left lateral decubitus CTM for a given patient, the two CTM exams were subjectively compared to assess which side down decubitus CTM demonstrated a greater amount of such contrast.

Results
Of 31 patients with a unilateral CVF diagnosed on lateral decubitus DSM, 24 had both right and left lateral DSM/CTM performed.
Two (8%) of the CVF cases (both right) demonstrated no renal contrast on either decubitus CTM and were excluded. In the remaining 22 patients, a greater amount of renal contrast was present on the same side down CTM in 17 (77%) cases (14/17 right, 3/5 left). A relatively greater amount of renal contrast was false localizing on the contralateral side down CTM in 5 (23%) cases (3/17 right, 2/5 left). Agreement statistical assessment of laterality of CVF and the decubitus side of the CTM with more renal contrast demonstrated kappa of 0.40 (95% CI -0.039 - 0.83, p=0.062).

Conclusions
Although the results did not reach statistical significance, in patients with CVF who have renal contrast to a greater degree on one lateral decubitus CTM than the other, the CVF tended to be present on the ipsilateral side. Despite this trend, the relative amount of renal contrast on one side down CTM compared to the other can be false localizing. The finding of renal contrast should prompt careful review of the CTM and DSM images on the ipsilateral side, but does not perfectly correlate with the laterality of a CVF. Additional studies with larger patient cohorts are warranted for further investigation.

1319
The Pins and Needles of Intrathecal Chemotherapy
K Wang1, A Cooc1, G Wu1, T Uribe1, C Malayil Lincoln1
1Baylor College of Medicine, Houston, TX

Purpose
We present a rare and often irreversible complication of intrathecal chemotherapy that is currently without an established treatment. Our case of dorsal column myelopathy following intrathecal methotrexate has characteristic, albeit nonspecific imaging findings that a neuroradiologist can successfully diagnose if privy to an accurate clinical history and with a strong awareness of this complication.

Materials and Methods
A 27-year-old male with a history of T-cell acute lymphoblastic leukemia with relapse in the brain received salvage chemotherapy and two rounds of intrathecal methotrexate. After his second round of intrathecal chemotherapy, he reported intermittent paresthesia in his bilateral lower extremities and issues with his balance. He denied any bladder or bowel incontinence or saddle anesthesia. On exam, there was reduced sensation to light touch and pinprick in the bilateral lower extremities. Proprioception and vibration were absent up to the bilateral knees. Patellar and Achilles reflexes were also bilaterally absent. Romberg sign was positive with a wide-based and unsteady gait. His nerve conduction study, Vitamin B12, and folate were normal, and his HIV test and cerebrospinal fluid VDRL were negative. He was started on a five-day course of intravenous methylprednisolone. However, his course was subsequently complicated by disseminated intravascular coagulation, tumor lysis syndrome, and vancomycin-resistant enterococcemia, and ultimately succumbed to his complications.

Results
Spine MRI demonstrated longitudinally extensive intramedullary signal abnormality conforming to the dorsal columns from the level of T9 to the conus. There was no associated enlargement or enhancement of the cord. In addition, the pia and nerve roots did not display abnormal enhancement.

Conclusions
Dorsal column myelopathy is a rare complication of intrathecal chemotherapy in the treatment for acute lymphoblastic leukemia and is most frequently reported in association with methotrexate. As in this indexed case, individuals may develop myelopathy despite previously tolerating treatments of the same intrathecal regimen. The myelopathy is often irreversible, and without an established treatment with reports of folate, vitamin B12, and steroid use failing to demonstrate measurable change. The patient's history is key to the diagnosis as the imaging findings are nonspecific, with the differential diagnosis including subacute combined degeneration, HIV myelopathy, and tertiary syphilis.
S. Montoya¹, T. Rencus²
¹Massachusetts General Hospital, Boston, MA, ²New England Baptist Hospital, Boston, MA

Purpose
Low back pain is a leading cause of disability. Transitional lumbosacral vertebrae (TLSVs) are normal variants, seen in up to one-third of the population. Bertolotti first described the relationship between back pain and TLSV in 1917, yet this entity continues to be under-recognized. Using a typical case of Bertolotti syndrome as a frame of reference, we aim to review the morphologic variants of TLSV, identify the various pain-generating pathologies associated with TLSVs and their respective prevalences in our practice, and describe the implications for image-guided spinal interventions.

Materials and Methods
A 56-year-old woman was referred to our practice for treatment of axial back pain, described as a deep dull aching pain located on both sides of the lower back. Facet injections were planned and performed at the L3-4 and L4-5 facet joints bilaterally. Upon review of the patient's imaging for treatment planning purposes, a transitional lumbosacral vertebra was noted, with a unilaterally prominent transverse process and diarthrodial joint with the sacrum (Castellvi type IIa). The L5-S1 joints bilaterally were hypoplastic and without significant degenerative changes. In contrast, the L3-4 and L4-5 facet joints were noted to be hypertrophic and edematous, suggestive of excessive joint stresses and correlating with the clinical findings. Per report, the patient experienced improvement in back pain after the procedure.

Results
Left: Sagittal STIR of the midline lumbar spine shows increased signal within the L3-4 and L4-5 intervertebral discs (blue arrows), consistent with edema and raising suspicion for hypermobility at these levels. Top right: Axial T1 at the level of L5 shows an enlarged right transverse process (orange outline) and pseudoarticulation with the sacrum (green outline). Both L5-S1 joints (yellow arrows) are hypoplastic. Bottom right: RPO fluoroscopic image shows pseudoarticulation between an enlarged right L5 transverse process (orange outline) and sacrum. A spinal needle is positioned within the right L4-5 facet joint (red arrow), which is notably hypertrophic as compared to the ipsilateral L5-S1 facet joint (yellow arrow).

Conclusions
Although TLSVs are prevalent and readily recognizable on imaging, they remain an under-appreciated cause for low back pain. Furthermore, appropriate identification and characterization is important for predicting pain generators and guiding treatment. We use our institution's experience to highlight this entity and its implications.
National Trends in Lumbar Punctures from 2010-2018: A Reversing Shift from the ED to the Hospital Setting for Radiologists and Non-Physicians

A Gandhi¹, A Karambelkar¹, A Flanders¹
¹Thomas Jefferson University Hospital, Philadelphia, PA

Purpose
The purpose of this study is to analyze national trends in lumbar punctures (LPs) among the Medicare population from 2010-2018.

Materials and Methods
Medicare Part B Physician/Supplier Procedure Summary master files from 2010-2018 were analyzed for all Current Procedural Terminology, version 4 (CPT-4) codes related to lumbar punctures (62270 and 62272). Lumbar puncture procedure volume and utilization rate were assessed and stratified by place of service and specialty background of the providers.

Results
From 2010 to 2018, the overall number of lumbar puncture procedures essentially has not changed (92,579 vs 92,533), with a slight decrease in diagnostic LPs (86,347 vs 85,665) and an increase in therapeutic LPs (6,232 vs 6,868). However, the procedure rate has decreased by 9% when accounting for the growing Medicare fee-for-service population (2.62 vs 2.39 per 1,000 enrollees). The inpatient hospital setting remains the largest place of service for LPs (42,685 vs 47,533: 11%) with a 5% increase in procedure share since 2010. As a reversal to earlier decade trends, the emergency department LP procedure volume has dramatically decreased (24,519 vs 17,701: -28%) with a 7% decrease in overall procedure share. Similarly, the outpatient hospital department (HOPD) procedure volume has increased (18,200 vs 21,889: 20%) while the private office volume has decreased (6,287 vs 4,672: -26%). Radiologists hold the largest and increasing procedure share of diagnostic and overall LPs (overall share 46% vs 53%). Non-physician providers' (physician assistants and nurse practitioners) have increased procedure share (4% vs 8%) with a 130% increase in procedure volume, particularly in the HOPD and inpatient setting. Emergency medicine physicians and neurologists have a decreasing procedure share (22% vs 15% and 13% vs 9%, respectively).

Conclusions
Over the past decade, LP procedures among the Medicare population have remained stable with a shift in procedure volume from the emergency department and private offices to the hospital setting. This shift has largely affected radiologists and non-physician providers, which further consolidates their role in patient care.

Reducing Reoperation After Interspinous Spacers with Spinoplasty – a 9-year Cohort Study

I Gil¹, A De Vivo², H Alqatami³, G D'Anna⁴, L Manfrè²
Purpose
Lumbar spinal canal stenosis and lumbar spinal foraminal stenosis are common, degenerative pathologies which can result in neurogenic claudication and negatively impact function and quality of life. When conservative measures fail the traditional surgical treatment has been lumbar decompression with or without a fusion. Percutaneous interspinous devices (PID) are a recently-developed, minimally-invasive, alternative treatment option. This study details a 9-year single-centre experience with PIDs and examines the complementary use of spinous process augmentation (spinoplasty) to reduce failure rates.

Materials and Methods
A retrospective cohort assessment of 800 consecutive patients who presented to a specialized spine hospital was performed with 688 receiving treatment. 256 had a PID alone while 432 had concurrent polymethyl methacrylate (PMMA) augmentation of the adjacent spinous processes. The patients were followed up at 3 and 12 months.

Results
Both groups showed marked improvement in the patients Zurich Claudication Questionnaire scores (3.2 to 1.3) and Oswestry Disability Indices (32 to 22), with strong satisfaction results (1.7). The symptom recurrence rate for the group which received concurrent spinous process augmentation was reduced when compared with the PID alone cohort. (<1% vs. 11.3%)

Conclusions
This study demonstrates the efficacy of percutaneous interspinous devices in treating lumbar spinal stenosis. It also provides evidence that concurrent spinous process augmentation reduces the rate of symptom recurrence.

EBM Programming: Unruptured Aneurysms: To Treat or Follow
2074 6:10PM - 6:15PM
Flow Diversion of Anterior Circulation Aneurysms using p64: Occlusion Rate, Procedural Morbidity and Mortality
p Bhogal1
1The Royal London Hospital, London, London

Purpose
To present the findings on the use of the p64 flow diverter, a device with 64 braided nitinol wires. This is the largest series on the use of the p64.

Materials and Methods
A retrospective review of individual patient data from a single centre between 2012 and 2019 to identify all patients treated with the p64 flow diverter (n=614) with anterior circulation, saccular aneurysms that were unruptured or beyond 30 days after SAH. Aneurysms previously treated with intrasaccular devices were included but those treated with intraluminal devices were excluded. Fusiform and dissecting aneurysms were excluded.

Results
Overall the occlusion rate at last follow-up was 94%. The overall morbidity was 1.8% and mortality was 0.5%. The results at individual sites e.g. ICA bifurcation, ophthalmic, anterior choroidal etc. will be presented

Conclusions
The p64 provides reliable and robust aneurysm exclusion with a good safety profile. Response testing to anti-platelet agents is mandatory prior to implantation of the p64. Optimal sizing of the device is required and shorter implants expand better hence, where appropriate shorter devices should be used.

2157 6:15PM - 6:20PM
A Shift from Open to Endovascular Repair of Ruptured Middle Cerebral Artery Aneurysms and its Association with Improved 6-month Clinical Outcomes: Single Institution Experience
Y Li1, J Diestro1, J Spears1, W Montanera1, D Sarma1, T Marotta1, A Bharatha1
1St. Michael's Hospital, University of Toronto, Toronto, Ontario

Purpose
Middle cerebral aneurysms were underrepresented in the two largest trials (BRAT and ISAT) for the treatment of ruptured intracranial aneurysms. Recent institutional series addressing the choice between endovascular or open repair for this subset of aneurysms are few and have not yielded a definite conclusion. We compare clinical outcomes of patients presenting with acute subarachnoid hemorrhage from ruptured middle cerebral artery aneurysms undergoing either open or endovascular repair.
Materials and Methods
We conducted a retrospective review of 116 consecutive patients with ruptured middle cerebral artery aneurysms admitted into our institution from March 2009 to March 2017.

Results
Of the ruptured middle cerebral artery aneurysms, 44 underwent endovascular repair while 72 were treated with open surgery. Over the study period there was a notable shift in practice toward more frequent endovascular treatment of ruptured MCA aneurysms (29% in 2009 vs. 67% in 2016). At 6 months, patients who underwent endovascular repair had a higher proportion of patients with good clinical outcomes (mRS 0-2) compared to those undergoing open surgery (78% vs 50.8%; p=0.011). While 4 patients underwent retreatment (9.1%) for aneurysm recurrence in the endovascular group, no retreatment was documented in the surgical group. Two patients from each group (4.5% endovascular repair VS 2.8% open surgery) had rebleeding. There was no cross-over between the two treatment groups.

Conclusions
Our data suggest that endovascular repair is a feasible treatment strategy for acutely ruptured middle cerebral artery aneurysms. In this study, endovascular repair was associated with improved functional outcome at 6 months. The main limitation of this study is its retrospective design and possible selection bias. Future randomized trials for MCA aneurysms could further clarify the complimentary roles of these treatment modalities.

Are additional coils necessary for flow diversion in giant paraophthalmic aneurysms? – A systematic review
H Yu¹, K Faiz², S Ande³, J Linton², Z Kaderali¹, T Krings⁵, J Shankar⁶

(Filename: TCT_2157_ASNRImages.jpg)
Purpose
Flow diversion is an endovascular procedure used in treating intracranial aneurysms. There is limited data regarding the use of flow diverters in treating giant or paraophthalmic aneurysms. It is also unclear whether coiling in combination with flow diversion improves outcomes. The purpose of this systematic review was to evaluate the efficacy of using flow diverters with and without coiling for the treatment of intracranial aneurysms, especially in giant paraophthalmic aneurysms.

Materials and Methods
A comprehensive search in the databases Ovid MEDLINE and Ovid EMBASE was done. Two independent screeners evaluated the studies for patient and aneurysm characteristics, procedural details including success rate and complications, and follow-up imaging and clinical outcomes.

Results
Of the original 289 articles, nine studies were eligible for inclusion within our systematic review. All were observational studies with five retrospective and four prospective. There were 318 patients with 318 aneurysms. Procedure-related mortality rate was 3.5% (11/318). Six months occlusion rate was 79.7% (149/187) 83.3% (5/6) for giant aneurysms, and 100% (8/8) for paraophthalmic aneurysms. There was no significant difference in occlusion rate in FD alone vs. FD with coils (p = 0.299) at six months. There also did not seem to be a difference in morbidity, mortality, or clinical outcomes between FD alone and FD with coils. Limitations included the small number of studies, the heterogeneous study populations and types of aneurysm treated, and the significant heterogeneity in reporting outcomes and follow-up data.

Conclusions
Flow diverters alone are an effective way to treat giant and paraophthalmic aneurysms. The use of FD with coils was not shown to be superior to the use of FD alone.

Scientific Abstract Session: Brain Stroke

1071
5:05PM - 5:11PM

The value of arterial spin-labeling MRI in collateral evaluation of carotid occlusive disease ; correlation study with acetazolamide-stress SPECT

H Kang¹, Y Kim¹
¹Seoul Veterans Hospital, Seoul, Korea, Republic of

Purpose
We investigated the relationship between the level of collateral circulation on arterial spin-labeling (ASL) magnetic resonance imaging (MRI) and cerebrovascular reserve (CVR) on acetazolamide (ACZ)-stress single photon emission computed tomography (SPECT) brain scans in internal carotid artery (ICA) stenosis.

Materials and Methods
This study enrolled 129 patients with severe ICA stenosis (>70%). Collateral circulation was assessed in pulsed ASL images based on the presence of arterial transit artifact (ATA) that late-arriving flow appears as serpiginous high ASL signal within cortical vessels. All patients underwent SPECT imagings with Tc-99m-ECD in the resting and after ACZ challenge. CVR based on rest-SPECT and ACZ-stress SPECT was calculated. The ASL CBF maps were independently assessed by two neuroradiologists blinded to clinical information. The two neuroradiologists graded on two slices of images corresponding to Alberta Stroke Program Early Computed Tomography Score (ASPECTS) location using a 4-point scale for ASL intensity (0, no or minimal ASL signal; 1, moderate ASL signal with ATA; 2, high ASL signal with ATA; and 3, normal perfusion without ATA). The patients were divided into subgroups as either showing or not showing evidence of decreased CVR according to the ACZ-stress SPECT findings.

Results
With ACZ-stress SPECT, the 88/129 (68%) patients showed normal CVR and 41/129 (32%) patients showed decreased CVR. In 73/88 (82%) of the normal CVR group patients, ASL showed ATA in ipsilateral to the stenosis. In 19/41 (46%) of the decreased CVR group patients, ASL showed no evidence of ATA in ipsilateral to the stenosis. Significant positive relationship was observed between the normal CVR group and the ATA showing group in ICA stenosis patients (p = 0.001, chi-square test). The ASL-based ASPECTS scores of brain in the ipsilateral side was lower than the scores in the contralateral side to the ICA stenosis (p < 0.0001, Wilcoxon signed rank test). The ASL-based ASPECTS scores of brain ipsilateral side to the ICA stenosis was lower in the reduced CVR group than normal CVR group (p = 0.005).

Conclusions
This study demonstrated the statistically significant positive correlation between good collaterals on ASL MRI and intact CVR in patients with ICA stenosis.
Table 1. Comparison of ASL-based ASPECTS scores between the normal CVR group and reduced CVR group.

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<th>Normal CVR group (n = 88)</th>
<th>Reduced CVR group (n = 41)</th>
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<tr>
<td>ASL-based ASPECTS score;</td>
<td>23.5 ± 5.0</td>
<td>20.8 ± 6.4</td>
<td>0.005</td>
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<tr>
<td>ipsilateral side to the ICA</td>
<td>(mean ± SD, range)</td>
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<td>stenosis</td>
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<td>ASL-based ASPECTS score;</td>
<td>29.5 ± 0.6</td>
<td>29.5 ± 2.0</td>
<td>0.694</td>
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<td>contralateral side to the ICA</td>
<td>(mean ± SD, range)</td>
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Mann-Whitney U test (p < 0.05)

Table 2. Comparison of ASL-based ASPECTS scores between the normal CVR group and reduced CVR group.

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Mann-Whitney U test (p < 0.05)

Figure 1. 70-year-old male, severe stenosis of the right proximal cervical ICA.

Multiple serpiginous high intensity (red) structures were seen in the right frontotemporal area on pulsed ASL with right proximal cervical ICA stenosis patient, and on acetazolamide stress SPECT image, there was no vascular reserve change in the right frontotemporal area (Fig. 1).

Figure 2. 64-year-old male, occlusion of the left ICA.

No ATA in the left frontotemporal area were seen on pulsed ASL with left ICA occlusion patient, and on acetazolamide stress SPECT image, there was reduced vascular reserve change in the left frontotemporal area (Fig. 2).
Resting-State Functional Magnetic Resonance Imaging in Predicting Long-Term Outcome After Acute Ischemic Stroke

J. Puig1, E Camacho-Ramos2, A Jimenez-Pastor2, C Biarnes3, A Alberich-Bayarri2, M Essig4, K Nael5, C Leiva Salinas6, M Wintermark7, M Terceho8, Y Silva9, J Serena10, S Pedraza11
1IDI-IDIBGI, Girona, Spain, 2QUIBIM, Valencia, Valencia, 3IDI-IDIBGI, Girona, Girona, 4University of Manitoba, Winnipeg, Manitoba, 5Icahn School of Medicine at Mount Sinai Hospital, New York, NY, 6University of Missouri, Los Angeles, CA, 7Stanford, San Carlos, CA, 8Stroke Unit, Hospital Universitari Dr Josep Trueta, IDIBGI, Girona, Girona

Purpose
Stroke is one of the main causes of disability in adults. Resting-state functional magnetic resonance imaging (rs-fMRI) is able to map functional-anatomic networks by analyzing spontaneously correlated low-frequency activity fluctuations across the brain. However, the role of rs-fMRI to predict functional outcome after acute stroke remains unclear. We aimed to evaluate the impact of rs-fMRI at 72h after stroke symptoms onset to predict the functional outcome at 1-year follow-up.

Materials and Methods
Thirty-five reperfused stroke patients (12 female, age: 68±14 years, 3-day National Institutes of Health Stroke Scale (NIHSS) score: 6±5) were consecutively scanned 72 hours after symptom onset. Modified Rankin Scale (mRS) was used to evaluate functional outcome at 90 days (patients with good functional outcome, mRS ≤2; poor outcome, mRS>2). Image pre-processing included motion and slice-timing correction, outliers' detection, brain tissue segmentation, MNI space normalization, smoothing and band-pass filtering to remove undesired components. Region-of-interest analyses were performed to calculate the correlation coefficients for every pairwise region and a weighted General Linear Model was used to discover significative differences (p < 0.05 FWE) between groups.

Results
Patients with good outcome had higher intrahemispheric and interhemispheric connectivity at 72 h after symptoms onset (Figure). However, the NIHSS score at 72 h score was the most relevant predictor of functional outcome at 1 year follow-up. Discrimant models provided an accuracy of 74.3% using only NIHSS scores. Adding functional connectivity networks increased accuracy to 97.1% and 100% with clinical and imaging variables.

Conclusions
These results show the relevance of rs-fMRI in acute phase to predict long-term functional outcome in stroke patients.

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Outcomes after Thrombectomy for Minor Stroke: A Meta-Analysis

A. Malhotra1, X Wu2, Y Wang3, C Zhu4, C Matouk5, D Gandhi5, P Sanelli6

(Filename: TCT_2591_OutcomesafterThrombectomyforMinorStrokeAMetaAnalysis.JPG)
Purpose
The utility of mechanical thrombectomy (MT) in patients with acute, minor ischemic stroke due to large vessel occlusion (LVO) remains uncertain. The purpose of this study is to determine the outcomes after MT versus medical management in patients with minor stroke symptomatology.

Materials and Methods
A systematic review and meta-analysis were performed for studies reporting outcomes after mechanical thrombectomy, either as stand-alone therapy or with intravenous thrombolysis (IVT) in patients with minor stroke with LVO. Quality of the included studies was assessed.

Results
Nine studies with 1,230 patients met the selection criteria and were included. Two studies compared immediate thrombectomy versus BMM (and rescue thrombectomy) and the ORs of excellent outcomes, mortality and incidence of sICH after IMT vs BMM were 1.07 (95% CI: 0.93 – 1.22%), 0.65 (95% CI 0.30 – 1.38), and 2.89 (95% CI: 0.82 – 10.13) respectively. Among the 3 studies that compared mechanical thrombectomy outcomes versus medical management, OR of excellent outcomes after MT vs MM was 0.97 (95% CI: 0.82 – 1.16), although in 2 out of the 3 studies, the proportion of excellent outcome was equivalent or more in the MT group. The pooled proportion of excellent outcome after thrombectomy was 56.9% in the fixed-effects model, and 55.8% by in the random-effects model, with the lowest at 39.4% and highest at 65.9%. The pooled proportion of good outcome after thrombectomy was 71.7% in the fixed-effects model, and 72.8% by the random-effects model. The lowest proportion was 57.5% and the highest was 93.3%. The pooled risk of mortality after thrombectomy was 8.12% in fixed-effects model and 7.34% in the random-effects model, with the lowest at 0%, and highest at 13.1%. The pooled incidence of sICH was 5.66% by fixed-effects model and 5.20% by random-effects model, with the lowest at 1.18% and 11.8%.

Conclusions
Our study shows significant selection bias and heterogeneity in the literature assessing outcomes after thrombectomy in minor stroke patients, emphasizing the need for a randomized controlled trial. MT results were better in patients who were younger, had greater NIHSS values at presentation (NIHSS 4 or 5 relative to 0-2) and more MCA-M1 and less M2 occlusions.
Can CTA differentiate free-floating thrombus in the internal carotid artery from atherosclerotic plaque in patients evaluated for stroke or transient ischemic attack? A Canadian Multi-centre Study

P Puac Polanco1, D Dowlatshahi1, R Lun1, M Shamy1, G Stotts1, A Bharatha2, B Menon3, C Torres1
1University of Ottawa, Ottawa, ON, 2St Michael's Hospital, Toronto, Ontario, 3University of Calgary, Calgary, Alberta

Purpose
Carotid free-floating thrombus (FFT) is at high risk for distal embolization and recurrent stroke. FFT is visualized on CTA as an intraluminal filling defect at the origin of the internal carotid artery (ICA). While this finding is suspicious for FFT, it can also represent stable mimics such as ulcerated carotid plaque. To date, there is no proven diagnostic definition for FFT nor any rule to differentiate it from its mimics. Our group has previously derived a cranial-caudal length threshold of 3.8 mm to diagnose FFT using CTA with a sensitivity/specificity of 88/86%, respectively. Our primary objective was to prospectively validate this threshold to distinguish FFT from stable ulcerated plaque. The secondary objective was to estimate the prevalence of FFT among patients with ambiguous diagnosis.

Materials and Methods
This is a prospective multicentre observational study. Consecutive patients presenting with TIA/stroke within 72 hours of symptom onset with an ICA intraluminal filling defect on CTA were recruited. Patients underwent a follow-up CTA one week later and repeated CTAs at weeks 2 & 4 if the intraluminal filling defect was unchanged in length. The cranial-caudal length of the filling defect was measured at each time interval, blinded to previous measurements. Resolution or decreased of the filling defect at any point was diagnostic of FFT; those that remained unchanged were classified as ulcerated plaques.

Results
A total of 99 consecutive patients with intraluminal filling defects on CTA were identified. True FFTs were present in 84 patients (84.4%) and ulcerated plaques in 15 (15.2%). FFTs had a larger cranio-caudal length than ulcerated plaques: 8.8 mm (1.7-42.7) versus 4 mm (1.4-7.7) (95% CI 1.09-8.65, p=0.012). The threshold of >3.8 mm had a sensitivity of 90%, specificity 50%, positive predictive value 90%, negative predictive value 50% to distinguish FFT from ulcerated plaque. Finger length predicts true FFT with an odds ratio (OR) of 1.72 for every 1 mm of finger length ([95% CI] 1.17-2.52; p=0.005).

Conclusions
Our previously validated threshold (>3.8 mm) to distinguish FFT from ulcerated plaque demonstrated a sensitivity/specificity of 90%/50%, respectively. Finger length predicts true FFT with an OR of 1.72 for every 1 mm increase of finger length.
Low Dose, Low kV Cerebral Computed Tomographic Angiography (CTA) Using Third Generation Reconstruction Algorithm: Feasibility and Image Quality

G Bathla¹, S Priya², N Soni², C Derdeyn³
¹Univ. Of Iowa Hospitals & Clinics, Iowa City, IA, ²University of Iowa hospitals and Clinics, IOWA CITY, IA, ³University of Iowa, St. Louis, MO

Purpose
We aimed to determine if cerebral CT Angiogram performed using third generation reconstruction algorithm and lower contrast dose-low kVp technique (LD-CTA) was comparable to regular contrast dose CTA at 120 kVp using a sinogram affirmed iterative reconstruction algorithm (ND-CTA).

Materials and Methods
Retrospective imaging review of 100 consecutive patients (50 each in LD- and ND-CTA groups). Two readers independently assessed the subjective image quality across multiple vascular segments on a Likert-like scale. Differences in contrast dose, CT-dose index (CTDI) and dose length product (DLP) were compared using Mann-Whitney U test. Fisher's exact test was used to compare subjective image quality. Similarly, contrast- and signal-to-noise ratios (CNR/ SNR) were compared for the mid-M1-MCA vessels bilaterally and the mid-basilar artery using Mann-Whitney U test. Interclass correlation coefficient (ICC) was calculated for the SNR/CNR values.

Results
Both observers showed excellent correlation in subjective image quality (mean percentage agreement of 95.2% for group-1 versus 89.2% for group-2). LD-CTA group showed better SNR and CNR (p < 0.0001) for both MCA vessels and the basilar artery. ICC showed moderate correlation (0.51-0.63) between readers. LD-CTA group also used lower contrast (49 cc versus 97 cc in ND-CTA) and had lower radiation exposure (DLP/ CTDI for both groups 268.3/80.7 vs 519.5/ 36.08, both < 0.0001).

Conclusions
Next-generation reconstruction algorithm and low-Kv scanning significantly improved image quality on cerebral CTA images despite lower contrast dose, and in addition, have lower radiation exposure.

Virtual Non-Contrast Dual-Energy CT Reconstructions More Accurately Estimate Core Infarct Volume Over Conventional Non-Contrast CT

D Wolman¹, F van Ommen¹, E TONG², F Kauw¹, L Molvin¹, M Wintermark¹, J Heit⁴
¹Stanford University Hospital, Stanford, CA, ²STANFORD UNIVERSITY, STANFORD, CA, ³Stanford, San Carlos, CA, ⁴Stanford University, Stanford, CA
Purpose
Non-contrast dual-energy CT (DECT) reconstructions may detect acute cerebral infarction with increased sensitivity compared to standard non-contrast CT (NCCT) [1,2]. We determined if baseline virtual non-contrast (VNC) DECT was superior to NCCT in core infarct estimation in acute ischemic stroke (AIS) patients presenting with large-vessel occlusion (LVO).

Materials and Methods
We included consecutive AIS patients with LVO who underwent non-contrast DECT, CT angiography and perfusion, and follow-up MRI with DWI over one year at our neurovascular referral center. Core infarct volumes were manually segmented from VNC, NCCT, and DWI acquisitions, and automatically derived from CTP and DWI using RAPID postprocessing software. Three blinded neuroradiologists independently reviewed all imaging for core infarct agreement and provided an Alberta Stroke Program Early CT Score (ASPECTS) for both VNC and NCCT, which were compared against a consensus DWI-ASPECTS using the Wilcoxon signed rank test. Pairwise comparisons of pre-treatment NCCT and VNC core volumes to final DWI core volumes were performed in patients with either no perfusion mismatch on baseline imaging or patients with near complete reperfusion after thrombectomy. Volumes were compared using the Mann-Whitney U test. Volume agreement was expressed as manually segmented CT volume divided by the DWI volume. Interobserver reliability was assessed with Fless' κ test and the intraclass correlation coefficient (ICC).

Results
Twenty-nine patients (mean age 63.6±15.4 years, 45% female) met inclusion criteria. Presentation NIHSS was 14 (IQR 6.8-20). LVO involved the ICA (28%) and M1 MCA segment (41%). Mean time from last seen normal to CT was 13.3±15.5 hrs. VNC better approximated final DWI volume compared to NCCT volume (0.53±0.53 vs. 0.27±0.32; P<0.001). Core infarct volume was similar between VNC and DWI (P=0.19) but differed between NCCT and DWI (P=0.01). VNC- and NCCT-ASPECTS differed significantly (P<0.001), with greater VNC accuracy than NCCT compared to MRI (71% vs 65%). VNC was more sensitive (49-65% vs 32-46%) but less specific (85-89% vs 92-93%) for core infarct detection than NCCT. Interobserver reliability for ASPECTS was greater for VNC (κ=0.23; ICC=0.64) than for NCCT (κ=0.17; ICC=0.62).

Conclusions
DECT VNC reconstructions may more sensitively and accurately detect core infarction compared to NCCT in patients with AIS due to LVO.
Prediction of Malignant Posterior Circulation Strokes Using CT based Quantitative Lesion Water Uptake

S Elsayed1, G BROOCKS2, H KNIEß3, P Sporns4, T Lindner5, J Fiehler5, U HANNING5
1University Medical Center Hamburg-Eppendorf, Hamburg, Germany, 2UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, 3UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, Germany, 4Muenster University Hospital, Muenster, North Rhine-Westphalia, 5N/A, N/A, 6University Medical Center Hamburg-Eppendorf, Hamburg, AK

Purpose
In ischemic strokes involving the posterior circulation, malignant cerebellar edema (MCE) is a life-threatening complication that requires timely diagnosis and management. Yet, there is no established imaging biomarker available that may serve as predictor of MCE. Early edematous water uptake can be determined using quantitative lesion net water uptake (NWU), but this biomarker has only been applied in anterior circulation strokes. We hypothesized that NWU in early posterior circulation stroke lesions predicts MCE with poor clinical outcome.

Materials and Methods
179 patients with acute vessel occlusion in the posterior circulation (excluding isolated posterior cerebral artery) and multimodal CT imaging at admission were included. 35 (19.5%) patients developed MCE defined by using an established 10-point scale in FUCT, of which ≥ 4 are considered malignant. NWU was quantified in admission CT and FUCT based on CT-densitometry and compared with posterior circulation Alberta Stroke Program Early CT Score (pc-ASPECTS) as predictor of MCE using univariable receiver operating curve (ROC) analysis and multivariable logistic regression analysis.

Results
The mean pc-ASPECTS score at admission was 6.4 (SD ± 3.25) for malignant and 8.7 (± 1.7) for non-malignant infarctions (p<0.0001). Edematous tissue expansion by NWU within the early infarct lesion was 24.6% (± 8.4) for malignant and 7.2% (± 7.4) for non-malignant infarctions, respectively (p<0.0001). Based on ROC analysis, NWU above 14.9% identified MCE with high discriminative power (AUC: 0.94, 95%CI: 0.89-0.97) and was superior to pc-ASPECTS (AUC: 0.81, 95%CI: 0.75-0.87). In multivariable logistic regression analysis, early NWU (odds ratio [OR]: 1.28; 95%CI: 1.15-1.42, p<0.0001) and pc-ASPECTS (OR: 0.71, 95%CI: 0.53-0.95, p=0.02) were significantly associated with MCE adjusted for age and recanalization status.

Conclusions
Quantitative NWU in early posterior circulation strokes is an important surrogate marker for developing MCE. Besides pc-ASPECTS, the measurement of lesion water uptake may further support identifying patients at risk for MCE at an early stage indicating stricter monitoring and consideration for decompressive surgery.
Automated Cerebral Attenuation Measurement on CT Angiography for Ischemia Detection and Outcome Prediction in Patients with Ischemic Stroke

W Kunz
LMU Munich, Munich, Bavaria

Purpose
Stroke triage using CT perfusion (CTP) or MRI gained importance after successful application in recent trials on late time window thrombectomy or intravenous thrombolysis. Surrogate parameters are required to facilitate triage as advanced imaging is not widely available and time-consuming. CT angiography (CTA) source images may contain data that reflect properties in CTP. We tested the clinical value of software-based analysis of cerebral attenuation on CTA in stroke patients.

Materials and Methods
In a retrospective analysis we used software-based automated segmentation and Hounsfield unit (HU) measurements for all regions of the Alberta Stroke Program Early CT Score (ASPECTS) on CTA source images in patients with large vessel occlusion stroke. To normalize values, we calculated the relative HU (rHU) as ratio of affected to unaffected hemisphere. Ischemic tissue on cerebral blood flow maps, the regional ischemic core and final infarction were determined on simultaneously acquired CTP data and follow-up imaging as ground truth. Receiver operating characteristics analysis was performed to calculate the area-under-the-curve (AUC) to analyze classification performance.

Results
Seventy-nine patients were included in the analysis. ASPECTS regions were correctly identified and automated attenuation measurements feasible in all cases (Figure 1, left without and right with segmentation). rHU values enabled significant classification of ischemic involvement on CTP in all ten ASPECTS regions with AUC values from 0.72 to 0.99 (each p<0.001, except M4-cortex p=0.002). Classification of ischemic core resulted in lower AUC values (0.55 to 0.87), however still providing significant
classification for all regions except M3- and M5-cortex. Final infarction was predicted with AUC values between 0.65 and 0.85 with significant results in all regions except M3- and M5-cortex.

Conclusions
Automated attenuation measurements on CTA provide excellent performance in detecting acute ischemia as identified using CTP and allow morphologic outcome prediction in large vessel occlusion stroke. This technique has the potential to facilitate and accelerate stroke imaging triage and serve as surrogate of CTP.

Safety and Efficacy of Mechanical Thrombectomy for the Treatment of Tandem Basilar Artery Occlusion: a Case-Control Study.

M ELHORANY1, E Shotar1, K Premat1, A Elhfnawy1, O Mansour2, E Tag El-din3, W Ahmed3, F Clarençon1
1Pitie Salpetriere Hospital, Paris, Paris, 2Alexandria University, Alexandria, Alexandria, 3Tanta University, Tanta, Tanta

Purpose
Tandem basilar artery occlusions (tBAO) are defined as basilar artery (BA) occlusion associated with extracranial dominant vertebral artery (VA) occlusion. The prognosis of such tBAO treated by mechanical thrombectomy (MT) has been scantily reported. The purpose of our study was to compare the safety and effectiveness of mechanical thrombectomy for patients with tBAO compared to those with non-tandem basilar artery occlusions (ntBAO).

Materials and Methods
Retrospective analysis of a prospective database at 2 academic centers (Pitie-Salpetriere and Sainte-Anne University Hospitals, Paris, France). Seventeen tBAO patients who underwent MT were enrolled and paired with 34 patients with ntBAO based on National Institute of Health Stroke Scale (NIHSS) at admission, prethrombectomy Diffusion weighted imaging posterior circulation Alberta stroke program early CT score (DWI-pc-ASPECTS) and age as pairing baseline covariates. tBAOs was defined as an acute occlusion of the extracranial dominant VA with concomitant BAO. Patients with occlusions at intracranial portion of the VA's V4 segment, and those with occlusion of non-dominant VA were not considered to be tBAO.

Results
Mean age was 60.8±11.1 years versus 60.6±15.8 years (p=0.96), median NIHSS at admission was 20 (IQR, 10-40) versus 27 (IQR, 11-36; p=0.91) and median prethrombectomy DWI-pc-ASPECTS was 5 (IQR, 3-6) versus 6 (IQR, 4-7; p=0.13) in the tBAO and ntBAO groups, respectively. Successful reperfusion (modified Thrombolysis In Cerebral Infarction score ≥ 2b) was obtained in 65% tBAO versus 71% ntBAO (p=0.75) cases, respectively. Good clinical outcome (modified Rankin Scale score of 0–2 at 3 months) was reached by 23% tBAO patients versus 29% ntBAO patients (p=0.74). Mortality at 3 months was 47% in tBAO group versus 26% ntBAO group (p=0.2). The rate of symptomatic intracranial haemorrhage (SICH) was 12% in tBAO group versus 6% the ntBAO group (p=0.59). The time metrics defined as delays from symptoms' onset to imaging, from symptoms' onset to arterial puncture, from arterial puncture to successful reperfusion did not differ significantly between both groups despite a more complicated treatment of the tBAO group.
Conclusions
In patients with tBAO, mechanical thrombectomy achieves similar rate of successful recanalization, and 3 months clinical outcomes are comparable to patients with ntBAO. The tBAO may not be a good argument to deny MT.

**Scientific Abstract Session: Brain Vascular**

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Epideimiological Measures and Angiographic Features of Unruptured and Ruptured Cerebral Aneurysms in Mongolia

M BECHSTEIN1, T Gansukh2, A Gansukh2, B Regzengombo3, O Byambajav3, G BROOCKS4, U HANNING5, J Fiehler6

1UNIVERSITY MEDICAL CENTER HAMBURG - EPPENDORF UKE, HAMBURG, 20246, HAMBURG, 2Mongolian Academy of Sciences, Oyun Onosh Medical Center, Ulaanbaatar, Mongolia, 3Mongolian Academy of Sciences, Shastin Central Hospital, Ulaanbaatar, Mongolia, 4UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, 5UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, Germany, 6University Medical Center Hamburg-Eppendorf, Hamburg, AK

Purpose
The frequency of cerebral aneurysms differs significantly among ethnicities. Nevertheless, our knowledge about incidence rates of intracranial aneurysm rupture in developing countries is very limited and lack precise estimation (1). Subarachnoid hemorrhage frequently leads to persistent neurological impairment, need for long-term care or death and hence constitutes a major socioeconomic burden, particularly in low-income countries. Epidemiological measures about disease frequency and the identification of potential geo-environmental risk factors in these countries are necessary in order to tailor local neurovascular health service infrastructure. This is the first study to measure the incidence rate of ruptured cerebral aneurysms with subsequent intracranial bleed leading to hospitalization in the Asian country of Mongolia.

Materials and Methods
A retrospective single-center analysis of all intracranial digital subtraction angiographies (DSA) acquired because of acute onset neurological symptoms (paresis, cephalgia, impaired consciousness) during the two years period 2016 to 2017 (n=1714) was performed. The hospital in which the study took place is the only one in the country with intracranial DSA availability and serves as single medical facility for neurological emergencies in a country with a total population of 3.1 million. DSA is used as the primary imaging modality. Numbers and locations of incidental and ruptured aneurysms were determined. Population figures for Mongolia valid in the year of 2017 served as basis for the calculation of annual incidence rates.

Results
Intracranial aneurysms were identified in 694 individuals (40.4%) of the two years patient cohort. The ratio of unruptured to ruptured aneurysms was 276 (39.7%) to 418 (60.3%). This corresponds to an incidence rate of 6.78 ruptured aneurysms per 100.000 persons/year in Mongolia. This is in line with a recent estimation of the global incidence rate of aneurysmal cerebral bleed of 6.67 per 100.000 persons/year1. Aneurysms were most frequently located in the anterior circulation with the anterior communicating artery and M2 branch of the MCA at the highest probability of rupture (Figure).

Conclusions
Disease management of over 200 individuals/year with aneurysmal cerebral bleed constitutes a considerable socioeconomic burden on the low-income country of Mongolia. Based on this data increased efforts to improve the nationwide availability of neurovascular treatment options are justified.
Comparison of Anterior Cerebral Artery Asymmetry Frequency Between Older Adult and Pediatric Patient Populations

M Lach¹, J Bullen¹, T Emch¹, D Moon¹, S Jones¹, D Lockwood¹

¹Cleveland Clinic, Cleveland, OH

Purpose
Asymmetry of A1 segments of the anterior cerebral artery (ACA) has long been considered a congenital or developmental variant, with Circle of Willis (COW) anatomy established at birth. Based on clinical experience, we hypothesized that there was a much higher rate of asymmetry in A1 segments in older adult patients compared to pediatric patients. A difference in frequency between ages could have broad and significant implications, suggesting changes in COW anatomy in some patients over time rather than static COW anatomy. This new understanding of vascular development could potentially affect our understanding of cerebrovascular disease.

Materials and Methods
311 magnetic resonance angiogram (MRA) examinations performed for headache at our institution were enrolled. 159 MRAs of patients 18 years old and younger and 152 MRAs of patients 65 years old and older were included. Examinations were retrospectively evaluated by two experienced neuroradiologists for significant A1 symmetry based on subjective criteria of estimated 50% difference between the two vessels. Discordant A1 evaluations were resolved by consensus with measurement of vessel diameter on source images requiring 50% difference between A1 segments. Pearson's chi-squared test was used to assess the difference in the frequency of asymmetric A1 ACA segments among the older and younger patients.

Results
The frequency of asymmetric A1 ACA segments was higher among patients age 65 and older (60/152 = 39%) compared to patients age 18 and younger (28/159 = 18%) (95% CI for the difference: 11%, 32%; p-value < 0.001).

Conclusions
Our study demonstrates a statistically significant difference in the frequency of A1 asymmetry between younger and older populations. This is a significant departure from traditional understanding of the Circle of Willis anatomy as static. Changeable rather than static vascular anatomy could potentially lead to new ways of approaching and treating cerebrovascular disease and a new way of viewing vascular development. Authors have previously associated hypoplastic A1 segments with differences in cerebrovascular disease presentations. This includes specific stroke syndromes, differences in aneurysm morphology, and differences in outcomes after aneurysm treatment. We included only studies performed for the indication of headache to try to eliminate bias between our study populations. Nevertheless, it is possible that the results were affected by bias. Further study is needed.
Purpose
MRI-based high resolution vessel-wall imaging (VWI) has shown promise in identifying high risk aneurysms (1,2). In this study we aimed to identify whether VWI can predict and identify unstable from stable aneurysms in a cohort of patients with unruptured intracranial aneurysm (UIA).

Materials and Methods
In this prospective study patients with known UIA underwent annual 3T MRI using VWI and MRA since July 2016. VWI sequence included a 3D T1-weighted fast-spin-echo sequence (CUBE; on a MR 750, GE Healthcare) or a 3D variable refocusing flip angle acquisition with inherent black-blood effect (SPACE, on a Magnetom Skyra; Siemens Healthineers). Sequence parameters (identical between two vendors) were as follows: field of view, 220 mm; TR/TE: 500/20 ms; Matrix: 288 mm2; 180 slice x 0.9 mm thick; voxel: 0.8 x 0.8 x 0.9 mm3 and parallel acceleration with acceleration factor of 2 was applied along the phase-encoding direction. VWI was obtained before and after intravenous administration of 0.05 mmol/kg of gadolinium chelate (10 mL gadobenate dimeglumine, Multihance, Bracco, Milan, Italy). Unstable aneurysms were defined by change in size, aspect-ratio, morphology or when new relevant symptoms were developed. Using VWI each aneurysm was evaluated by using a 3-grade score: 0: none; 1: partial; 2: circumferential. The association of IA-wall enhancement in addition to a variety of clinical variables and risk factors were assessed between stable vs. unstable IAs using univariate analyses and categorical tests when appropriate.

Results
For this cross sectional analysis we included patients who had at least 2-year follow up since the initial enrollment. A total of 57 patients with 67 IAs were included. Mean (SD) follow up time was 29 (8) months. Patients' demographic, risk factors, and aneurysm size, aspect-ratio, and wall enhancement sores are summarized in the Table. A total of 16/67 aneurysms (24%) had aneurysm wall enhancement at the baseline MRI (partial enhancement 10, circumferential enhancement 6). A total of 9 (17%) out of 52 IAs that remained stable had initial wall enhancement while 7/15 (46%) of unstable IAs had initial wall enhancement (p=0.02). Among IAs with circumferential enhancement, 2 remained stable while 4 determined as unstable.

Conclusions
In patients with UIA, aneurysm wall enhancement detected by VWI can predict instability.

<table>
<thead>
<tr>
<th>Variable</th>
<th>57 patients, 67 IAs</th>
<th>Stable IAs (n=52)</th>
<th>Unstable IAs (n=15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, mean (SD)</td>
<td>58 (12)</td>
<td>59 (11)</td>
<td>56 (15)</td>
<td>0.47</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>13:44</td>
<td>11:32</td>
<td>2:12</td>
<td>0.42</td>
</tr>
<tr>
<td>Family history of IAs (%)</td>
<td>14 (25%)</td>
<td>10 (19%)</td>
<td>4 (27%)</td>
<td>0.78</td>
</tr>
<tr>
<td>Hx of smoking n (%)</td>
<td>27 (47%)</td>
<td>22 (42%)</td>
<td>5 (33%)</td>
<td>0.26</td>
</tr>
<tr>
<td>Hx of HTN n (%)</td>
<td>29 (51%)</td>
<td>20 (38%)</td>
<td>9 (60%)</td>
<td>0.35</td>
</tr>
<tr>
<td>Follow-up time (month), mean (SD)</td>
<td>29 (8)</td>
<td>30 (8)</td>
<td>28 (6)</td>
<td>0.51</td>
</tr>
<tr>
<td>Hx of Migraine n (%)</td>
<td>10 (18%)</td>
<td>7 (13%)</td>
<td>3 (20%)</td>
<td>0.54</td>
</tr>
<tr>
<td>Multiplicity of IAs n (%)</td>
<td>9 (16%)</td>
<td>6 (11%)</td>
<td>3 (20%)</td>
<td>0.38</td>
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<td>Initial aspect-ratio, mean (SD)</td>
<td>1.5 (0.7)</td>
<td>1.5 (0.7)</td>
<td>1.4 (0.7)</td>
<td>0.57</td>
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<tr>
<td>Initial aneurysm size (mm), mean (SD)</td>
<td>3.6 (2.1)</td>
<td>3.3 (1.8)</td>
<td>4.5 (3.0)</td>
<td>0.09</td>
</tr>
<tr>
<td>Initial aneurysm wall enhancement, n (%)</td>
<td>16 (24%)</td>
<td>9 (17%)</td>
<td>7 (46%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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Transitional Ischemic Attack versus Acute Ischemic Stroke: Differential Atherosclerotic Plaque Features in the Culprit Middle Cerebral Artery Stenosis

J Xiao1, M Padrick1, Q Yang2, T Jiang3, S Xia4, F Wu2, Y Guo4, K Schlick1, M Maya1, D Li5, S Song1, Z Fan1
1Cedars Sinai, Los Angeles, CA, 2Beijing Xuanwu Hospital, Beijing, Beijing, 3Beijing Chaoyang Hospital, Beijing, Beijing, 4Tianjin First Central Hospital, Tianjin, Tianjin, 5Cedars Sinai, Los Angeles, CA

Purpose
Intracranial atherosclerosis disease (ICAD) is one of the important causes of acute ischemic stroke (AIS) and transient ischemic attack (TIA). Recent studies have demonstrated the use of high-resolution MR vessel wall imaging (VWI) for assessing ICAD. In patients with AIS secondary to ICAD, several plaque characteristics revealed on VWI have been linked to symptomatic plaques. However, it remains unclear whether such "high-risk" features present in ICAD-induced TIAs.

Materials and Methods
We retrospectively analyzed VWI from 42 TIA patients and 45 AIS patients with ICAD. All patients fulfilled the following criteria: (1) symptoms contralateral to the middle cerebral artery with >30% stenosis; (2) no coexisting stenosis at other major vessels. All scans were obtained on a 3T system (MAGNETOM Prisma or Verio, Siemens). The protocol included routine brain MR imaging, 3D TOF-MRA, pre- and post-contrast VWI. VWI was performed using a recently developed 3D whole-brain VWI sequence3. Plaques
were analyzed with VWI with respect to the stenosis degree, vessel wall irregularity, plaque burden, remodeling index, plaque-wall contrast ratio (CR) and plaque enhancement grade. We compared the two groups using either Welch t-test or Mann-Whitney. Univariable and multivariable logistic regression models were fitted to estimate the odds ratio of AIS.

**Results**

There were no significant differences regarding gender (p=0.236), age (p =0.467), hypertension (p=0.509), diabetes mellitus (p=0.306) and history of smoking (p=0.516), except for hyperlipidemia (p=0.01). In the multivariable analysis, grade 2 enhancement (OR 3.88, 95%CI 1.42-10.57, p=0.006) was a risk factor for AIS, whereas high values of plaque burden (OR 1.54, 95%CI 0.65-3.70, p=0.008) were a risk factor for TIA. When focusing on mild-to-moderate stenoses, high values of CR (OR 5.38, 95%CI 1.39-20.75, p=0.008) were a risk factor for the AIS subgroup (n=28), while high values of plaque burden (OR 2.50, 95%CI 0.61-10.00, p=0.006) remained a risk factor for TIA subgroup (n=21). There was no significant difference in plaque features between TIA (n=21) and AIS (n=17) subgroups with severe stenosis only. Representative TIA and AIS cases are shown in the Figure.

**Conclusions**

Our study reveals differential atherosclerotic plaque features associated with TIA and AIS despite their identical underlying etiologic origin. VWI may provide insights into the risk and management of ICAD, which would be beneficial for both symptomatic and asymptomatic patients.
The main learning objectives are to understand the basic steps to successfully implement a BCTA protocol within a clinical practice and to reflect on most efficient neuroimaging solutions in the management of acute ischemic stroke patients.

Materials and Methods
To reveal contrast opacification delay (COD), interphase ROI-based registration and subtraction (RS) was performed. The resulting volume was filtered (Gaussian thresholding) and overlaid as a color gradient on the early phase volume. Different ROIs and denoising parameters were ranked by 4 blinded readers on 35 BCTAs. A diagnostic performance study was then conducted on 40 BCTAs from patient presenting to our center with acute stroke from January 2018 to March 2019. The cases were balanced by design according to MCA occlusion location ranging from M1 to M4 to no occlusion. RS images were added to paired copies of the 40 BCTAs. Using a digital form, 17 interpreters (radiology and neurology residents, and neuroradiologists) were timed while they completed the reading of the two complementary and randomly allocated series, at least 2 weeks apart.

Results
Calvaria ROI-based registration performed best according to radiologists (p<0.01) and Dice Similarity Coefficient (p<0.05). Gaussian denoising using $\sigma=1.5$ and a 1 HU threshold was most highly ranked (p<0.01). Post-processing time was less than 3 minutes. Visualization of COD using RS increased the sensitivity for MCA occlusion detection (0.82 to 0.90, p=0.002), inter-user agreement for all groups (p<0.01) and level of confidence, but did not significantly reduce interpretation time.

Conclusions
We propose a simplified BCTA protocol and efficient post-processing pipeline to assist with detection of MCA occlusion in acute stroke. RS significantly increased sensitivity and inter-user agreement without affecting interpretation time.
Fig 1. Radiologists blinded to the recalibration ROIs evaluated the recalibration quality of RS (starting from the first row: whole-head volume, whole-head bone volume, calvaria volume, and cochlear bounding box volumes), with the calvaria obtaining the highest rank (A). The post processing sequence used early and late arterial phase CTA to create a subtraction volume (B, third), which was further processed using gaussian denoising and overlaid on the early arterial phase CTA (B, fourth), which corresponded well to DWI on the 24h follow-up MRI (B, fifth). RS successfully revealed COD for all MCA occlusion levels (M1: left, M2: center left, M3: center right, M4: right)(C).

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Purpose
To provide a unique case of a progressively enlarging cerebral cavernous malformation (CM), secondary to abnormal arteriovenous shunting through an associated developmental venous anomaly (DVA).

Materials and Methods
An 82-year-old female with no significant past medical history presented with new onset seizures. Initial workup demonstrated a 1 cm predominately T2 hyperintense lesion centered on the right putamen consistent with a CM, with an associated DVA. The patient was managed conservatively, with yearly outpatient neurosurgery follow up. Three years later, the patient presented to our institution with acute encephalopathy.

Results
The initial MRI demonstrated a 1.0 x 0.7 cm lobulated T2 hyperintense mass associated with chronic blood products (not shown) centered on the right putamen consistent with a CM (Figure A). MRI approximately 3 years later at the time of presentation showed enlargement of the mass and new mass effect (Figure B). T2*-weighted imaging showed extensive susceptibility artifact within and along the margins of the mass, consistent with hemosiderin deposition (not shown). A prominent DVA along the posterior margin of the mass drained via a trunk in the right superior frontal sulcus (Figure C). Contrast-enhanced imaging also demonstrated heterogeneous enhancement of the lesion (not shown). On digital subtraction angiography, a small vascular malformation supplied by the right anterior cerebral artery (Figure D) drained via the DVA trunk, demonstrating unusual arteriovenous shunting of the DVA.

Conclusions
CMs are the second-most common vascular malformations of the brain. They are comprised of clusters of abnormal hyalinized capillaries and are often associated with and drain into DVAs [1]. The association of DVA with CMs is not fully understood. Some proposed mechanisms include de novo CM formation secondary to increased venous pressure in a DVA leading to recurrent microhemorrhages, eventually forming a CM [2]. Abnormal arteriovenous fistulization of the DVA in the presented case would theoretically exacerbate venous hypertension and potentially cause reflux into the CM, contributing to its progressive growth [3]. Our case demonstrates a striking example of a progressively enlarging CM likely due to abnormal hemodynamics and not recurrent hemorrhage, which has not been previously demonstrated in the literature and should not be mistaken for an aggressive neoplasm.
Mathematical Modeling for Cerebral Venous Congestion: Clinical Observations and Mathematical Correlates

A Arun1, R Mittal1, T Vannorsdall1, N Tariq1, A Moghekar1, P Vosler1, N Theodore1, M Luciano2, F Hui3
1Johns Hopkins University, Baltimore, MD. 2Johns Hopkins, Baltimore, MD, 3Johns Hopkins Hospital, Baltimore, MD

Purpose
Cerebral venous pathology remains poorly understood. SVC syndrome is the most dramatic version and is well described [Rice]. Idiopathic intracranial hypertension (IIH) is characterized by elevated intracranial pressures, seen in women of childbearing age [Markey]. Styloidogenenic jugular venous compression syndrome has also recently been described [Zhao]. Prior research into a venous component in multiple sclerosis demonstrated equivocal results, but may explain symptoms relating to stasis and congestion [Dake]. The above conditions relate to impaired cerebral venous drainage and result in venous congestion. 1-D hemodynamic mathematical models accounting for viscoelastic vessel properties can accurately simulate arterial flow and pressure dynamics. Innovative modeling of veins and collateral networks may elucidate failure points in cerebral venous networks. In this study, we seek to identify pathophysiological correlates for clinical observations, using institutional experience to guide venous modeling.

Materials and Methods
30 patients with venous stenosis and intracranial hypertension treated at Johns Hopkins were retrospectively reviewed in an IRB-approved study. Parameters recorded included patient demographics, location of stenosis, pre- and post-treatment venous sinus and internal jugular manometry, and patient symptoms. The stenosis will be translated into 1-D hemodynamic mathematical models, and simulated results compared to manometric data.

Results
27 patients demonstrated stenosis in the venous sinuses, 1 at the C1 level, and 2 at the internal jugular level. Mean pre-treatment gradients across the stenosis were 20.8 mmHg, 5 mmHg, and 3 mmHg, respectively. Post-treatment mean gradients were 2 mmHg for venous sinus stenosis and 1.5 mmHg for jugular stenosis (no treatment yet for the C1-level patient). Symptomatology was notable for near universal reduction in papilledema but variable reduction in headache. Facial fullness was seen exclusively with stenosis at or below the C1 level.

Conclusions
Intracranial hypertension caused by venous stenosis is a complex phenomenon with symptoms relating to venous congestion and stasis. Level-dependent pressure gradient findings suggest distinct series- and parallel-type resistance patterns depending on the level of stenosis, with symptoms and manometry supporting this theory. Development of a mathematical model of intracranial and neck veins can simulate parameters and suggest pathophysiological explanations for correlating clinical observations.

Follow-up MRI for Small Brain Arteriovenous Malformations Treated by Radiosurgery: Is Gadolinium Really Necessary?

O Guillaud1, O Guillaud2, G Kuchinski2, J Pruvo2, L Hacein-Bey3, X LECLERC2
1CHRU LILLE, LILLE, Non, merci, 2Lille University Medical Center, Lille, France, Lille, Other, 3UC Davis School of Medicine, SACRAMENTO, CA

Purpose
Follow-up MRI of brain AVMs (BAVMs) currently relies on contrast-enhanced sequences. Non-contrast techniques including arterial spin labeling (ASL) and TOF may have value in detecting residual nidus after radiosurgical treatment. The aim of this study was to compare non-contrast (ASL and TOF) with contrast-enhanced MRI in radiosurgically treated BAVM patients.

Materials and Methods
Twenty-eight consecutive patients with small brain BAVMs (< 20 mm) treated with radiosurgery were followed with DSA and MRI. MRI techniques used were: (i) post-contrast-images alone (4D contrast-enhanced MRA and post-contrast 3D T1 gradient-recalled echo (GRE), (ii) ASL and TOF images alone and (iii) all MR sequences combined. The studies were independently reviewed by three experienced neuroradiologists who were blinded to the results. The primary endpoint was performance for the detection of residual BAVM using a 5-point scale, with DSA as the reference standard.

Results
The highest interobserver agreement was for ASL/TOF (κ = 0.88; 95% confidence interval [CI]: 0.72, 1). Regarding BAVM detection, ASL/TOF had higher sensitivity (Se = 85%, Sp = 100%; 95% CI: 62-97) than contrast-enhanced MRI (Se = 55%, Sp = 100%; 95% CI 27-73) and all MR sequences combined (Se = 75%, Sp = 100%; 95% CI: 51-91) (p = 0.008). All nidi obliterations on DSA were detected on MRI. In 6 patients, residual BAVM present on DSA was only detected with ASL/TOF.

Conclusions
In this study of radiosurgically treated patients with small BAVMs, ASL/TOF was found to be superior to gadolinium-enhanced MRI in detecting residual AVM.

Assessment of Architectural Distortion of Neurovascular Contact in Trigeminal Neuralgia
Purpose
Vascular compression of the trigeminal nerve is the most common factor associated with the etiology of trigeminal neuralgia (TN). Nevertheless, anatomical and imaging studies have also reported neurovascular contact (NVC) in trigeminal nerves of individuals without TN making the diagnosis challenging. The purpose of this study was to determine the incidence of NVC in asymptomatic vs. symptomatic patients as well as to determine whether anatomical changes differed between groups.

Materials and Methods
Single-institution, retrospective analysis of consecutive patients with a clinical diagnosis of TN over four years, and age-matched asymptomatic controls underwent imaging analysis (3D high-resolution T2-weighted cisternography). Two neuroradiologists, blinded to clinical data, evaluated for the presence of NVC, degree of contact, and atrophy.

Results
A total of 47 consecutive patients (29 females and 18 males, median age 61 +/- 17 years) with 1-sided TN and 48 healthy controls (24 females and males, media age 53 +/- 13 years) were analyzed. NVC was found in 68% (32) of the symptomatic group vs. 62% (89) of the asymptomatic group; the difference was not statistically significant (p=0.470). Neurovascular contact was attributed to an artery in 87.5% of symptomatic nerves and 73% of asymptomatic nerves (p=0.96). Symptomatic nerves had a greater degree of compression (moderate-severe) than the asymptomatic group (60% vs. 25%; p=<0.001) and were also more often associated with atrophy (47% vs. 10%; p=<0.001).

Conclusions
NVC is commonly seen in symptomatic and asymptomatic patients, and therefore the presence of contact is not enough for diagnosis of a conflict. Symptomatic nerves are associated with a greater degree of compression and the presence of atrophy in compare to asymptomatic nerves; this may help to identify patients who are likely to benefit from microvascular decompression.

2011

Is neck CTA indicated in traumatic seat belt injury?

B Chen1, F Ghazi Sherbaf2, A Kamali3, R Riascos4, D Yousem5
1University of Texas McGovern Medical School, Houston, TX, 2Johns Hopkins Medical Institutions, Baltimore, MD, 3UT Health, Houston, TX, 4Univ. Of Texas - Houston, Houston, TX, 5Johns Hopkins Medical Institutions, Owings Mills, MD

Purpose
The purpose of the study is to determine if CTA of the neck is warranted in the initial evaluation of patient with only seat belt sign.

Materials and Methods
IRB approved, retrospective review of the Primordial database using the keywords: seat belt sign, CT Angiography of the neck, CT Angiography of the neck and brain was performed from 2012-2019 as part of a multi-center study for presence of cervical vascular injury in a Level I Trauma center. Patient's demographic information was collected from the electronic medical record.

Results
103 unique patients were identified who received neck CTA in the setting of trauma with seat belt sign including 69 females (67%) and 34 males (33%). The mean age of the population is 39.6 with a range of 7-89. 3/103 (3%) patients had cervical arterial injury and 100/103 (97%) did not. All 3 arterial injuries occurred in the vertebral artery and Grade I based on the Biffl scale. 1/3 of the vertebral artery injury patient also suffered from cervical spine trauma. 1/3 endorsed sternal tenderness due to fracture and had visible lower extremity injury. 1/3 had subjective neck pain without other physical exam findings. Excluding two patients with confounding additional injuries, 1/101 (1%) had cervical vascular injury in the setting of the seat belt sign.

Conclusions
Physical stigma that portends the severity of internal traumatic injury remains elusive. Diagnostic medical imaging serves to bridge this gap. Seat belt sign after motor vehicle remains a valuable physical exam finding in the screening protocol in Modified Denver Criteria and Modified Memphis Criteria for blunt cerebrovascular injury. The prevalence of blunt cerebrovascular injury in the setting of trauma is estimated to be 1-1.6%. The current literature on the utility of CTA remains heterogeneous, while the clinical practice favors screening cervical CTAs. Our single institution demonstrates same rate as previous study. Our result supports the previous research that cervical CTA should be performed on those with associated injury and not based on seat belt sign alone. This counter some of the recent literature of the more liberal uses of CTA in trauma setting from the Emergency medicine literature.
Obstructive Sleep Apnea Impacts Brain Development in Obese Children and Adolescents: an MRI Study

F Sarzetto¹, I Narang², T Naik², A Kassner²
¹University of Toronto, Toronto, Ontario, ²The Hospital for Sick Children, Toronto, Ontario

Purpose
Obstructive sleep apnea (OSA) is a breathing disorder characterized by recurrent episodes of nocturnal hypoxia and sleep fragmentation, causing chronic systemic inflammation and endothelial dysfunction [1], and affects more than 50% of obese youths [2]. Obesity is also characterized by systemic inflammation. Both obesity and OSA independently have been shown to have a negative impact on brain structure and function [3,4], but there is a paucity of data on their combined effect on the developing adolescent brain. The purpose of this study was to assess MRI measurements of cortical thickness in obese youths with various degrees of OSA severity, and compare these to obese peers with no OSA. We hypothesized that cortical thickness is abnormal in obese patients with OSA.

Materials and Methods
55 obese subjects (29 males, 26 females, mean age ± SD = 14.3 ± 2.4 years, range 9-18 yrs.) were included in the analysis for this cross-sectional study, which was approved by the local ethics board. All subjects were assessed with polysomnography to evaluate presence and severity of OSA, based on the Obstructive Apnea and Hypopnea Index (OAHI). T1-weighted MPRAGE images were acquired with a 3T MRI scanner, using a 32-channel head coil (TR/TE = 2300/2.96 ms, FOV = 256 mm, voxel size = 1.0 × 1.0 × 1.0 mm, FA = 9°, parallel acquisition technique = 2). Cortical thickness was extracted using the CIVET 2.1.1 pipeline, and statistical analysis was performed on SurfStat (MATLAB) to examine global and local cortical thickness, and its correlations with age.

Results
Based on their PSG outcome, subjects were divided into 3 groups, No OSA (OAHI < 1.5 events/hr., n = 15), Mild OSA (OAHI < 5 events/hr., n = 14), and Moderate/Severe OSA (OAHI ≥ 5 events/hr., n = 26). Cortical thickness analysis revealed a negative-trending correlation between global cortical thickness and age in No OSA (F = ─1.11, P = 0.29, see Figure 1a,b), which is in line with typical development [5]. This correlation reversed in Mild OSA (F = 0.21, P = 0.8, Figure 2a,b), and became significantly positive in Moderate/Severe OSA (F = 4.05, P = 0.0005, Figure 3a,b), affecting large areas of the whole cortex.

Conclusions
In contrast to typical cortical development, characterized by progressive cortical thinning during adolescence, we observed a significant positive correlation between cortical thickness and age in obese subjects with severe OSA, possibly indicating brain development alterations. More data is needed to validate these findings.
Impact of childhood snoring on brain structure and cognitive function suggest revisions to clinical guidelines

M OLRU1, A RAUSCHECKER1, R Nillo1, C Hess1, L SUGRUE1
1UCSF RADIOLOGY, San Francisco, CA

Purpose
Sleep-disordered breathing (SDB), including obstructive sleep apnea (OSA) and habitual snoring, is the leading sleep disturbance in children (1). Concern for negative neurodevelopmental consequences of SDB has led the American Association of Pediatrics to recommend assessment and treatment of children with habitual snoring, defined as snoring three or more nights on average per week (2). However, the effects of snoring on cognitive function and brain development remain unclear. We investigated the relationship between habitual snoring and both cortical structure and cognitive function in a large demographically diverse population of US adolescents.

Materials and Methods
We examined data from over 11,000 typically developing adolescents (ages 9-10) enrolled in the Adolescent Brain and Cognitive Development study using NDA version 2.0.1 (3). Parents reported sleep measures for their children, including frequency of snoring, and 'gasping for breath/inability to breathe' during sleep. Cortical morphology was measured with isovolumetric T1-weighted imaging using FreeSurfer (4). Cognitive function was measured by the NIH Toolbox cognitive battery. Linear mixed-effects models were used to examine the association between measures of sleep disturbance, cortical morphology, and cognitive function while controlling for demographic factors.

Results
Children who snore daily showed significant regional decreases in cortical thickness and lower fluid intelligence scores compared to children who never snore (Figure 1A). However, children who snore often, defined as 3-5 nights on average per week, did not show decreases in cortical thickness or cognitive performance compared to children who never snore (Figure 1B). Results from a subpopulation of children whose parents endorsed symptoms of OSA, including 'gasping for breath/inability to breathe' during sleep, mirrored those of daily snorers (Figure 1C).

Conclusions
The clinical definition of habitual snoring may need to be revised to better target children at risk for associated negative neurodevelopmental effects. Children who snore daily show changes in fluid intelligence scores and cortical morphology similar to children with symptoms of OSA, however, children who meet criteria for 'habitual snoring' but are not daily snorers do not show these effects. These results may be driven by a high prevalence of undiagnosed OSA among daily snorers and suggest potential value for formal sleep testing in this specific subset of children with sleep-disordered breathing.

(Filename: TCT_2177_ASNR_snoring_Figure.jpg)
Fetal and Postnatal Imaging in Segmental Callosal Agenesis

E George¹, Y Li¹, E Sherr¹, O Glenn²
¹University of California, San Francisco, San Francisco, CA, ²Univ. California San Francisco, Palo Alto, CA

Purpose
The corpus callosum is thought to be formed by the fusion of separate segments, with callosal fibers guided across midline by the anterior and hippocampal commissures as well as by pioneer cingulate axons. This is followed by front-to-back translation of the splenium due to expansion of the frontal lobes and associated fibers in the anterior callosum. Segmental callosal agenesis (segACC) is a type of callosal dysgenesis characterized by the absence of the central corpus callosum and hence a disconnection between the anterior corpus callosum and the splenium. There are 3 reported variants of segACC depending on the location of the hippocampal commissure. This is, to our knowledge, the first report of segACC diagnosed by in utero MRI. The purpose is to illustrate the appearance of segmental callosal agenesis on fetal MRI and to use postnatal DTI findings to better understand the embryology and imaging variants of callosal dysgenesis.

Materials and Methods
A G1P0 female who conceived via in vitro fertilization was referred for fetal MRI due to failure to visualize the normal cavum septum pellucidum on obstetric ultrasound. Fetal MRI performed at 23 weeks 3 days gestation revealed segACC. Cesarean section delivery was performed at 38 weeks gestation due to breech presentation and the perinatal course was uncomplicated. Post-natal MRI confirmed segACC. At 6 months, the infant demonstrates early signs of developmental delay in motor and pre-language domains.

Results
Fetal MRI demonstrated segmental agenesis of the posterior body and isthmus of the corpus callosum (Figure a,b). No additional brain or craniofacial malformations were identified and the ventricles were normal in size. Postnatal MRI at 3 and 6 months confirmed segACC (Figure c, d). The anterior commissure was hypoplastic and the fornices were noted to be associated with the anterior segment of the corpus callosum (most consistent with Type I). Probst bundles were noted at the agenetic segment of the corpus callosum.

Conclusions
Fetal MRI has been established to have high accuracy for the detection of midline malformations including corpus callosal dysgenesis. In segACC, the loss of homotopic interhemispheric connections is likely due to a defect in axonal guidance, supported by the presence of Probst bundles at the agenetic segment. Whole exome sequencing, radiogenomic correlation, and further advances in fetal imaging, including fetal DTI will offer further insight into the development of white matter connectivity and associated malformations.

(Filename: TCT_2451_Figure_final.jpg)
Prevalence, heritability and concordance rate in adolescent twins inform genetic basis for prominent perivascular space risk

Z Luo¹, N Stabo¹, A Alexander¹, A Field², H Goldsmith¹, H Rowley³
¹University of Wisconsin Madison, Madison, WI, ²UNIVERSITY OF WISCONSIN, MADISON, WI, ³Univ. of Wisconsin, Madison, WI

Purpose
Prominent perivascular spaces (PVS) are an anatomical variant associated with a wide range of neurological conditions. The risk of developing prominent PVS may result from genetic susceptibility and/or environmental factors. We used a quantitative genetic approach to investigate the genetic and environmental contributions of prominent PVS in a large community-based twin sample.

Materials and Methods
Magnetic resonance images (MRI) were acquired on a 3T scanner (GE HealthCare) from a healthy community sample (age 13-20) of 506 monozygotic (MZ) and same-sex dizygotic DZ adolescent twins recruited using statewide birth records. Board-certified radiologists blind to the zygosity of the twin pairs reviewed 3D T1-weighted scans (1mm slice thickness) for the presence of prominent PVS. Concordance rates for MZ and DZ twin pairs and heritability of prominent PVS using structural equation (ACE) modeling were calculated.

Results
127 (25% of the sample) twin individuals had prominent PVS, with a male-to-female ratio of 1.8:1. The proband-wise concordance rate, which denotes cotwin risk, was 83% for monozygotic pairs and 52% for dizygotic pairs. Heritability analysis indicated 77% of the total variance of PVS status was explained by genetic factors.

Conclusions
A quarter of normal young volunteers were found to have PVS, and these were more commonly seen in males. MZ cotwins of probands with prominent PVS were 1.6 times more likely be affected compared with DZ cotwins of probands. The higher concordance rate among MZ compared to DZ twin pairs, who on average only share half of their genes identical by descent, combined with the high heritability estimate of 77%, suggest that genetic risk factors play a key role in the development of prominent PVS.
Fetal MR imaging of the fetal brainstem – an in vivo study

G Dovjak¹, V Schmidbauer¹, D Prayer², G Kasprian³
¹Medical University of Vienna, Vienna, Austria, ²N/A, N/A, ³MEDICAL UNIVERSITY OF VIENNA, VIENNA, Austria

Purpose
The brainstem is involved in different types of hindbrain anomalies, which are nowadays increasingly detected by prenatal sonography and MRI. However, little is known about the proportions of different fetal brainstem segments and their evolution throughout pregnancy. This study aimed to assess the midsagittal two-dimensional area of brainstem substructures with fetal MRI.

Materials and Methods
Prenatal cases with a normal brain development were retrospectively assessed. The midbrain, pons, medulla oblongata and the cerebellar vermis were two-dimensionally segmented using a T2-weighted median sagittal slice in the software ITK snap. The in-vivo cases were compared to brain-normal postmortem MRI of corresponding gestational age. The ratios of the brainstem substructures were calculated and correlated to gestational age.

Results
161 brain-normal fetal MRI with a mean age of 25.7±5.4 gestational weeks (GW) showed a sufficient image quality to be assessed. The ratio midbrain:pons significantly decreased (p<0.01) from 0.6 to 0.5 between 18 and 40 GW whereas the ratio pons:medulla oblongata increased significantly (p<0.01) from 1.5 to 1.8. The ratio midbrain:medulla oblongata remained 0.9 throughout gestation (p=0.91).

Conclusions
Two-dimensional segmentation of brainstem substructures revealed that there was an increase in the size of pons compared to midbrain and medulla oblongata during the 2nd and 3rd trimester. Brainstem proportions at the early second trimester (midbrain:pons:medulla – 3:4:3) differ from those postnatally (1:2:1), which has to be acknowledged, when assessing the brainstem in fetal hindbrain malformations.
Materials and Methods
After obtaining an IRB, using institutional radiology report search engine MARS, we found 32 cases of HPE. 8 cases with only head CT were excluded. We reviewed head MRI of 24 cases for pituitary size and presence/absence of posterior bright spot. Then we evaluated hypothalamus for interhypothalamic fusion, tuber cinerium (TC) thickness, appearance of lamina terminalis (LT), anterior commissure (AC), mammillary bodies (MB) and anterior recess (AR). Statistical analysis for correlation between imaging findings and biochemical tests was done for various subtypes of HPE. We will also correlate imaging findings with available genetic data.

Results
24 cases of HPE consisted of 7 Syntelencephaly, 8 Lobar, 8 Semilobar & 1 Alobar subtypes. There were 5 males & 19 females. All Syntelencephaly subjects had normal size pituitary & hypothalamus. In Lobar cases, 2 had hypothamic fusion, 2 thickened TC, 3 LT nonvisualization, 3 AC thickening/ nonvisualization, 2 MB fusion, 2 AR obliteration & 1 absent posterior bright spot. 1 case of confirmed hypopituitarism showed hypothalamic abnormalities. In Semilobar subtypes, 6 had hypothalamic fusion, 6 thickened TC, 7 LT nonvisualization, 7 AC thickening/ nonvisualization, 5 AR obliteration & 2 MB fusion. 5 cases with pituitary dysfunction, had hypothalamic abnormalities. Single case of Alobar subtype had diabetes insipidus & hypothalamic fusion, thickened TC, LT, AR & AC abnormalities but normal pituitary. Overall 7 confirmed patients with pituitary dysfunction had hypothalamic fusion or thickened TC (>2.4 mm) despite normal pituitary volumes & posterior bright spot. In 16 cases of normal pituitary function, only 1 case demonstrated thick TC (3.9 mm), while 15 cases had TC thickness < 1.7 mm (mean 1.2, std 0.8). Pituitary gland volume was normal in (22/24) 91.7 percent and only 2 patients had hypoplasia, however had normal pituitary functions.

Conclusions
Hypothalamic fusion and tuber cinerium thickness predict hypothalamus-pituitary axis dysfunction in patients with holoprosencephaly.

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1874

Neonatal Presentation of Glutaric Aciduria Type 2

D Treister¹, O Glenn², C Lindan¹, H Glass¹, R Gallagher¹, Y Li³
¹UCSF, San Francisco, CA, ²UCSF, Palo Alto, CA, ³UCSF, Corte Madera, CA

Purpose
Glutaric Aciduria Type 2 is a rare, autosomal recessive metabolic disorder caused by a defect in electron transfer flavoprotein (ETF) or ETF dehydrogenase, resulting in deficiencies in multiple acyl-CoA dehydrogenases. The disease is part of newborn screening and has an unknown prevalence, estimated to be 1:200,000. Patients can present in infancy or childhood with life-threatening metabolic acidosis. Multiple malformations, including those of the CNS, have been associated with the disease. We report a case of this unusual entity with a discussion of postnatal MRI findings as well as differential considerations of other inborn errors of metabolism.

Materials and Methods
A term neonate with prenatally diagnosed severe pulmonic stenosis and enlarged echogenic kidneys experienced respiratory distress upon vaginal delivery requiring emergent intubation. The neonate was noted to have an abnormal odor. Postnatal evaluation included neurosonogram, abdominal ultrasound, and brain MRI. Metabolic and genetic workup revealed urine elevation of multiple organic
acids and mutation in the ETFDH gene, compatible with Glutaric Aciduria Type 2. The patient died 6 days after birth due to respiratory failure.

Results
Non-contrast MRI of the brain demonstrated diffusely abnormally increased T2 signal of the white matter with periventricular hypointensities. Bilateral germinolytic cysts were present, containing layering hemorrhage. In addition, diffuse supratentorial periventricular microhemorrhages were noted, with intraventricular hemorrhage. The brain morphology was notable for broad, abnormal gyration, regions of polymicrogyria and prominent extra-axial spaces, some of which was likely secondary to hypoplasia of the frontal and temporal lobes. Renal ultrasound demonstrated bilateral, large, echogenic kidneys with subcentimeter cystic structures.

Conclusions
Given the rare incidence of glutaric aciduria type 2, MR brain findings are incompletely described in the literature. Our case adds to previous case reports and series in further defining the neurologic manifestations of the disease, commonly manifested as abnormal frontal and temporal gyration with hypoplasia and diffuse white matter signal abnormality. In constellation with the renal abnormalities, differential considerations for this case included peroxisomal disorders such as Zellweger syndrome. Although rare, it is important to keep glutaric aciduria type II on the differential diagnosis for this imaging appearance and clinical presentation.

1435

Isolated Temporal Lobes T2 Hyperintensity on Fetal MRI does not Predict Congenital CMV Infection

L Gorenstein¹, E Katorza¹, C Hoffmann², S Shrot¹
¹Sheba Medical Center, Ramat Gan, Israel, ²Sheba Medical Center, Ramat-Gan, Israel

Purpose
CMV (cytomegalovirus) is the most common prenatal infection in the developed world. Temporal lobes T2 hyperintensity was previously described in association with prenatal CMV infection. However, these findings are often perplexing with high inter-observer variability. Our objective was to evaluate the diagnostic value of quantitative temporal lobes T2 signal on fetal MRI in predicting prenatal CMV infection.

Materials and Methods
In this retrospective study, 51 fetuses with suspected CMV exposure, based on maternal seroconversion, were included. CMV infection status was confirmed or excluded by viral DNA amplification using polymerase chain reaction (PCR). All fetuses had 3T MRI between 29 and 36 weeks of gestation. Normalized mean and maximal T2 temporal lobe hyperintensities were evaluated quantitatively by measuring T2 signal in the temporal lobes relative to the signal of the surrounding amniotic fluid. Intra-observer and inter-observer variability as well as diagnostic performance were evaluated.

Results
Of our cohort, 29 fetuses were found to be positive for CMV infection on PCR analysis. There were no statistically significant differences in temporal lobes normalized mean and maximal T2 signal between CMV positive and CMV negative fetuses.

Conclusions
Although described in the literature as an associated imaging finding, isolated increased T2 signal in the temporal lobes on fetal MRI is not a reliable sign of CMV infection in fetuses suspected for congenital CMV infection. Further studies are required, expanding the
search for more sensitive imaging biomarkers of prenatal CMV infection. The current study illustrates the importance of quantitative imaging in diagnostic neuroradiology.

1851

Hemimegalencephaly: Imaging Evolution From Unusual Early Fetal MR Appearance to Typical Appearance Postnatally

M Tominna1, A Krishnan2
1Beaumont Hospital Royal Oak, Royal Oak, MI, 2Beaumont Health, Royal Oak, Royal Oak, MI

Purpose
• Illustrate evolution/development in a case of hemimegalencephaly from its initial somewhat mass-like appearance to the more typical late fetal and postnatal appearance • Review the prenatal and postnatal findings seen in hemimegalencephaly • Discuss a variant form known as focal hemimegalencephaly

Materials and Methods
A 37 y/o G1P0 female underwent a fetal US at 25 wks gestation, initially suspicious for absent cavum pellucidum and midline shift. MRI at 26 wks revealed a hypointense T2 mass-like focus near the expected germinal matrix/ganglionic eminence in an enlarged right frontal lobe. A tiny T2* hypointense focus at the margin possibly represented hemorrhage or calcification. Right frontal lobe cortical irregularity was suspicious for polymicrogyria. Right occipital horn was enlarged but a definite cortical abnormality was not seen. Constellation of findings were felt highly suspicious for a lobar/partial hemimegalencephaly or a large area of cortical dysplasia. MRI at 36 wks showed evolution with abnormality decreased in mass-like appearance and no longer central in location. Persistent asymmetric enlargement of the right frontal lobe & areas of cortical thickening/irregular gyration suggested diffuse cortical malformation. A distinctly enlarged right occipital horn was present. Findings were now felt more typical of hemimegalencephaly. Postnatal MRI at day 3 showed further evolution. Right frontal lobe was severely dysplastic. Right basal ganglia & periventricular region were dysmorphic with cysts/cavitation & possible calcifications. Right cerebral hemisphere was now more diffusely enlarged and a dilated occipital horn persisted. A pointed frontal horn was also seen. Due to intractable seizures, the patient underwent a modified hemispherectomy.

Conclusions
Although typical features of hemimegalencephaly postnatally & prenatally are well described, our child was unusual in the initial mass-like central T2 hypointensity, potentially a reflection of both the early prenatal timing of the scans and the focality of involvement. The findings evolved into the more classic appearance of hemimegalencephaly with more diffuse enlargement of the cerebral hemisphere and evident dilated occipital horn. The early suspicion and diagnosis on fetal MRI and confirmation on post-natal imaging led to appropriate and definitive management. It is important to have an understanding of the appearance of early and focal dysplastic hemimegalencephaly to facilitate appropriate care of the mother and fetus.

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Intracranial Abnormalities at Follow-Up in Extremely Premature Versus Very Premature Infants- An MR Comparison Study

E Snyder1, S PRUTHI2, M Hernandez-Schulman1
1Monroe Carell Jr. Children's Hospital at Vanderbilt, Nashville, TN, 2VANDERBILT UNIVERSITY, Nashville, TN

Purpose
Extremely premature infants (EPIs GA 23-27 weeks) survive with current advances in neonatology support, yet are known to be at risk for a variety of brain injuries. Little is known about some of the brain injuries affecting EPIs such as cerebellar germinal matrix hemorrhage (GMH), cerebellar injury or white matter injury. Our aim was to review MRI abnormalities of EPIs in comparison to those occurring in very premature infants (VPIs GA 28-31 weeks).

Materials and Methods
Study is IRB-approved. All consecutive neonates less than 32 weeks GA at birth admitted to the NICU over a 5-year period 2014-2019, were included. All brain MRIs performed for any indication prior to one year of age were reviewed for the presence of posterior fossa hemorrhage, cerebellar volume loss, periventricular white matter volume loss (PVWMVL), and post hemorrhagic hydrocephalus (PHH) by a pediatric neuroradiologist and a pediatric radiologist. Demographic data were extracted from the medical records. A Fisher exact test was used to compare the findings in the EPI and VPI patient groups; P values less than 0.05 were considered significant.

Results
There were 1353 neonates, of whom 210 (16%) had head MRI within the specified period. There were 89 EPIs and 121 VPIs. EPIs had higher rates of cerebellar hemorrhage (22.5% vs 9.9%; p<0.05) and cerebellar volume loss (12.4% vs 0.8%; p<0.05), compared to VPIs. EPIs also had a higher rate of hemosiderosis in the posterior fossa (11.2% vs. 3.3%; p<0.05). The incidence of PVWMVL was also significantly higher in EPIs compared to VPIs (37.1% vs 11.6%; p<0.05). However, rates of PHH were not statistically different between EPIs and VPIs (11.2% vs 7.4%; p = 0.47).

Conclusions
Cerebellar GMH and cerebellar volume loss occur more frequently in EPIs compared to VPIs, events and phenomena which may affect cerebellar development. PVWMVL also occurs more frequently in EPIs, suggesting a higher sensitivity to periventricular white matter injury, or exposure to greater number and severity of systemic events leading to such injuries. However, the development of post hemorrhagic hydrocephalus shows no significant difference between these two groups of markedly premature infants despite higher incidence of posterior fossa hemosiderosis in EPIs. Documentation and understanding of such brain injuries is important in understanding implications for neurodevelopmental outcomes, and for the development of proactive interventions.

SIS Programming: Diagnosing and Treating Discogenic Pain: Do Intradiscal Treatments Work?

2423

Incorporating Data on The Prevalence of Findings Among Asymptomatic Individuals into Lumbar Spine Imaging Reports- A Pragmatic, Cluster, Stepped-Wedge, Randomized Trial: the Lumbar Imaging with Reporting of Epidemiology (LIRE) Trial

J Jarvik1, E Meier1, K James1, L Gold2, K Tan1, L Kessler3, P Suri2, D Callmes4, R Deyo2, K Sherman6, B Comstock4, A Avins7, S Rundell2, B Griffith8, J Friedly2, D Lavallee1, J Turner2, B Bresnahan1, P Heagerty2, T LIRE Investigator Group2
1Univ of Washington, Seattle, WA, 2University of Washington, Seattle, WA, 3University of Washington-Seattle Campus, Seattle, WA, 4Mayo Clinic, Rochester, MN, 5Oregon Health and Science University, Portland, OR, 6Kaiser Permanente Washington Research Institute, Seattle, WA, 7Kaiser Permanente Northern California, DOR, Oakland, CA, 8Henry Ford Health System, Detroit, MI

Purpose
Lumbar spine imaging frequently reveals a wide array of findings, many of which are likely incidental, common among pain-free people. Some of these findings may be concerning to patients and physicians. Prior work suggested that inserting the prevalence of imaging findings in people without back pain into spine imaging reports may reduce subsequent interventions. Our purpose was to test the hypothesis that inserting this type of information decreases subsequent spine-related care.

Materials and Methods
We used a cluster, stepped-wedge design, randomly assigning when each of 98 primary care clinics at four health systems would receive lumbar spine imaging reports with prevalence data for common imaging findings in individuals without back pain. We included adult outpatients who had lumbar spine imaging ordered by their primary care provider (PCP). We excluded patients who had a lumbar spine imaging study within the prior 12 months. We captured all outcomes passively through the electronic medical record. Our primary outcome was spine-related relative value units (RVUs), testing the hypothesis that the intervention would reduce subsequent spine-related RVUs within 365 days. We also report pre-specified subgroup analyses and secondary outcomes of opioid prescriptions.
Results
Between October 2013 and September 2016, we enrolled 3,278 PCPs and 250,401 patients, of whom 238,886 met eligibility for this analysis. While there was no significant difference in cumulative spine-related RVUs at one year of follow-up comparing intervention and control conditions through 365 days, rates of subsequent RVUs differed by type of index imaging. Among the small proportion of patients who received an index CT, the intervention group had significantly fewer subsequent spine-related RVUs than the control group (% difference (95% CI) = 29.5% (-42.1 to -13.5)). We also observed a small but significant decrease in the likelihood of opioid prescribing from a study provider within 90 days of the index image in the intervention versus control group, OR=0.95 (95% CI=0.90-0.99).

Conclusions
Inserting benchmark prevalence information into radiology reports did not decrease subsequent spine-related RVUs overall. However, it reduced spine-related RVUs for patients who underwent CT and also reduced the odds of subsequent opioid prescriptions. While our findings are modest, they impact some important spine-related interventions using a simple, inexpensive, and easily implemented.

Joint ASIPP/ASNR Programming: Advanced Spinal Intervention
2058
9:20AM - 9:25AM
Head Rotation Effectively Shifts Vasculature out of Trajectory of Anterolateral Approach Fluoroscopic Guided Cervical Transforaminal Epidural Steroid Injections.

K Dahlstrom1, M PECKHAM1, L Shah1, T Hutchins1
1University of Utah Health, Neuroradiology, Salt Lake City, UT

Purpose
Determine the safety profile of contralateral cervical spine rotation for translation of the cervical carotid and internal jugular vein during anterolateral approach fluoroscopic guided cervical transforaminal epidural steroid injection (TFESI).

Materials and Methods
Multilevel neural foramina were evaluated utilizing cervical spine MRI or CT with the patient in neutral position and rotated to degree of comfort. Rotation was measured at C2. At each level from C2-C3 through C7-T1, a straight line was drawn parallel to the posterior foraminal wall, along the fluoroscopic trajectory for anterolateral approach TFESI. Perpendicular distance was measured from the trajectory line to the posterior wall of the ipsilateral carotid artery (CA) and internal jugular vein (IJV). The relationship of the trajectory line to the ipsilateral CA and IJV was documented at each level: medial, through (crossing lumen or wall), or lateral. Data acquisition was repeated at each level with contralateral head rotation (figure).

Results
72 foraminal levels in 7 patients were evaluated. Average cervical rotation at C2 was 15.1° (+/-6.4°). The trajectory line traversed a vessel lumen or wall in the neutral position 35 times, majority involving the IJV (27/35) and 8 traversing the CA. This was most commonly seen from C2/3-C4/5 (9 instances each). After contralateral rotation, average translation of the CA was 7.1 mm, and IJV 12.5 mm, and the trajectory line became lateral to 34/35 of the vessels. In one case, the foraminal level included on neutral imaging was excluded from the rotational field of view and translation could not be ascertained. At one level the trajectory line was medial to the IJV in the neutral position and with contralateral head rotation the trajectory line traversed the lumen.

Conclusions
Contralateral head rotation effectively moves the cervical vasculature out of the trajectory of anterolateral approach fluoroscopic guided cervical TFESI.
Scientific Abstract Session: Brain Epilepsy & Miscellaneous
1293
11:00AM - 11:06AM

Functional Activation Patterns Produced by Deep Brain Stimulation of the Anterior Nucleus of the Thalamus in Humans

E Middlebrooks1, C Lin1, L Okromelidze1, S Grewal1
1Mayo Clinic, Jacksonville, FL

Purpose
Deep brain stimulation (DBS) of the anterior nucleus of the thalamus (ANT) is a recently approved therapy for drug-refractory epilepsy for patients not amenable to resective surgical options. Unfortunately, outcomes remain variable due to multiple factors. One key issue is the poor understanding of the mechanism of action and the lack of in vivo biomarkers. In this study, we propose a method for investigating the human in vivo effects of ANT DBS using blood-oxygen-level dependent (BOLD) MRI and present the first human data showing the whole brain activation pattern with DBS stimulation of the ANT.

Materials and Methods
Two patients undergoing ANT DBS for epilepsy were prospectively recruited. After DBS implantation, BOLD MRI was performed using a block design after the DBS was programmed to alternate ON/OFF in 30 second blocks. The scanner was triggered during the beginning of a DBS OFF block utilizing surface electrophysiological recording to detect the DBS cycle. Nine total runs were obtained. Each individual run then underwent general linear modeling (GLM) correlated to an "ideal" waveform followed by a fixed-effects model. The resultant group-level results were thresholded using a cluster threshold of $z > 3.1$ and cluster p threshold of 0.05.

Results
Active ANT stimulation produced activation within several areas, including the bilateral anterior cingulate (ACC) and posterior...
cingulate cortex (PCC), precuneus, medial prefrontal cortex, amygdala, ventral tegmental area, hippocampus, striatum, and right angular gyrus.

Conclusions
Utilizing block-design BOLD MRI, we were able to show widespread activation resulting from ANT DBS. Numerous studies have highlighted the potential role of the default mode and limbic networks in seizure propagation and seizure threshold. Importantly, our study shows overlap with multiple areas of both the default mode and limbic networks suggesting that these nodes may modulate the effect of seizure control with ANT DBS. Our findings may ultimately provide an imaging-based biomarker for successful DBS targeting and programming, but additional studies are needed.

**Left Hemisphere**

**Right Hemisphere**

(Filename: TCT_1293_Fig3.jpg)

1761

**The Role of Advanced Imaging and Post-processing in Stereotactic EEG**

B Brinkmann¹, K Starnes¹, D Burkholder¹, J Britton¹, G Cascino¹, A Fine¹, S Grewal², K Krecke¹, T Lagerlund², B Lundstrom¹, R Marsh¹, S Messina¹, K Nickels¹, E Payne¹, E So¹, C Shin¹, J Van Gompel¹, R WATSON⁴, E Wirrell¹, G Worrell¹, L Wong-Kisiel¹

¹Mayo Clinic, Rochester, MN, ²Mayo Clinic, Jacksonville, FL, ³200 First St. SW, Rochester, MN, ⁴MAYO CLINIC, ROCHESTER, MN

**Purpose**
For patients with drug resistant epilepsy, resective surgery and focal neuromodulation therapy can be effective treatments if a focal seizure onset zone can be identified and confirmed with invasive EEG monitoring. Stereotactically placed depth electrodes may offer advantages in access to brain areas, patient comfort, and reduced surgical morbidities. However, accurately targeting brain structures or lesions can be challenging, and the complex three-dimensional arrangement of recording electrode channels is not intuitive during EEG review.

**Materials and Methods**
We report methodology in advanced imaging techniques for identifying the seizure onset zone in stereotactic EEG. Targeting is achieved using a neuronavigation system with Gadolinium-enhanced stereotactic MRI or CT-Venogram for avoidance of vessels, and structural MRI for neuroanatomy. Co-registration of functional imaging including ictal SPECT, PET, magnetic source imaging, EEG source imaging, and fMRI permit targeting functional abnormalities. Following electrode placement, a CT is acquired to rule out hemorrhage and confirm electrode placement. This CT is registered with the patient's pre-operative images, electrode positions are labeled, and three-dimensional renderings of the combined brain volume are generated.
Results
Between January 1, 2015, and October 20, 2019, 104 stereotactic implants were performed on 103 patients. Of the implanted patients 48 (47%) were female, with median (range) age of 24 (3-66) years. Twenty-six patients (25%) had nonlesional MRI exams, and 16 (16%) had bilateral MRI lesions. Fifty patients (49%) had implants with bilateral electrode coverage, and 45 (44%) eventually underwent resection, with 23 patients (22%) achieving seizure freedom. Figure 1 illustrates the imaging and implantation for a pediatric patient. Interictal discharges and seizure onsets on scalp EEG were observed over the left front-central region, and hypometabolism was noted on PET (A). Morphometric analysis of the T1 MRI showed GM-WM blurring in the superior frontal gyrus (B), and EEG source localization dipole and sLORETA solutions localized to the left superior mid-frontal region (C). A 7-Tesla MRI showed a transmantle sign in the left superior frontal gyrus (E). The patient was implanted with 11 stereotactic depth electrodes (D, E, F) and monitored revealing focal seizure onset in and near the lesion (F, red electrodes).

Conclusions
Image processing and analysis play an important role in stereotactic EEG targeting and verification.

Multimodal Assessment of the Neurochemistry and Functional Connectivity in Adolescents with Generalized Anxiety Disorder

K Cecil¹, L Lu², J Strawn²
¹CINCINNATI CHILDREN'S HOSPITAL MED. CTR., CINCINNATI, OH, ²University of Cincinnati College of Medicine, Cincinnati, OH

Purpose
Characterized by uncontrollable, diffuse anxiety and accompanied by functionally impairing somatic and cognitive symptoms, generalized anxiety disorder (GAD) is among the most common anxiety disorder in adolescents. We sought to characterize the relationship of excitatory and inhibitory tone within the dorsal anterior cingulate cortex (dACC) with resting-state functional connectivity in adolescents with generalized anxiety disorder.

Materials and Methods
Whole brain resting state fMRI measurements and localized proton MEGA-PRESS MRS [1-2] were conducted using a 32 channel head coil at 3 Tesla in adolescents with moderate to severe generalized anxiety disorder (n=46; 74% female, mean age 14.8 ± 1.66 years, Pediatric Anxiety Rating Scale mean 17.33 ± 2.31). The resting state fMRI sequence was acquired with a single shot, fast Fourier echo, echo planar imaging (echo time 30 milliseconds (ms), repetition time 2000 ms; 150 dynamics) sequence at isotropic 3 mm resolution. The MEGA-PRESS MRS acquisition (TE 68 ms, TR 2000 ms) was localized within the dACC. GABA+/Creatine (Cr), GLX(glutamate and glutamine)/Cr and GLX/GABA+ ratios were determined using Gannet software. A region-of-interest mask from the MRS acquisition was created (BrainNetome atlas) [3]. Seed-based resting-state functional connectivity (FC) analysis was conducted [4]. The regional time series within the dACC was extracted. Voxel-wise correlation analyses were performed between dACC and the rest of the brain. The correlation coefficients were transformed to z-value images using the Fisher r-to-z transformation.

To detect the brain regions for which the dACC's FC is linked with MRS measures, a whole-brain correlation analysis was conducted using GABA+/Cr, GLX/Cr, and GLX/GABA+ as variables of interest.
Results
A whole-brain correlation analysis showed that a higher level of GABA+/Cr was associated with greater functional connectivity between dACC and right insula, and between dACC and right orbital gyrus. A higher level of GLX/Cr was associated with greater functional connectivity between dACC and left middle frontal gyrus. In contrast, a higher level of GLX/GABA was associated with lesser functional connectivity between dACC and right angular gyrus.

Conclusions
In adolescents with generalized anxiety disorder, excitatory/inhibitory tone in the dACC predicts its connectivity to brain regions involved in fear and threat processing.

(Filename: TCT_2046_Figure1-GAC.jpg)

2242
11:21AM - 11:27AM

Synthetic MRI of Neurofibromatosis Type 1

G COBAN CIFCI¹, S Parlak¹, E Gumeler¹, B Konuškan¹, B Anlar¹, K Oguz¹
¹Hacettepe University Faculty of Medicine, Ankara, Turkey

Purpose
Neurofibromatosis type 1 (NF-1) is a multisystem genetic disorder that is characterized by cutaneous findings, skeletal dysplasias, and by the growth of both benign and malignant nervous system tumors. Patients present with cognitive deficits indicating to a more complex pathology of the brain microstructure, such as myelin. Synthetic magnetic resonance imaging (SynMRI) is based on measurement of tissue properties and generates parametric maps and different contrast weighted images. The aims of this study were to compare the diagnostic yield between synthetic and conventional MRI in terms of detection of hamartomas, and also automatic sementation of brain tissues to evaluate the myelin, gray matter (GM), white matter (WM) volumes of NF-1 with SynMRI.

Materials and Methods
The SynMRI sequence QRAPMASTER was obtained last in the protocol and encompassed the whole brain with equal slice angulation, slice thickness, gap, positioning and field of view (FOV) as the conventional axial FLAIR, T1W and T2W series from 20 patients and 20 control subjects. The hamartomas were evaluated by two neuroradiologist by visual assessment on conventional MRI and SynMRI for confirmation of the findings. Quantitative maps and measurements of myelin, WM, GM and nonWM/GM/CSF were also obtained.

Results
Both hamartomas were marked in nonWM/GM/CSF maps accurately. Mean quantitative measurements of white matter volume, gray matter volume, myelin and myelin fraction for patients (mean age ± 11.5) were 366.9, 750.4 ml, 102.3 ml and 9 %, respectively. Outcome of control subjects (mean age ±11.9) were 425.8, 903.4, 128.8 ml and 9.5%; which showed a decrease in myelin and white matter volume in patients with NF-1. The statistical results significant (p< 0.005).

Conclusions
Although our group was small, SynMRI was able to demonstrate hamartomas accurately on nonWM/GM/CSF maps. The first qualitative results indicate a decrease in WM, GM and myelin volume in NF-1, which is consistent with loss of myelin shown in NF-1.
Correlation of Normal Cortical NF1 Expression with Cortical Morphology in Neurofibromatosis Type 1

M BARKOVICH¹
¹UNIVERSITY OF CALIFORNIA-SAN FRANCISCO, SAN FRANCISCO, CA

Purpose
Children with Neurofibromatosis Type 1 (NF1) have non-neoplastic overgrowth of both the cortex and deep grey nuclei, with temporal course matching that of other non-neoplastic NF1 manifestations such as neurocognitive delay. Correlation with normal patterns of NF1 gene expression in the cortex throughout development may further clarify the role of the NF1 gene in normal and abnormal brain development.

Materials and Methods
RNA expression across 45 cortical brain regions was evaluated in six adult patients using publicly available gene expression data from the Allen BSI database. A nonlinear effects model analysis was performed across four RNA probes (z-score average) in the six patients to determine if there was a significant difference in gene expression across the 45 brain regions. This regional cortical gene expression was then correlated with abnormal cortical thickness in 14 children with NF1 relative to age and sex matched controls, covarying for gender and correcting for multiple comparisons.

Results
In normal adults, highest cortical NF1 RNA levels are seen in the occipital cortices with lowest levels in the frontal cortices, however these differences are not statistically significant. NF1 patients have significantly thicker cortices in the occipital lobe and significantly thinner cortices in portions of the frontal lobe.

Conclusions
In normal adults, cortical NF1 RNA expression is higher in areas where thicker cortices are seen in NF1 patients relative to controls and lower in areas where NF1 patients have thinner cortices than controls. Although the differences in cortical RNA expression did

<table>
<thead>
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<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
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not reach statistical significance, this may be in part due to a small sample size. Further investigation of changes in the pattern and levels of NF1 gene expression by age may explain the cortical abnormalities seen in NF1 patients and their temporal course.

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2100

T2 Hyperintense Extradural Thickening Posterior to the Confluence of Sinuses in Newborns

A. Ceylan1, C. Ozutemiz2, H. Huang2, N. Rubin2, D. Nascene2
1Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, MN, 2University of Minnesota, Minneapolis, MN

Purpose

The epidural space is a potential intracranial space and cannot be recognized unless there is an underlying pathology. T2 hyperintense thickening of the extradural space posterior to confluence sinuum is observed in MRI examinations of newborns within the first week of life, which resembles epidural edema. To the best of our knowledge, there are no prior studies that explain this finding. Our aim is to identify the frequency and any possible associations with this finding.

Materials and Methods

Retrospectively, brain MRIs of 194 neonates, obtained within first week of life, were evaluated by a resident and an attending neuroradiologist using sagittal/axial T2WI and sagittal FLAIR. 36 were excluded due to motion artifact (11), lack of sagittal T2WI (21), and lack of clinical data (3). Extradural collection thickness was measured from the posterior margin of the sinus to the anterior margin of the inner table. Presence of cranial molding and extracranial edema was also assessed. Medical records were evaluated for patient sex, gestational age, birth method, fetal position during birth, birth complication, maternal age and neurologic sequelae. Newborns with extradural thickening were compared to those without. Student t-test and chi-square test were used for numeric and categorical variables respectively. Follow-up exams were evaluated if available.

Results

Extradural T2-hyperintense thickening was present in 64 (40%) of 158 included patients with a mean thickness of 3.6 mm (0.8-6 mm). There was significantly more cranial molding (64% vs 35%, P<0.001) and extracranial edema (78% vs 42%, P<0.001) in the cases with extradural T2 hyperintense thickening. No difference was found between the two groups in terms of sex, gestational age, birth weight, delivery type, fetal position, birth complication, maternal age, birth difficulty and neurological sequelae (P>0.05). 7 patients with extradural thickening underwent follow-up imaging, and in 5/7, the thickening completely resolved. Two patients showed persistent extradural thickening, improving from 3.2 mm to 1 mm in one child and from 3.2 mm to 2.8 mm in the other within a week.

Conclusions

T2 hyperintense extradural thickening posterior to confluence sinuum frequently occurs in newborns following birth, particularly in...
those with coexisting cranial molding and extracranial edema. This finding does not appear to be associated with factors related to delivery, shows complete resolution in most cases, and is likely of no clinical importance.

Heatstroke: A Case Report and Review of Classic and Atypical Brain Imaging Findings

R Ahmed¹, C Brown¹, M Baumann¹
Purpose
To present a case of pediatric heat stroke and review the range of imaging findings in patients presenting with symptoms of classic heat stroke in an emergency setting. Cerebral injury is a result of decreased cerebral perfusion, coagulation aberrations, and direct injury. As such, the range of potential abnormal imaging findings are many and can be varied, and may overlap with other acute childhood neurologic emergencies. Our goal is to acquaint the radiologist with imaging findings including atypical imaging features, which may help to ensure a timely and accurate diagnosis.

Materials and Methods
We will provide a brief review of most common imaging findings in pediatric patients with heat stroke in particular a case at our institution of a 21-month-old female with CT, MRI, and follow up MR imaging correlate.

Results
Patient had acute presentation with MRI performed within 6 hours demonstrating restricted diffusion in the cerebellum with findings representing cytotoxic edema, among other associated findings. Symmetric abnormal T2/FLAIR signal hyperintensity, T1 hypointensity, and restricted diffusion compatible with acute cytotoxic edema is noted the bilateral cerebellum, predominantly involving the gray matter structures. There is mild local mass effect within the posterior fossa, with effacement of the involved cerebellar folia. The basilar cisterns remain are patent and there is no 4th ventricular effacement or downward cerebellar tonsillar displacement. Susceptibility weighted images (not shown) show no abnormal signal suspicious for hemorrhage. There is no abnormal enhancement following contrast injection.

Conclusions
Although the pathophysiologic mechanism of neuronal damage is well understood, imaging documentation is not well known. Previous studies have also described MR imaging findings of signal alteration in the cerebellum, external capsule and adjacent lateral putamen, medial thalamus, and hippocampus; and patchy cortical lesions in the frontal and parietal lobe. We present an interesting pediatric case example, and review acute and chronic imaging findings, with an emphasis on potential acute MR imaging alterations which may alert the radiologist to make a correct diagnosis. Knowledge of the patterns of brain injury involvement may be helpful to aid in differentiating between other potential acute pediatric neurologic disorders, and may be especially helpful in cases where there is absent or sparse clinical history.
Purpose
Concerns over the neurotoxic potential of small amounts of retained gadolinium (Gd) in brain tissues following intravenous gadolinium-based contrast agent (GBCA) administration have led to dramatic changes in clinical practice worldwide, yet the clinical implications and symptoms associated with Gd deposition remain undefined. In the current study, we used a rat model to determine if GBCA exposure was associated with adverse neurologic or cognitive findings.

Materials and Methods
Male Wistar rats exposed to 20 intravenous injections over a 4 week period of 2.5 mmol/kg (80 human equivalent doses, HED) of various linear or macrocyclic GBCAs (gadodiamide, gadobenate dimeglumine, gadopentetate, gadoxetate disodium, gadobutrol, gadoterate meglumine, and gadoteridol) were compared to saline-exposed controls. Behavioral and cognitive tests, including novel object recognition test (assessing sensory, memory and cognitive function), open field test (motor function and mood), Y-maze test (short-term positional spatial memory and motor function), social anxiety test, and horizontal ladder rung walking test (motor coordination, planning, and balance), were performed at 6 and 34 weeks post-injection to assess for potential short- and long-term effects of GBCA exposure on neurologic function. ANOVAs with appropriate post-hoc tests were used to compare GBCA groups to the controls.

Results
No significant differences in any behavioral test were observed between GBCA-exposed rats and saline controls at 6 weeks post-injection (p=.11 - .99) or 34 weeks post-injection (p=.32 - .99).

Conclusions
In this rat model, no potential clinical evidence of neurotoxicity was observed following exposure to various linear and macrocyclic GBCAs. Additional studies are necessary to further assess the potential clinical effects of Gd retention.

Scientific Abstract Session: Functional/fMRI
2032

7T resting state connectivity applied to HIFU procedures for planning and efficacy

S Jones1, J Cooperrider2, D Lockwood1, S Nagel1, E Obusez1, R Rammo3, P RUGGERI4, M Lowe1
1Cleveland Clinic, Cleveland, OH, 2Cleveland Clinic Lerner School of Medicine, Cleveland, OH, 3Cleveland Clinic Foundation, Cleveland, OH, 4CLEVELAND CLINIC FOUNDATION, PEPPER PIKE, OH

Purpose
High Intensity Focused Ultrasound (HIFU) treats essential tremor (ET) by ablating the ventral intermediate nucleus of the thalamus (VIM). Current targeting methods rely on stereotactic measurements and structural imaging. Given the functional goal of treatment, there would be utility in targeting with functional imaging. We used 7T resting state fMRI to address two clinical problems: (1) initial targeting to enable customization of the target by knowing the functional relationship to adjacent tissue; (2) evaluate objectively the effect of HIFU by computing an fMRI metric. Currently, the lesion is visualized structurally, and compared with distances to the posterior limb of the internal capsule, but such simple measurements may not reflect variability of functional efficacy and durability of the result.

Materials and Methods
To evaluate functional targeting of the ViM, we first understand rsfMRI connectivity in a set of 20 controls at 7T, whose studies are concatenated for more reliable visualization of subtle connections. A grid of thalamic seed points is explored, systematically computing the temporal correlation coefficient to all voxels in the sensorimotor cortex. We hypothesize that the region of highest connectivity colocalizes with ViM. To evaluate efficacy of a treatment, we acquire 7T rsfMRI in patients after HIFU, and example alterations in connectivity from the thalamus to remaining cortex. To date, 3 patient have been scanned at 7T after HIFU procedures.

Results
(1) rsfMRI connectivity maps from the thalamus to the sensorimotor cortex show regions of increased connectivity that are proximal to expected location of ViM. Figure 1 shows one example in a plane 1mm above the AC-PC, with the region of highest connectivity involving portions of ViM, and anterior portions of the pulvinar. (2) Figure 2 shows a connectivity map in one patient with the seed being in either the HIFU cavity, or in the contralateral thalamus at the presumed location of the ViM. In both cases there is connectivity from the thalamus to the sensorimotor cortex, and supplementary motors regions in the medial frontal convexities. This connectivity is reduced with the seed in the HIFU lesion, versus the seed in contralateral ViM.
Conclusions

7T rsfMRI provides a promising technique to identify the regions of the thalamus with highest cortical connectivity. Such maps can help guide targeting based on functional activity. Secondly, 7T rsfMRI can potentially evaluate efficacy of a HIFU treatment.

1154

Structural and Functional Abnormalities of the Dorsal Anterior Cingulate Cortex in Obsessive-Compulsive Disorder

M Manchandia¹, M OLARU¹, R Nillo¹, C Hess¹, L SUGRUE¹
¹University of California, San Francisco, San Francisco, CA

Purpose

Dysfunction within neural systems for cognitive control is thought to be central to the pathophysiology of obsessive-compulsive disorder (OCD). Recent developments in neuroscience suggest that the dorsal anterior cingulate cortex (dACC) acts a key hub for cognitive control within a network of frontal regions that enable adaptive decision making. Taken together, these results raise the
possibility that dACC dysfunction may be central to the neurobiology of OCD. We sought to test this hypothesis by examining the relationship between dACC structure/function and OCD.

Materials and Methods
Using data from the Adolescent Brain and Cognitive Development study of 12,000 typically developing adolescents, subjects meeting criteria for OCD diagnosis were identified based on KSADS-5 criteria. Using multivariate linear mixed-effects models, we examined differences between OCD subjects and matched controls in regional cortical volume and fMRI activity during the 'stop-signal task' (SST), an assessment of cognitive control. Using the Child Behavior Checklist OCD T-score, we further examined the effect of OCD symptom severity on dACC cortical volume and task-based fMRI activity. Lastly, we examined how resting-state fMRI (rsfMRI) connectivity across 13 resting-state networks differed between OCD subjects and matched controls.

Results
Compared to matched controls, subjects with OCD demonstrated significant decreases in both dACC cortical volume (p=0.03; Figure A) and dACC relative task activation during correctly executed 'stop' versus 'go' trials of the SST (p=0.03; Figure B). Furthermore, both dACC cortical volume (p=0.03) and relative task activation (p=0.03) showed significant negative correlations with OCD severity (Figures C & D). Finally, in OCD subjects, rsfMRI correlations demonstrated significantly altered network connectivity both within and between the dorsal attention (task-positive) and default mode (task-negative) networks.

Conclusions
We found systematic differences in dACC structure/function between subjects with OCD and matched controls. Specifically, in OCD subjects, the dACC showed decreased cortical volume and selectively decreased activity during SST trials that demand cognitive control. Furthermore, we found that these effects varied with increased OCD symptom severity. These results support the hypothesis that dysfunction in cognitive control mediated by dACC structural/functional aberrations plays a central role in the neurobiology of OCD.

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Salience Network in Patients with Brain Tumors

J Yang1, S Gohel2, B Vacha3
1NYU Langone School of Medicine, New York, NY, 2Rutgers University School of Health Professions, Newark, NJ, 3Memorial Sloan Kettering Cancer Center, New York, NY

Purpose
Patients with glioma often show disruptions in three key neurocognitive resting state networks (RSNs) the default mode network (DMN), central-executive network (CEN), and salience network (SN). While previous research in this area has largely focused on tumor-induced changes in the DMN, our study examined effects of gliomas on the salience network (SN), a key modulator of attention that has been implicated in a variety of psychopathologies. This study used resting state fMRI (rsfMRI) to investigate the effect of tumor grade, sidedness (R vs. L) and location (anterior vs posterior) on average resting state connectivity.

Materials and Methods
rsfMRI data were acquired on 69 patients with glioma (mean age 48.74; 65.2% male) sub-divided into left-sided tumors (n=41), right-sided tumors (n=28), anterior (frontal or anterior temporal) (n=53), and posterior tumors (posterior temporal, parietal, or occipital) (n=16). Four spatially distinct SN regions of interest (L-dACC, L-AIns, R-dACC, R-AIns) were defined for rsfMRI analysis. A linear regression-based approach and GLM based model were implemented to understand effects of tumor grade, sidedness and location, respectively, on functional connectivity.

Results
Average resting state functional connectivity in the SN was significantly decreased in tumor patients compared to healthy controls (p<0.05). Between subgroups, anterior tumors were associated with decreased global SN connectivity (p<0.01), while posterior tumors were not. There was no significant effect of sidedness on average RSFC based on location differences (R vs. L), but there were notable differences based on tumor grade. Grade 3 and Grade 4 tumor patients had significantly lower average connectivity compared to controls (p<0.01), while Grade 2 did not.

Conclusions
Average connectivity of the SN was decreased on average in glioma patients, and high-grade, anteriorly located tumors were the most disruptive of global connectivity. This is likely due to the infiltrative nature of these tumors, their proximity to known network nodes, and further research on the effects of tumor grade and location on resting state connectivity can help provide valuable clinical insight for prognosis of neurocognitive changes in glioma patients.

Improved Detection of fMRI Activation in Brain Tumor Patients through MP-PCA Denoising

B Ades-aron1, J Veraart2, D Novikov2, E Fieremans2, T Shepherd3
1New York University, New York, NY, 2New York University School of Medicine, New York, NY, 3NYU Langone Health, New York City, NY

Purpose
Functional MRI improves preoperative surgical planning in brain tumor patients, however BOLD signal changes for task-based 3-T fMRI in the ideal patient are only 2-3% and the tumor often compromises patient performance. This study tested the hypothesis that Marchenko-Pastur Principle Component Analysis (MP-PCA) denoising improves activation sensitivity for pre-operative fMRI language mapping, and also can be used to reduce fMRI scan times.

Materials and Methods
We evaluated the performance of the MP-PCA using clinical data. This study retrospectively identified 23 left-language dominant brain tumor patients (13 female; 42.5±18.1yrs) that successfully performed verb generation, sentence completion, listening comprehension and finger tapping fMRI task-based paradigms. Original and MP-PCA denoised volumes were processed using FSLFEAT. For each task, histograms of t-scores for original and MP-PCA denoised data were extracted from relevant eloquent regions and their contralateral homologs identified by neuroradiologist blinded to the fMRI data. Mean t-scores were compared using paired 2-sided t-tests and their distributions compared with Kolmogorov-Smirnov tests. Scan time reduction was evaluated by sequentially reducing fMRI volumes from 160 to 40 images and observing the relationship between sensitivity (% of voxels with t > 3) and scan time.

Results
MP-PCA denoising increased magnitude of task-based fMRI correlations for all tasks. For language tasks, MP-PCA denoised statistic maps showed median t-score increasing from 4.9 ± 1.1 to 5.7 ± 1.5 (p<0.0001). Mean t-scores did not increase significantly after MP-PCA denoising in contralateral homolog regions not involved in the task. Histogram of t-scores in cortical language regions shifted to stronger statistical correlations to the task (p<0.0001) and appeared less Gaussian, consistent with widespread cortical recruitment during language performance not typically observed using standard fMRI in clinical patients. For all tasks denoising provides...
equivalent sensitivity to scanning with 60% of the total included images, indicating the potential for shortening individual fMRI tasks up to 40%.

Conclusions
MP-PCA denoising demonstrated increased sensitivity for cortical regions recruited during language-based fMRI paradigms in brain tumor patients and has the potential to facilitate scan time reduction.


F Chiang¹, M Feng¹, R Romero¹, L Price², C Franklin¹, S Deng¹, F Yu³, B Tantiwongkosi⁴, S Huang⁵, P Fox¹
¹University of Texas Health Science Center at San Antonio, San Antonio, TX, ²Texas State University, San Marcos, TX, ³UT Southwestern Medical Center, Dallas, TX, ⁴University of Texas Health San Antonio, SAN ANTONIO, TX, ⁵Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose
Misdiagnosis in multiple sclerosis (MS) remains a challenge with significant clinical and economic consequences.¹ The aim is to aid in the diagnostic accuracy of MS by developing functional imaging biomarkers. Recently, Chiang et al. confirmed the network degeneration hypothesis in MS using functional meta-analytic connectivity modeling (fMACM).² The study included coordinate-based voxel-based morphometry results from 1,666 MS and 1,269 healthy controls (HC) in the BrainMap neuroimaging database and concluded that: 1) grey matter atrophy is regionally selective; and 2) affected regions are functionally connected. In the present study, it was hypothesized that the fMACM model would predict biomarkers in rsfMRI. To this end, network-based biomarker development was undertaken while drawing from the robust existing neuroimaging literature.

Materials and Methods
Whole-brain rsfMRI was acquired for 20 MS and 20 age- and sex-matched HC (Table 1). After image preprocessing, timeseries extraction was performed at ROIs specified by the fMACM model.³ For fMACM paths, standardized semi-partial regression coefficients based on maximum likelihood estimation were computed via structural equation modeling then Fisher's z transformed. Between-group alteration was determined per path with the Mann-Whitney U test.⁴ The paths found to be significantly different were included as predictors in logistic regression models; based on the probability estimates, ROC curves were derived to demonstrate overall diagnostic accuracy.⁴

Results
In MS, four paths demonstrated significantly increased functional connectivity relative to HC: P2, P6, P10, P14 (Figure 1, Table 2). P6 remained significant after FDR-correction for multiple comparisons (corrected-p < 0.05). The 4-path network predictor resulted in an area under the curve (AUC) of 0.805 (Figure 2). The AUC for P2, P6, P10, and P14 were 0.688, 0.785, 0.689, and 0.683, respectively.

Conclusions
The fMACM model yielded an imaging marker in rsfMRI with diagnostic performance considered to be excellent.⁵ This study showcased a stepwise approach in applying a fully meta-analytically constructed network model to a distinct, prospective dataset. Furthermore, model-based hypothesis testing was carried out without the constraints of intra-laboratory idiosyncrasies in building the applied network model. Therefore, the results suggest that network-based functional imaging metrics could improve diagnostic accuracy in MS. Further work is needed to validate the network model longitudinally.
Figure 1. Model-based hypothesis generation using functional meta-analytic connectivity modeling (FMCAM). The FMCAM node- and edge-wise was applied to a prospective resting-state MRS dataset. Four paths predicted by the FMCAM model (connections in red) demonstrated significantly increased functional connectivity in MS when compared with healthy controls. Network seed and node abbreviations: rLPic, R. precentral gyrus; L. precentral gyrus; Pre, precentral gyrus; Put, putamen; Pre, precentral gyrus; Post, postcentral gyrus; Ins, insula; Cuneus, cuneus; putamen, Put; cuneus, cuneus; Frontal, frontal lobe; dOFC, orbitofrontal cortex; pOFC, prefrontal cortex; dACC, dorsal anterior cingulate cortex; pACC, posterior anterior cingulate cortex.

Figure 2. Diagnostic accuracy of activated FMCAM paths. The receiver operating characteristic curve (ROC) curve of the 8-path network predictor resulted in an area under the curve (AUC) of 0.805, which is considered excellent in terms of diagnostic accuracy. Path 6 (P6) alone demonstrates an AUC of 0.795, which is within the upper limits of acceptable performance.

<table>
<thead>
<tr>
<th>MS</th>
<th>HC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>36.3 ± 6.8</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>5/12</td>
</tr>
<tr>
<td>EDSS</td>
<td>4.0 ± 2.1</td>
</tr>
<tr>
<td>Disease Duration (year)</td>
<td>7.9 ± 5.6</td>
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</table>

Table 1. Subject characteristics. Relapsing-remitting multiple sclerosis (MS) patients and age- and sex-matched healthy controls (HC) were included.

<table>
<thead>
<tr>
<th>Path #</th>
<th>Seed</th>
<th>Node</th>
<th>Fisher’s Z score</th>
<th>P-Value</th>
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<tr>
<td>P1</td>
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<td>LPre</td>
<td>0.24</td>
<td>0.77</td>
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<tr>
<td>P2</td>
<td>LPre</td>
<td>LPut</td>
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</tr>
<tr>
<td>P3</td>
<td>LPost</td>
<td>RPre</td>
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</tr>
<tr>
<td>P4</td>
<td>LPre</td>
<td>RPre</td>
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<tr>
<td>P5</td>
<td>RPost</td>
<td>RPre</td>
<td>0.14</td>
<td>0.19</td>
</tr>
<tr>
<td>P6</td>
<td>RPut</td>
<td>LClau</td>
<td>0.23</td>
<td>0.14</td>
</tr>
<tr>
<td>P7</td>
<td>RMDN</td>
<td>RPuv</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>P8</td>
<td>LPre</td>
<td>RPre</td>
<td>0.26</td>
<td>0.19</td>
</tr>
<tr>
<td>P9</td>
<td>LPre</td>
<td>LPut</td>
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<tr>
<td>P10</td>
<td>RIns</td>
<td>LIns</td>
<td>0.39</td>
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<tr>
<td>P11</td>
<td>RPuv</td>
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<tr>
<td>P12</td>
<td>LClau</td>
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* Significant groupwise difference (p < 0.05).
** p < 0.05 after FDR-correction for multiple comparisons.

Table 2. Functional connectivity alterations in MS. A Mann-Whitney U test was conducted for each path of the FMCAM model. In MS, four paths demonstrated significantly increased functional connectivity relative to healthy controls (p < 0.05). Network seed and node abbreviations: rLPic, R. precentral gyrus; L. precentral gyrus; Pre, precentral gyrus; Post, postcentral gyrus; Put, putamen; Pre, precentral gyrus; Post, postcentral gyrus; Ins, insula; Cuneus, cuneus; putamen, Put; cuneus, cuneus; frontal lobe; dOFC, orbitofrontal cortex; pOFC, prefrontal cortex; dACC, dorsal anterior cingulate cortex; pACC, posterior anterior cingulate cortex; Caudal, body of caudate; Caudal, posterior cingulate cortex; PLing, anterior cingulate cortex; ACing.
Assessment of Functional Connectome in End-Stage Organ Disease Patients After Life-Threatening Surgery

G Sparacia¹, G Parla¹, M Shahriari², G Mamone¹, V Lo Re¹, A Iaia², R Miraglia¹
¹IRCCS-ISMETT, Palermo, Italy, ²Christiana Care Hospital, Wilmington, DE

Purpose
The purpose of this study was to assess the organization of intrinsic functional brain networks (functional connectome) in end-stage organ disease patients after major surgery for life-threatening conditions and compare it to a control group.

Materials and Methods
Resting-state functional magnetic resonance imaging (rest-fMRI) was performed in 10 adult patients with end-stage organ disease. The patients (7 men, 3 women, mean age 57.9 ± 7.4 years) underwent to: n=4 coronary artery bypass graft (CABG) for heart failure, n=2 orthotopic liver transplantation (OLT) for non-alcoholic cirrhotic liver failure, n=3 mitral valve repair for heart failure, n=1 pancreaticoduodenectomy for pancreatic papillary tumor. Rest-fMRI was acquired within 48 hours after intensive care unit (ICU) discharge. Structural brain MR imaging was acquired with T1-weighted, T2-weighted, diffusion weighted imaging, and susceptibility weighted imaging along with 3D isotropic T1-weighted MR images. MR examinations were performed on a 3T MR scanner. Ten age- and sex-matched healthy controls were studied with the same MR protocol. Brain functional networks were analyzed by calculating the interregional correlation of low-frequency fluctuations in spontaneous brain activity. Weighted graph-based models were employed to topologically recognize reproducibly determined large-scale functional networks, including the default mode, salience, dorsal attention, sensorimotor, visual and language networks using a seed-based approach with the Functional Connectivity Toolbox (CONN) running under MatLab. Network comparisons were thresholded using a FDR cluster-level correction approach in patients and controls.

Results
Functional connectivity in patients and controls was successfully assessed for the default mode, salience, dorsal attention, sensorimotor, visual, and language networks of the brain. Reduced connectivity was found between seeds within the default mode, salience, sensorimotor, and language networks in patients compared to the controls and the differences were significant (p < .05). No acute structural lesions were observed in patients at MR imaging.

Conclusions
Assessment of functional connectome in end-stage organ disease patients is feasible in routine clinical setting. Demonstration of functional connectivity alterations may be a useful prognostic indicator of early and long-term clinical outcome after major surgery performed for life-threatening conditions.
Purpose
Resting state functional magnetic resonance imaging (rsfMRI) is an emerging tool to explore the functional networks and disruption of normal functional connectivity in patients with brain tumors. We proposed to explore the relationship of Default Mode Network (DMN), Fronto-Parietal Network (FPN) and Dorsal Attention Network (DAN) in glioma patients using rsfMRI.

Materials and Methods
rsfMRI data of 35 patients with treatment-naïve gliomas (2015-2019; 17 WHO grade I-II, 18 grade III-IV; age: 44.6 years old +/- 18.5; 18 females, 17 males) and 70 age matched controls from the 1000 Functional Connectomes Project were analyzed using Conn functional toolbox. Seed Based Connectivity Analysis (SBCA) and Independent Component Analysis (ICA) with different number of independent components (10 to 100 ICs) and different statistical parameters (cluster-extent FDR-corrected threshold: p<0.05; voxel-extent uncorrected threshold: p<0.001 and FDR-corrected threshold: p<0.05) were used to study the DMN, FPN and DAN.

Results
Global increased connectivity was found when examining the DMN in patients compared to controls, with consistency using 4 seeds and different number of ICs (e.g. Cluster 1: 663 voxels including the subcallosal cortex, height: p<10^-6; Cluster 2: 615 voxels including the Posterior Cingulate Gyrus and the Precuneus, height: p<10^-5) (Fig 1A). However, an area of decreased connectivity was found in the posterior corpus callosum (Cluster 1: 358 voxels corresponding to the corpus callosum, height: p<10^-5) (Fig 1B). The DAN demonstrated small areas of increased connectivity in patients, in particular in occipital regions (multiple clusters with height: p<10^-6). For the FPN, increased connectivity was noted in the precuneus, posterior cingulate gyrus and frontal cortex (regions of the DMN). No difference in the connectivity of the networks of interest (for both SBCA and ICA) was demonstrated between low- and high-grade tumors as well as pertaining to their IDH (isocitrate dehydrogenase) molecular status.

Conclusions
We found disrupted functional connectivity in the three networks of interest in glioma patients, the most affected network being the DMN with global increased connectivity, suggesting a global dysregulation of brain connectivity due to gliomas. This could be explained by decreased connectivity between the cerebral hemispheres across the corpus callosum.

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Recent National Trends in Functional MRI Utilization Among Medicare Beneficiaries

S Asnaﬁ1, R Duszak1, J Hemingway2, J Allen1, D Hughes3
1Emory University School of Medicine, Atlanta, GA, 2Harvey L. Neiman Health, Reston, VA, 3Georgia Institute of Technology, Atlanta, GA

Purpose
To evaluate evolving functional MRI (fMRI) utilization by provide specialty and place of service in the Medicare fee-for-service population since the establishment of dedicated fMRI CPT codes.

Materials and Methods
Using annual aggregate Medicare Physician Supplier Procedure Summary claims data from 2007 through 2017, all fMRI services were identified using the following Current Procedural Terminology (CPT) codes: 70554, 70555, and 96020. fMRI utilization rates (per 1,000,000 Medicare enrollees) by specialty group and place of service were calculated using annual enrollment data.
Results
Between 2007 and 2014, fMRI utilization rates increased 85% (from 17.7 to 32.8 per 1,000,000 Medicare beneficiaries). Since 2014, the fMRI utilization rates have remain static (32.8, 32.6, 32.7, and 33.3 from 2014 through 2017, respectively). Radiology (defined as diagnostic radiology, interventional radiology, and nuclear medicine) consistently remains dominant specialty group providing fMRI for Medicare beneficiaries (86.4% to 88.6%, in 2007 and 2017, respectively) (Figure 1). Most fMRI services were rendered in an outpatient setting (including office, outpatient hospital, and independent clinic), accounting for 65.4% and 65.4% of all services in 2007 and 2017, respectively (Figure 2).

Conclusions
In the first 7 years since fMRI became trackable with unique CPT codes, utilization among Medicare beneficiaries increased markedly, reaching a plateau in 2014. Radiologists have consistently remained the dominant specialty group, with outpatient settings consistently the most frequent places of service. Further work is necessary to assess whether these utilization levels are adequately meeting clinical needs overall and across sociodemographic and geographic groups.
Scientific Abstract Session: Interventional/AVM/Aneurysm

1834

Efficacy of intravenous milrinone versus intra arterial nimodipine in the management of clinical vasospasm secondary to aneurysmal sub arachnoid hemorrhage

S GAIKWAD1, M GUPTA1

1ALL INDIA INSTITUTE OF MEDICAL SCIENCES, new delhi, delhi

Purpose

Vasospasm causes significant morbidity and mortality in aneurysmal subarachnoid hemorrhage (aSAH) patients. Apart from induced hypertension, hemodilution and hypervolemia (HHH therapy), except for nimodipine, none has proved to be effective. Intraarterial (IA) nimodipine is commonly used in the management of vasospasm along with supportive treatment. It is invasive, requires repeated sessions, associated with reflux vasospasm. Intravenous (IV) milrinone is also reported in the literature as effective drug for the management of vasospasm. In this study, we observed the efficacy of IV milrinone versus IA nimodipine in the management of clinical vasospasm secondary to aneurysmal subarachnoid hemorrhage.

Materials and Methods

Total 105 patients of clinical vasospasm were observed from January 2017 to March 2019. 65 patients reviewed retrospectively who underwent for IA nimodipine therapy and 40 patients reviewed prospectively who received continuous IV milrinone infusion.

Results

There were 65 and 40 patients in IA nimodipine and IV milrinone protocols, respectively. Clinical response (as primary end point of the study) was comparable between 2 cohorts: 55.38% (95% confidence interval [CI], 43% - 67 %) in the IAN versus 52.5 % (95% CI, 37%- 67.9 %) in IVM group (p=0.773). The standard error was 0.061 and 0.078 in IAN and IVM cohorts respectively. Multiple logistic analysis showed that nimodipine or milrinone use was an independent factor for treatment of vasospasm (OR 0.96, 95% CI 0.38-2.38, p = 0.773). The favourable clinical outcome mRS 0-2 at 3 months was 58% in IAN and 70% in IVM cohort with p value=0.373. Average follow up was 14.5 months (4-31) in IA nimodipine and 9 months (3-17) in IV milrinone group. So, there was no statistical difference in clinical improvement, MRS at 3 months and subsequent follow-ups in both the groups.

Conclusions

We can conclude that no significant difference in the clinical responses and neurological outcomes in IAN or IVM treatment protocols. So, IVM treatment protocol appears to be as effective as IAN in management of cerebral vasospasm. IVM is easy-to-use, safe, low-cost, and bedside tool and alternative treatment of CVS in aSAH patients and demonstrates the potential to avoid the use of angiography, a high cost, invasive procedure.
A Feasibility Study of MR Angiography with Ultrashort Echo Time (UTE) in the Follow-up of Intracranial Aneurysms Treated with Endovascular Coiling: Comparison of TOF, PETRA, and CE-MRA

S You¹, B Kim¹, B KIM¹, J Ryu¹
¹Korea University Medical Center, Seoul, Korea, Republic of

Purpose
To evaluate diagnostic performance of pointwise encoding time reduction with radial acquisition (PETRA) magnetic resonance angiography (MRA) in detection of residual flow and visualization of in-stent flow in patients undergoing endovascular coiling compared with those of time-of-flight (TOF) and contrast-enhanced (CE) MRAs.

Materials and Methods
Patients treated with simple or stent-assisted coiling for intracranial aneurysms were retrospectively enrolled. All sets of MRA including TOF, PETRA and CE sequences were obtained in the same day. The degree of aneurysm occlusion and height of residual flow were evaluated by independent readers at digital subtraction angiography (DSA) and MRA. In patients undergoing stent-assisted coiling, visibility of in-stent flow and relative signal-to-noise ratio (SNR) of the stent-placed vessel were estimated on MRA. In-stent flow diameter was measured both on DSA and MRA. Decision tree analysis was performed to find optimal follow-up sequences after endovascular coiling.

Results
A total of 189 patients who had assessable TOF, PETRA, and CE MRAs after endovascular coiling were enrolled. In patients who undergoing simple coiling (n=128), all MRA sequences showed similar accuracies (> 85.00%) in detection of residual flow and there was no significant difference in measured height of residual flow between DSA and each MRA sequence (p = 0.183). In patients who undergoing stent-assisted coiling (n=61), PETRA (90.0%) showed higher accuracy in detection of residual flow than TOF and CE MRA (p = 0.003) and measured height of residual flow were similar to those on DSA in the order of PETRA, CE, and TOF MRAs (p = 0.003). The PETRA MRA was proved to have higher visual score of in-stent flow (p < 0.001) with the highest relative SNR (p < 0.001) and most similar measured values of in-flow diameter to DSA among the three MRA sequences (p < 0.001). In the decision tree model, type of stent and diameter of in-stent flow were adopted as significant factors to determine optimal follow-up MRA sequence.

Conclusions
PETRA MRA might be useful in diagnosis of residual flow and assessing in-stent flow after stent-assisted coiling. All three sequences (TOF, PETRA, and CE-MRA) were sufficient to assess the neck remnant after simple coil embolization.
Breaking Down Barriers in Intracranial Flow Diversion: The Silk Vista Baby

C Parra-Farinas, J Diestro, J Spears, T Marotta
St. Michael's Hospital, University of Toronto, Toronto, Ontario

Purpose
Flow diversion has emerged as minimally invasive armamentarium for intracranial aneurysms' repair. However, treatments for aneurysms of distal vessels have not yet been perfected. The Silk Vista Baby (SVB) offers the unique feature of deliverability via a 0.017 inch microcatheter. The aim of our study was to assess the SVB technical success and safety in these technically demanding aneurysms.

Materials and Methods
The medical records from patients who underwent endovascular aneurysm repair with the SVB between November 2018 and September 2019 were retrospectively reviewed. Demographics, clinical presentation, anticoagulation and antiplatelet therapy, aneurysms' features, stent information, technical success, intra-procedural and post-procedural complications, and clinical and radiological follow-up characteristics were recorded. DSA and MRI assessed the efficacy of the SVB after deployment and at the first outpatient clinic follow-up. Raymond-Roy and O'Kelly-Marotta scales were used to assess aneurysms' occlusion.

Results
We prospectively included 11 consecutive patients (11 aneurysms). A total of 13 SVBs were employed. Mean age was 58.5±8.5 years old, 81.8% female. Two patients presented with subarachnoid hemorrhage. Three had recurrent aneurysms after initial clipping (n=2)/coiling (n=1). Aneurysms' locations: anterior communicating artery (n=4), basilar artery (n=3), middle cerebral artery (n=2), anterior cerebral artery (n=1), vertebral artery (n=1). Mean aneurysms' maximum diameter: 10.2±5.5 mm. The Headway-17 was used in 10 treatments and the Phenom-17 in 1. Adjuvant coiling was required in 7 patients. There were 3 intra-procedural stent-related complications: in 2 patients the stent prematurely detached while still inside the tortuous path of the microcatheter and in 1 case the SVB herniated into the aneurysm dome after requiring balloon angioplasty to fully open the stent. Median length of stay was 3 days (1-29). The discharge mRS score did not change from the admission. Immediate flow diverting effect: complete occlusion (n=3), near-complete occlusion (n=1), persisting filling (n=7). Follow-up occlusion rates: complete occlusion (n=4), near-complete occlusion (n=1), persisting filling (n=2). Median time to follow-up was 75 days (52-129). In 4 cases follow-up MRAs are pending.

Conclusions
The new low-profile flow diverter SVB provides a feasible option in the treatment of distal circulation technically demanding aneurysms obtaining high adequate occlusion and low complication rates.
Ear Arteriovenous Malformation Management

W Yakes

Purpose
To determine the efficacy of Ethanol Endovascular Repair of Ear Arteriovenous Malformation (AVMs).

Materials and Methods
14 patients (9 female, 5 males; age range 6-39 years; mean age: 22 years) with ear AVMs presented for therapy. Two patients had failed prior embolizations (PVA/coils/nBCA/steroids) and 2 patients had other therapies (laser/excisions/grafting). All presented with a grossly enlarged painful ear, and 5 patients had intermittent bleeding. All patients underwent transcatheter and direct puncture ethanol treatments. (86 procedures).

Results
All 14 patients were cured of their AVM at long-term follow-up (mean follow-up: 52 months). One patient had transient partial VII nerve palsy. Two patients had minor blisters and ear injuries that healed on the outer tragus. The longest follow-up demonstrating cure was 12 years.

Conclusions
Ethanol endovascular repair of Ear AVMs can achieve cures in this vexing lesion that previously was treated with resection of the ear and with high recurrence rates. This series documents long-term cures of AVMs of the ear and scalp that were not treatable by endovascular approaches as previously documented in the world's literature. Permanent treatment of the auricular AVMs is
documented and no recurrence occurred in any patient. Only one article is published (group from Shanghai, China) emulating this technique.

11:28AM - 11:34AM

**False Localization of Arteriovenous Shunting to the Jugular Foramen on Arterial Spin Labelled MRI and Time-of-Flight MRA**

M Caton¹, A Callen¹, A Copelan¹, M Amans¹

¹University of California, San Francisco, San Francisco, CA

**Purpose**

Arterial spin labelled (ASL) MRI is a useful tool for detecting arteriovenous shunting lesions, such as small dural arteriovenous fistula (dAVF), by localizing spin-labeled blood in veins [1]. Time-of-flight (TOF) MRA can complement ASL by co-localizing abnormal venous flow-related signal [2]. We observed several cases of ASL-MRA co-localization to the sigmoid sinus and jugular foramen in asymptomatic patients leading to catheter angiogram which ultimately excluded the diagnosis of dAVF (example case Fig 1A, 1B). We hypothesize that this imaging pattern may occur during transient reflux of spin-labelled venous blood in the internal jugular vein, plausibly related to intrathoracic pressure or valve closure, a pattern which has previously been shown in the cavernous sinus [3]. The purpose of this report is to describe this case series with the aim of understanding the mechanism of this false-positive imaging finding and to reduce the need for confirmatory catheter angiography.

**Materials and Methods**

We retrospectively reviewed our imaging database for MRI/MRA reports during the period of March 2015-October 2019 in which the presence or absence of intracranial arteriovenous fistula was mentioned in the radiologist's report or study indication. We excluded cases performed to evaluate known but untreated dAVF, suspected carotid-cavernous fistula, and studies that did not include both ASL and MRA. We present several cases of de novo diagnosed transverse sinus/sigmoid dAVF from the same period to show the overlapping imaging appearance of true and false positive exams (example of true dAVF, Fig 1B, 1C).

**Results**

60 exams met criteria for further review. Of these, 6 cases of false-positive ASL-MRA signal abnormality were identified. 6/6 (100%) of ASL-MRA co-localization occurred on the left side and the affected jugular vein was patent on time-resolved angiography or post-contrast imaging in all cases. 5/6 cases occurred on the non-dominant jugular vein; one patient had a codominant jugular venous system. 4/6 patients had follow-up with conventional angiogram showing no fistula; one patient had near resolution of this finding on subsequent MRI/MRA and one patient had stable findings at follow-up.

**Conclusions**

False localization of ASL/MRA signal in the jugular foramen may mimic dAVF. This finding is common in select populations and typically occurs in the non-dominant, left jugular vein, suggesting jugulosigmoid reflux as a plausible mechanism.
Purpose
The aim of the study is to assess morphologic characteristics of cerebral arteriovenous malformations (AVMs) and to determine the association between angio-architecture of AVMs with outcomes of repair.

Materials and Methods
A single-retrospective institutional study was performed to assess AVMs morphologic characteristics and outcomes. Baseline workout included CT-angiography, contrast-enhanced MRA and cerebral angiography. CTA/MRA-based semi-automated segmentation analysis was performed using Alma software to calculate AVM nidus volume (NV), venous drainage volume (VDV) and arterial volume (AV). Endpoints included re-interventions, post-operative intracranial hemorrhage and failed AVM exclusion (ICH+AVM re-intervention). Mann-Whitney-U tests were used for univariate analysis. Logistic-regression analysis was performed to determine individual odds-ratios.

Results
Over a 24-month period, 30 patients (11 men [37%] and 19 women [63%]) with median age of 36.5 years (interquartile range [IQR], 16-45 years) were included in the study. Median NV was 11.5 cc (IQR, 6.2-22.4 cc) with a median VDV of 2.32cc (0.87-7.07 cc) and
a median AV of 0.85 cc (IQR, 0.39-2.1 cc). Primary endovascular repair was performed in 18 patients (60%) and open repair in 12 patients (40%). Re-intervention was required in 13 patients (43%) and 2 patients (6%) presented post-operative ICH. In total, 15 patients (50%) were considered with failed AVM exclusion. Patients that required re-intervention were found with lower arterial volumes (0.43 cc [IQR, 0.11-.09 cc] when compared to patients successfully treated at a primary repair (2.10cc [IQR, 1.35-2.92 cc]) (p<0.01). Similarly, patients with failed AVM exclusion had lower arterial volume (0.5 cc [0.18-1.14 cc] versus 1.6 cc [IQR, 0.71-2.3 cc] [p=0.08]). Lower arterial volume was associated with a 27% increase per cc decreased of primary repair failure (odds ratio, 2.7, 95% Confidence-Interval, 1.7-5).

Conclusions
VM re-intervention was required in 43% of the patients with a frequency of post-operative ICH of 6%. AVMs with lower arterial volume were found at higher risk of failed repair.

(Filename: TCT_2099_AVMvolumecalculation.jpg)

2260

Mandibular AVM Diagnosis and Curative Treatment

W Yakes

1The Yakes Vascular Malformation Center, Englewood, CO

Purpose
To determine optimal management strategies for the treatment of intraosseous mandibular AVM.

Materials and Methods
Twelve patients (9 females, 3 males), age 9 -14; mean age 10, underwent endovascular therapy to treat their mandibular AVMs. Nine patients had distinct intraosseous AVMs. Three had additional multiple facial and intra-maxillary AVMs requiring treatment. Outside institutions recommended massive hemi-facial resections in these patients. Four patients had prior PVA and gel foam embolization, one patient had a lip graft, one had prior mandible surgery, all that had failed.

Results
All twelve patients have demonstrated MR and angiographic cure of their AVMs. One patient's therapy is not completed and is ongoing. The patients mandibular AVMs cured, a third AVM in this patient in the infratemporal fossa is still undergoing treatment. The follow-up range is 11 months – 41 months, with a mean follow-up of 29 months. No complications were noted in treatment of mandibular AVMS. One patient required a minor gingival surgery after treatment of an additional intramaxillary AVM with inferior extension.

Conclusions
Endovascular approaches to manage mandibular AVM can be curative. The mandibular intraosseous variety is largely a fistula between artery and vein within the bone and the bulk are Yakes Type IIIa/IIIb AVMs. All respond and can be cured by endovascular ethanol therapy alone. Surgery was not required in any patient. Surprisingly no complications were encountered in this patient series. Long-term cures are noted in this patient series with endovascular approaches alone. No massive surgical resections in any patient, even in patients with multiple AVMs of the soft tissues, mandible and maxilla, was required to effect cure. In patients who suffered
hemorrhages from floating teeth, bone formed and stabilized the teeth and no further hemorrhages occurred. Ethanol sclerotherapy proved curative in mandibular intraosseous AVMs in patients who had additional facial soft-tissue and intramaxillary AVMs that were cured as well at long-term follow-up.

2265
Management of Tongue Venous & Lymphatic Malformations
W Yakes 1
1The Yakes Vascular Malformation Center, Englewood, CO

Purpose
To determine the efficacy of ethanol embolization in management of tongue venous and lymphatic malformations.

Materials and Methods
40 patients (23 females, 17 males; mean age: 38 years) presented with tongue low-flow malformations. Forty-seven patients had undergone 61 failed previous procedures (embo, laser, surgery, steroid injection, alpha-interferon, radiation). All patients had baseline arteriograms and MRs. All patients underwent direct puncture ethanol endovascular therapy.

Results
Of 40 patients with venous and lymphatic malformations, 32 patients had dramatic reduction and 7 patients' therapy is ongoing with concurrent reductions (mean f/up: 60 months). One patient with AVM required additional surgery and 1 patient with mixed veno-lymphatic malformation required surgical debulking of excess tissues. Minor complications such as tongue blisters (9 instances) healed spontaneously; 3 tongue focal areas of necrosis healed spontaneously; 3 infections responded to antibiotic treatment; 1 focal tongue hemi numbness resolved. 1 patient with dense VMs had a portion of the tongue slough and the tongue healed and remolded with no treatment required.

Conclusions
Ethanol embolotherapy is a primary and consistent form of therapy to eradicate low-flow vascular malformations of the tongue permanently at long-term follow-up. Rarely is concurrent surgery required. Ethanol sclerotherapy is a curative treatment in which recurrences do not occur and permanent ablations are the rule. Complications are minor and rare.

ASFNR Programming: Quantitative Neuroimaging in the Clinic
2296
Supervised classifier versus independent component analysis for presurgical planning using resting-state functional MRI
M Fakhri 1, A Snyder 2, M Miller-Thomas 3, R Eldaya 4, J Shimony 5
1Mallinckrodt Institute of Radiology, Saint Louis, MO, 2Washington University School of Medicine, Saint Louis, MO, 3Mallinckrodt Institute of Radiology, Washington University, St Louis, MO, 4Washington University, St Louis, MO, 5Washington University School of Medicine, St. Louis, MO

Purpose
Resting-state functional MRI (rsfMRI) is increasingly used in the context of presurgical planning. There is no consensus regarding the optimal analytic approach. Challenges include reducing non-neural noise and identification of clinically relevant resting state networks. We compared Independent Component Analysis (ICA), which exemplifies unsupervised classification, vs. supervised classification using a trained multilayer perceptron (MLP) as techniques for identification of language-relevant eloquent cortex.

Materials and Methods
A total of 37 patients with a primary glial tumor near Broca's area, WHO grade 2-4, centered in the inferior frontal gyrus, were included. Each dataset was analyzed with both ICA and MLP methods. ICA was computed using FSL (Oxford University, UK, https://fsl.fmrib.ox.ac.uk/). For ICA, the language component was selected by three neuroradiologists and inter-rater reliability was calculated. The MLP was trained (1) to associate correlation maps with a priori defined, resting-state network identities such as language. For each subject, the area under the receiver operating characteristic curves (AUC) was calculated for both study methods in a language region of interest (ROI)(Figure 1). The ROI is derived from meta-analysis of 1101 fMRI studies using Neurosynth (https://neurosynth.org/). Key study variables included: patient age, number of independent components (ICs), MLP and ICA AUCs (with or without tumor masking), and the tumor volume.

Results
The mean age of the study participants was 42.7±14.4 years and 35% of the patients were female. MLP was able to successfully map language in all patients, while 3 cases (8%) ICA failed to show language network. Interclass correlation for the three readers was 0.534, p= 0.002. MLP outperformed ICA in mapping the language network (figure 2, p<0.0001). We observed a negative correlation between tumor volume and calculated AUC (Figure 3). Figure 4 shows mean language topography in patients as compared to a publicly available rsfMRI dataset.
Conclusions
Supervised classification is superior to the standard ICA method in the estimation of resting-state language network in the context of presurgical language mapping. Advantages include lower failure rate and no dependence on human pattern recognition that can address the concerns that have limited the clinical use of rsfMRI.

(Filename: TCT_2296_ASNR_image.jpg)

1739

Posterior circulation stroke: AI-based outcome prediction using quantitative image features

H KNIEP1, P Sporns2, G BROOCKS3, A Kemmling4, J Nawabi5, S Elsayed6, J Fiehler7, U HANNING1
1UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, Germany, 2Muenster University Hospital, Muenster, North Rhine-Westphalia, 3UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, 4University Hospital Kaiserslautern, Kaiserslautern, AK, 5Charité University Medical Center Berlin, Berlin, Berlin, 6University Clinic Hamburg-Eppendorf, Hamburg, Germany, 7University Medical Center Hamburg-Eppendorf, Hamburg, AK

Purpose
Posterior circulation strokes are often associated with adverse functional outcome or death. Early triage of patients according to the expected functional outcome could optimize therapeutic strategies and general patient care. Different approaches for predicting outcome in patients with posterior circulation stroke have been proposed (1-3). However, most methods rely on conventional visual assessments and suffer from high inter- and intra-reader variability. We propose an artificial-intelligence based evaluation of high-end image features extracted from non-contrast CT (NCCT) scans at admission to predict functional outcome.

Materials and Methods
The analysis includes NCCT brain scans from 69 patients with acute posterior circulation ischemia. Follow-up CT scans served as ground truth for the final infarct extend. In total, the dataset comprises 138 regions with definite infarction in the follow-up imaging (Table 1). 54% of the included patients were female, mean age was 69 years and mean functional outcome based on modified Rankin Scale (mRS) metrics was 4.9. Good functional outcome was defined as mRS ≤ 3 (observed for 17/69 patients). 9632 region-specific image features were extracted from admission NCCTs and evaluated utilizing random forest algorithms with 5-fold model-external cross-validation. For final model training and validation, the 100 most important features (Gini impurity) were determined for each training data set and employed in the respective validation run.

Results
Receiver Operating Characteristics area under the curve of the validation sets for predicting good functional outcome was 0.88 (95% confidence interval [0.80; 0.94]). Depending on selected cut-off points, specificities and sensitivities of 80% were observed (Figure 1). Gini impurity importance metrics demonstrate that image features extracted from midbrain and posterior cerebral artery (PCA) territories have the highest predictive value for outcome classification (Figure 2).

Conclusions
Quantitative features of acute NCCT images provided high discriminatory accuracy in predicting good functional outcome in patients with posterior circulation stroke. If applied in a larger cohort, state-of-the-art artificial intelligence-based evaluation of region-specific image metrics might help to better understand the determinants of functional outcome. After transition into clinical routine, the proposed approach could allow for efficient triage and optimized therapy regimes in patients with posterior circulation occlusion.

ASNR20 Virtual Proceedings Page 659
Multidisciplinary Management of Spine Tumors and Pain

1799

2:35PM - 2:40PM

Posterior Screw Stabilization Associated with “Armed Kyphoplasty” for Complex Thoraco-Lumbar Spine Fractures Avoids Corpectomy: a Case Series

L Bertulli¹, P Scarone¹, A CIANFONI¹

¹Neurocenter of Southern Switzerland, Lugano, Canton Ticino

Purpose

Complex unstable thoraco-lumbar fractures, with burst morphology, extreme collapse/kyphosis or extensive osteolysis, are treated with posterior stabilization (with or without decompressive laminectomy), and generally require fracture reduction and stabilization of the vertebral body (VB). Standard vertebroplasty and balloon-kyphoplasty might be not feasible or represent an undertreatment, while corpectomy and grafting carry significant morbidity. The aim of the present study is to evaluate feasibility, safety and results of the recently introduced "armed kyphoplasty" (AK) techniques to stabilize the VB, such as vertebral body stenting (VBS), stent-screw-assisted internal fixation (SAIF), and Spinejack (SJ), combined to a surgical posterior stabilization, in a single operative session, in a series of complex unstable thoraco-lumbar fractures.

Materials and Methods

Retrospective analysis of a consecutive series of patients with complex thoraco-lumbar fractures, treated concurrently with posterior transpedicular screw fixation, with and without laminectomy, and AK techniques. The screws were placed with navigation, the AK was performed with single or bi-plane fluoroscopy, CT scan and X-ray at the end of the procedure, and standing X-rays or CT scans at follow-up were obtained. Intraoperative data, complications and radiological outcome data were collected.

Results

20 fractures during 14 procedures in 13 patients were treated from 2013 to 2019. The fractures were of neoplastic (36%), traumatic (28%), and osteoporotic (36%) etiology. Half cases were treated with open surgery and half with minimally-invasive techniques. In 6 cases (43%) laminectomy was performed. During follow-up (1-28 months, mean 13 months), no mobilization of VB implants nor recurrent fracture of the treated levels was observed, while one surgical site infection, one screw pull-out and one adjacent level fracture required new surgical treatment, but in no case corpectomy was necessary.

Conclusions

Combining posterior stabilization and AK is a feasible, safe and effective technique to treat complex thoraco-lumbar spine fractures of all etiologies, and avoids corpectomy. Combined anterior and posterior support ensures a higher stability and prevents hardware failure or worsening of the treated fracture. Further investigation with larger series is needed to strengthen our results and implement this technique in daily clinical practice.
Value of Total Spine MRI in the Evaluation of Non-accidental Trauma

T Reher¹, R Radhakrishnan¹
¹Indiana University School of Medicine, Indianapolis, IN

Purpose
There is evidence that cervical MRI can demonstrate injuries not suspected on head MRI in about a third of the children evaluated for abusive head trauma (AHT). The added value of whole spine MR in AHT is unknown. The incidence of spine injuries in NAT cases varies in the literature, identified in 1.5% of cases in a recent analysis. The purpose of this study is to evaluate the role of MR of the whole spine in children suspected for AHT and characterize the findings and added value of including the thoracic and lumbar spine (TL spine).

Materials and Methods
This is an IRB approved retrospective (1/2017-10/2019) study in children younger than 3 years evaluated for AHT who had MR of the brain and whole spine MR. From the medical records we reviewed demographic and clinical information, and from the radiology reports the findings from skeletal survey, CT of the body and CT and MR scans of the head and spine. We recorded the type of injuries in the thoracolumbar spine detected in the spine MR and whether these injuries were reported on other imaging modalities. We also recorded any other spinal injuries and imaging findings of AHT.

Results
The study included 77 children (25 females, 33%) with a mean age of 6 months (range 15 days - 2.1 years). 34/77 children (44%) had positive spine findings of which the TL-spine was involved in 27/77 (35%). 19/77 (25%) children had positive TL-spine without
cervical spine findings. These 19 patients with injuries limited to the TL-spine had the following injuries: spinal cord hemorrhage (n=12, 15.6%) and vertebral fractures (n=6, 7.8%). Most (61/77, 79.2%) patients had positive findings for AHT on combined MRI or CT head scan as follows: with scalp injury (34, 44.2%), calvarial fractures (17, 22.1%), extraaxial hemorrhage including venous injury (38, 49.4%) and brain parenchymal injury (34, 44.2%). Isolated TL-spine injury on MR without evidence of AHT injuries in the cervical spine was found in four (4/77, 5.2%) children; compression fractures (n=3) and soft tissue edema related to rib fractures (n=1). The isolated TL-spine injury was identified skeletal survey in two of the four patients.

Conclusions
Thoracolumbar findings are more common than reported in the literature in the setting of NAT. Rarely, there may be positive findings in the thoracolumbar spine even in the absence of intracranial or cervical spine injury in these children. Imaging of the entire spine may be necessary to completely characterize spinal injury in this population.

<table>
<thead>
<tr>
<th>Positive total spine (n=34)</th>
<th>Positive TL-spine w/Negative C-spine (n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Head (n=61)</td>
<td>28 (36)</td>
</tr>
<tr>
<td>Negative Head (n=16)</td>
<td>6 (13)</td>
</tr>
</tbody>
</table>

Table 1: Incidence of spine and thoracolumbar (TL) spine findings and the overlap with positive or negative Head imaging. n=77

(Filename: TCT_1923_Table1.jpg)
Conclusions
Almost half of all complete spine MRI ordered by the ED resulted in normal or degenerative disease not requiring admission for spine issues. Pre-imaging consultation along with specific chief complaints were statistically significant when comparing normal and abnormal MRI results. These findings may potentially serve as ancillary information that the on-call resident or attending emergency radiologist can use for triage of MRI whole spines ordered by the ED.

Scientific Abstract Session: AI 3

2276

Unsupervised Machine Learning-Assisted Reporting Can Speed Up the Reporting Process while Concurrently Facilitating a Coherent Reporting Language

M MAROS¹, A Junge², V Saase³, C Cho⁴, B Kämpgen⁵, H Wenz²
¹MEDICAL FACULTY MANNHEIM, HEIDELBERG UNIVERSITY, GERMANY, HEIDELBERG, Germany, ²Medical Faculty Mannheim, Heidelberg University, Germany, Mannheim, BaWü, ³University Medical Center Mannheim, Mannheim, Baden-Wuerttemberg, ⁴University Medical Center Mannheim, Heidelberg University, Germany, Mannheim, Baden-Wuerttemberg, ⁵EMPOLIS Information Management GmbH, Germany, Kaiserslautern, Rheinland-Pfalz

Purpose
Efforts have been put forward to standardize and unify the radiological reporting language. However, the adoption of structured reporting has been only incremental. Tremendous amounts of information are laying around unexploited in form of conventional free-text reports at most institutions. Here, we present a pipeline of unsupervised clustering methods combined with language model-based deep learning algorithms and DICOM metadata to create automated context-sensitive CAD tools that can not only speed up reporting but also harmonize the reporting language while increasing adherence to local institutional standards.

Materials and Methods
We performed a single center retrospective cohort study of 15,000 consecutive imaging procedures (07/2018-07/2019). Conventional free-text reports were retrieved from local RIS (Syngo, Siemens). The DICOM metadata (e.g. protocol, sequences, etc.) were also retrieved and linked. The findings sections were used to create document embeddings[2]. Next, dimension reduction techniques (e.g. PCA and t-SNE[1]) were applied to this layer. Search trees, hashing functions and universal language model tuning [3] were also explored. These trained algorithms were then embedded into a locally developed open-source reporting tool, which during reporting of a new case automatically proposed complete reports or text segments that were most similar to the current case at hand while context-sensitively suggesting most common variations of relevant text snippets for insertion.

Results
Report level embeddings using Doc2Vec following PCA and tSNE clustering showed (Fig.1) clear clustering of modalities such as CT, DSA or MRI. Further, multiple (sub)clusters of protocols and clinical entities emerged. Interestingly, external reports were identified as a highly distinct subcluster (Fig. 1). The context-sensitive CAD algorithm utilizing the un- and semi-supervised models significantly improved reporting speed, when compared both to conventional free-text/speech (p<0.01) and clickable structured reporting templates (p<0.001).

Conclusions
Unsupervised machine learning methods exploiting information in readily available conventional free-text reports can support general- and neuroradiologists to improve reporting speed, harmonize the reporting language and concurrently increase quality, thus facilitating downstream research.
Direct, clinically-feasible visualization of functional neurosurgery targeted structures using deep learning architecture denoising of FGATIR MRI

B Ades-aron1, T Shepherd2
1New York University, New York, NY, 2NYU Langone Health, New York City, NY

Purpose
Conventional MRI does not directly visualize specific thalamus, basal ganglia and brainstem structures targeted by functional neurosurgery. 3D Fast Gray Matter Acquisition T1 Inversion Recovery (FGATIR) employs a short inversion time to suppress white matter signal and provides unparalleled direct visualization of relevant brainstem and deep gray matter structures. FGATIR though has low peak signal-to-noise ratio (pSNR) such that a clinically-useful 800-micron isotropic resolution dataset requires 42-56 min acquisitions. We applied a Denoising Convolutional Neural Network (DnCNN) architecture to make the FGATIR clinically-feasible.

Materials and Methods
DnCNN uses a feed-forward residual learning architecture. We compute the mean-squared-error loss between an estimated residual from a noisy input image and the desired residual image. The input layer consists of 64, 3 × 3 convolution filters to generate 64 feature maps and ReLu for nonlinearity, followed by 20 layers of 3 × 3 convolution, batch-normalization, and ReLu for feature maps, and a final reconstruction layer of size 3 × 3 × 64. Training data consisted of non-MRI images in order to reduce overfitting bias. Gaussian noise of SNR from 1 to 100 was added to a total of 400 training datasets prior to data augmentation, along with a validation dataset consisting of 40 images for regularization. FGATIR data was processed in 2D by running slices of raw data through the forward model and subtracting the computed noisemap. The trained network was tested on data from an individual FGATIR case and compared with pSNR levels for one average, 4 averages, and 9 averages.

Results
We observed an increase in pSNR from 30 to 42 (30.6%) using a single-average FGATIR acquisition (14 min scan time). This was equivalent to acquiring four averages using a conventional dataset (56 min scan time). Image contrast and quality were evaluated by board-certified neuroradiologist and neurosurgeon. Images were considered sufficient for visualization of the structures relevant to functional neurosurgery applications, including MR-guided focused ultrasound of the VIM.

Conclusions
Denoising FGATIR data using a DnCNN architecture provides the capacity for a 30% increase in SNR level in a single average, greatly increasing the feasibility of using the FGATIR sequence in functional neurosurgery or clinical-radiology correlations in subcortical disease (e.g. directly identifying brainstem structures affected by ischemic stroke).
Deep Neural Network Classification of I-123 Ioflupane SPECT

D Wang¹, B Williamson¹, B Mahoney¹, T Eluvathingal¹, J Scheler¹
¹University of Cincinnati, Cincinnati, OH

Purpose
Presynaptic Parkinsonian syndromes demonstrate a decrease in the nigrostriatal presynaptic pathway dopamine transporters (DaT), as opposed to diseases without presynaptic dopaminergic loss, such as essential tremor or drug-induced parkinsonism. I-123 ioflupane binds to presynaptic DaT in the nigrostriatal pathway and semi-quantitative analysis of radiotracer intensity on single-photon emission computed tomography (SPECT) can diagnose presynaptic dopaminergic deficits. Current visual assessment and semi-quantitative analysis can have interobserver variability. This study aims to use a deep neural network for classification, without the need for quantitative analysis.

Materials and Methods
I-123 ioflupane SPECT images were obtained from the openly available PPMI database (www.ppmi-info.org/data), with associated visual interpretation. 375 images were used in the training set, 100 in the validation set and 125 in the test set. Before downloading from the database, images were already preprocessed, including iterative reconstruction (HOSEM) of the SPECT signal, attenuation correction, smoothing, and alignment to a standard space template (MNI). The resulting dicom images were converted to nifti format. They were then whitened (normalized) to stabilize the neural network and read into a TFRecord Database. The network used to classify was a 3-dimensional extension of the ResNet34 architecture. Each convolutional layer was initialized using Glorot uniform initialization. Before the final dense classification layer, a dropout layer was added at a rate of 50% to prevent overfitting. Loss was measured by binary cross-entropy and an Adam optimizer was used with a learning rate of 0.0001. To further prevent overfitting, early stopping was used with a patience of 200 (out of 1000 epochs). The model was trained on a high-performance computing cluster, using 2 NVIDIA V100 GPUs.

Results
Our model was able to achieve an accuracy of 94%, sensitivity of 94% and specificity of 95% on the test set, with an AUC of 0.98.

Conclusions
Our deep neural network accurately identifies the presence of a nigrostriatal presynaptic dopaminergic deficit based on I-123 Ioflupane SPECT images.

Automated Detection of Intracranial Proximal Vessel Occlusion on Computed Tomography Angiography

A Malhotra¹, M Khunte², X Wu³, I Ikuta⁴, S Payabvash³
¹Yale University School of Medicine, New Canaan, CT, ²Yale School of Medicine, New Haven, CT, ³Yale University School of Medicine, New Haven, CT, ⁴YALE UNIVERSITY SCHOOL OF MEDICINE, MILFORD, CT

Purpose
Accurate and prompt diagnosis of proximal large vessel occlusion (LVO) is critical, as endovascular thrombectomy is highly effective in improving patient outcomes in patients with LVO. We assessed the accuracy of an automated LVO-detection algorithm in a cohort of acute ischemic stroke patients.

Materials and Methods
A convolutional neural network (CNN) model developed by Aidoc (Tel Aviv, Israel) was used to detect MCA-M1 and/or ICA.
occlusions. Retrospective review of stroke cases from the institutional stroke database was performed after approval from Institutional Review Board. A total of 243 patients were included in the study- including 103 known proximal LVOs - Internal Carotid artery (ICA) and Proximal MCA (M1) occlusions- confirmed on conventional angiography. Another cohort of 140 consecutive patients undergoing CTA in the month of August 2019 were included for analysis. The algorithm results for the second cohort were compared with the radiologist's reads. Sensitivity, specificity and accuracy for occlusion results (Positive versus Negative) as well as Site of occlusion was determined.

Results
The first cohort of 103 known proximal LVOs included 77 M1 and 26 ICA occlusions. The algorithm showed a sensitivity of 92.3% and specificity of 94.9% with an accuracy of 94.3% for identifying the site of occlusion. For detecting occlusion (positive versus Negative) in consecutive patients undergoing CTA, the algorithm showed sensitivity of 87.6% and specificity of 86.7% with accuracy of 87.5%.

Conclusions
The automated algorithm had very high sensitivity and specificity for detection of LVO, as well as identifying the site of occlusion. This has tremendous potential in the emergency setting as a screening tool to expedite formal diagnosis and improve work flow.

![ROC Curve: Vessel Location](Filename: TCT_2655_thumbnail_ROC_Vessel_Location.jpg)

**CNN Based Deep Learning Enhances 3D FLAIR Brain Perceived Quality, SNR and Resolution at ~30% less scan time**

L Tanenbaum¹, S Bash², W Gibbs³, L Wang⁴, H Gandhi⁴, P Gulaka⁴, A Shankaranarayanan⁵, T Zhang⁴

¹RadNet, Inc., new york, NY, ²RadNet, Inc., Encino, CA, ³N/A, Pasadena, CA, ⁴Subtle Medical, Menlo park, CA, ⁵Subtle Medical Inc, Menlo Park, CA

**Purpose**
To evaluate the capability of CNN based deep learning (DL) based image processing of brain MRI exams to improve quality while reducing scan times.

**Materials and Methods**
With IRB approval and patient consent, 11 consecutive patients (age: 48+/15 years; 7 female) undergoing clinical brain 1.5T MRI exams underwent an accelerated 3D sagittal FLAIR scan (average scan time reduction 27.1%+/3.5%) in addition to routine brain imaging using the institution's routine protocol which included a submillimeter isotropic resolution 3D FLAIR. A third set of images was created by processing the faster series with an FDA-cleared CNN based DL algorithm (SubtleMR™). The 3 sets (standard series (SS), accelerated series (AS), and DL processed accelerated series (DL)) were randomized and presented side-by-side for pair-wise comparisons and evaluated for relative (1) image sharpness, (2) perceived SNR, and (3) lesion/pathology conspicuity. Each series was also independently scored on overall image quality (5 point Likert). A two-sided paired t-test was performed to compare overall image quality, with P<0.05 considered as statistically significant. Average image preference and 95% confidence interval were calculated for each paired series and reader.
Results

The average overall image quality scores (SS/AS/DL) were 4.0/3.1/5.0, 4.0/3.2/5.0, and 4.8/4.5/5.0 for reader 1-3, respectively. Paired t-test results suggested that DL is significantly better than SS (P<0.05) for reader 1 and 2, but not for reader 3 (P=0.10). When presented side-by-side, DL is superior (significantly superior for reader 1 and 2, mildly superior for reader 3) for image sharpness, perceived SNR and lesion/pathology conspicuity when compared with SS or AS (Figure).

Conclusions

CNN based deep learning image processing of 3D FLAIR brain MRI produces a boost in perceived image quality, SNR, and resolution despite a ~30% reduction in scan time.

(Filename: TCT_1161_AllImagereconbrain.jpg)

2374

2:05PM - 2:11PM

Expert Assessment of Freesurfer and a Deep Learning-based Segmentation Model: DARTS (DenseUnet-based Automatic Rapid Brain Segmentation)

J Huang1, A Kaku1, C Hegde1, S Chung1, X Wang1, M Young1, A RADMANESH2, Y Lui1, N Razavian1

1NYU School of Medicine, New York, NY, 2NEW YORK UNIVERSITY MEDICAL CENTER, NEW YORK, NY

Purpose

Quantitative imaging analysis is useful for evaluating a host of central nervous system disorders.1–3 Despite availability of open-source brain segmentation software, widespread clinical adoption of volumetric analysis has been hindered due to processing times and reliance on manual corrections. We present a deep learning model for rapid brain segmentation and evaluate it against the current de-facto gold standard brain analysis tool, FreeSurfer.

Materials and Methods

In this IRB approved study, we use a neural network utilizing novel encoder-decoder style architecture inspired by U-net and state-of-the-art DenseNet architectures. The network is pre-trained with FreeSurfer labels obtained from 3T MPRAGE brain MRI from 1013 subjects (training:667, validation:222, test:222) from the Human Connectome Project. We fine-tuned the network using a) Mindboggle-101 manually annotated dataset (training: 60, validation: 20) and b) internal dataset processed with FreeSurfer (training: 6, validation: 2). We compared processing time and DICE score on the held out Mindboggle-101 (21 subjects) and internal dataset (3 subjects). Three neuroimaging experts graded the quality of 240 held out segmentations on a 5-point scale. We report inter-rater reliability using 2-way mixed, consistency, average-measures interclass correlation (ICC) and differences in quality using paired T-tests and Wilcoxon signed-rank tests.

Results

DICE scores of the non-fine-tuned and fine-tuned models on the held out Mindboggle-101 data were 0.74±0.02 and 0.82±0.01, and on the internal dataset were 0.80±0.01 and 0.80±0.01, respectively. The segmentation quality was higher using the model (both fine-tuned and non-fine-tuned) compared with traditional Freesurfer with manual corrections (3.4±1.1 vs 3.8±1.0 vs 3.9±1.1 in FreeSurfer, non-fine-tuned, and fine-tuned respectively), with inter-rater reliability ICC > 0.7. Processing time for 1 image volume was 65.7±0.9 s, yielding 102 segments.

Conclusions

We present a deep learning-based model using a novel network architecture (Dense U-net), to segment 102 brain structures in ~1
minute per 3D volume. This compares favorably against time needed for traditional boundary-rule based brain segmentation. We report DICE scores up to 0.8 compared against Freesurfer labels and manual labels. Experts graded the model segmentations favorably compared with Freesurfer. This work can enable more widespread clinical utilization of volumetric brain analysis.


A Abayazeed1
1University of Massachusetts, Northborough, MA
Purpose
Supported by the Du Pré grant from the MS International Federation. Volumetric measurement of multiple sclerosis lesion burden in the brain is increasingly used in the clinical setting to monitor the response to treatment and disease progression. Several methods exist and are frequently used to quantify total brain, grey matter, and lesion load volumes. Many improvements in MRI technology have been made over the past few years. A relatively new technology is Synthetic Magnetic Resonance Imaging (SyMRI). SyMRI allows for a shorter MRI acquisition time in comparison to standard MRI. Twenty patients with clinically proven MS were enrolled after IRB approval. Diagnostic accuracy of manual volumetric lesion load measurement on SyMRI using 3D Slicer software (MGH; Boston, MA) were compared with fully automated segmentation of standard MRI acquisitions using Icometrix (IcoMETRIX; Leuven, Belgium) which is an FDA approved software for MS quantification. We hypothesized that volumetric measurement of lesion load on SyMRI is non-inferior to volumetric lesion load measurement using Icometrix on the standard MRI acquisition.

Materials and Methods
In this retrospective study, 20 patients with clinically confirmed diagnosis of MS met inclusion and exclusion criteria. The MRIs were segmented both manually (using 3D slicer; Boston, MA) and using FDA approved icometrix software. For the manual segmentation the different MR images were skull-stripped and co-registered on the pre-contrast T1-weighted image using a rigid transformation. This procedure facilitated the comparison with icometrix, which was obtained from the same co-registered images. The Dice coefficient was used to measure the overlap of two regions, manual vs automatic segmentation. A target ROC of "0.95" of human raters when compared to icometrix was set for a positive validation.

Results
Comparison of automated standard MRI versus manual SynMRI segmentation of MS lesions showed no significant difference (p=0.29). Spearman's rank correlation coefficients (ρ) of Periventricular, deep white matter and infratentorial lesions showed highly significant correlations between automatic and manual segmentations.

Conclusions
The accuracy of volumetric measurement of MS lesions burden using a manually operated open source software (3D Slicer) using a shorter MRI acquisition technique known as synthetic MRI which is routinely used at UMMC under GE license under the name of MAGIC is non-inferior to an FDA approved software (Icometrix) that uses standard MRI acquisition.

1541
Automated acute ischemic stroke infarct volume detection based on NCCT and CTA images using a convolutional neural network

Y Liu1, B Hancock1, S Pomerantz2, P Schaefer2, L Schwamm2, R Gonzalez2, O Wu1
1Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital, Charlestown, MA, 2Dept. of Radiology, Massachusetts General Hospital, Boston, MA

Purpose
Acute ischemic stroke infarct volume (aka "core") may be useful for selecting patients for late-window endovascular stroke therapy. The "gold-standard" for measuring core is diffusion-weighted MRI (DWI). As an alternative, many centers use CT perfusion (CTP), which requires advanced software. Most hospitals lack access to either MRI or advanced software in the acute setting. We propose to estimate the "core" from non-contrast CT (NCCT) and CT angiography (CTA), using a novel convolutional neural network trained with DWI scans that were obtained within 1 h of completion of CT and CTA.

Materials and Methods
A consecutive cohort of 522 patients with suspected stroke imaged with CT and MRI within 1 h of one another were retrospectively analyzed. Lesions were semi-automatically segmented from DWI and used as ground truth infarct volume. A novel convolutional neural network (CNN) with attention mechanism was applied to estimate infarction volume from individual NCCT (NCCT-alone) and CTA images (CTA-alone) and in combination (NCCT+CTA). Models were trained using 321 patients, validated on 101 patients for optimizing hyperparameters and tested on 100 patients for performance evaluation. Performance of the CNNs were evaluated on the test cohort based on the absolute volume difference (AVD) between the DWI and estimated infarct volumes, Spearman's correlation coefficient, and binary classification accuracy (100 cc). Post-hoc one-sided paired Wilcoxon signed rank-test was performed.

Results
The median (IQR) of DWI lesion volumes were 4.2(18.1), 0.6(1.1) and 0.2 (0.4) cm3 for the training, validation and test cohort, respectively. For the NCCT-alone model, AVD was 17.0 ± 33.3 cm3, Rho=0.40 (p<0.0001), <50cc accuracy was 89%, and >100cc accuracy was 92% [See figure]. For the CTA-alone model, AVD was 9.3 ± 20.5 cm3, correlation Rho=0.55 (p<0.0001), <50cc accuracy was 94%, and >100cc accuracy was 96%. For the NCCT+CTA model, AVD was 5.9 ± 14.6 cm3, Rho=0.63 (p<0.0001), <50cc accuracy was 92% and >100cc accuracy was 95%. Post-hoc testing showed that NCCT+CTA model had significantly smaller AVD than either NCCT-alone (p<0.001) or CTA-alone (p<0.05).

Conclusions
CNN models using both CTA and NCCT as inputs can better estimate DWI lesion sizes, compared to using CTA alone or NCCT alone. The proposed approach may be useful to aid stroke treatment decision making.
Figure 1 Scatter plots for the three models. The lines represent linear regression fit and light gray areas are 95% CI
Optimal Convolutional Neural Network Selection by Bayesian Optimization for Prediction of Intracerebral Hemorrhage Expansion with Dual Energy Computed Tomography

K Groot Lipman\textsuperscript{1}, D Montes\textsuperscript{2}, S Moum\textsuperscript{2}, J Goldstein\textsuperscript{2}, C Tan\textsuperscript{2}, J Romero\textsuperscript{2}, R Gupta\textsuperscript{2}

\textsuperscript{1}Massachusetts General Hospital / University of Twente, Enschede, Netherlands, \textsuperscript{2}Massachusetts General Hospital, Boston, MA

Purpose

Multiple studies have examined radiographic predictors of intracerebral hemorrhage (ICH) expansion on non-contrast CT scan and CTA, such as the CTA spot sign. Dual-energy computed tomography (DECT) provides even richer information about iodine extravasation and ICH expansion. We describe an ICH expansion prediction system, built using artificial intelligence, that has potential to out-perform existing human-derived radiographic signs by detecting features not obvious to human readers. A novel feature of our system is a new paradigm for Deep Learning Convolutional Neural Networks (CNNs) selection and training that obviates the need for a large volume of training data.

Materials and Methods

A cohort of spontaneous ICH patients (n=111, expander=28) was retrospectively divided into a training (n=64, expander=15), validation (n=18, expander=4), and a test set (n=29, expander=9). Hematoma expansion was defined as an increase of \( \geq 33\% \) or \( \geq 6 \) mL. To focus the attention of the CNN, only the segmented hematoma volume in the iodine image was used as input (Figure 1.A). The best performing CNN architecture was selected through a Bayesian optimization algorithm that considered the domain of nine hyperparameters (Figure 1.B). Overfitting for specific features of any given individual expander was prevented by selecting a small number of convolutional blocks and filters. The CNN's ability to generalize was optimized through Gaussian processes, which constructed a new probabilistic model that considered the accuracies of the previous sets and yielded the most promising new set of hyperparameters for construction of a new CNN (Figure 1.C). Once this iterative process was finished, the best hyperparameters were extracted, and the final CNN was trained.

Results

The Bayesian optimization algorithm constructed 50 different CNNs, and the CNN with the best diagnostic performance was subsequently selected. On the test set, this CNN demonstrated 82.7\% accuracy, 66.7\% sensitivity, 90.0\% specificity, and 75.0\% precision. Figure 1.B shows the hyperparameters of the best performing CNN on the validation set.

Conclusions

A Bayesian optimization algorithm can be used to pre-select an optimal CNN for a task before training the CNN on a larger dataset. For the task of ICH expansion prediction, a CNN derived and trained in this manner predicted ICH expansion with excellent accuracy and specificity. The proposed paradigm of CNN selection and training may be useful for other clinical problems where data is scarce.


**Figure 1**  
A. The DECT scans were converted to virtual non-contrast images and corresponding iodine images. The hematoma volume was then segmented on the VNC images and used as a mask on the iodine maps. Subsequently, the whole brain volume was cropped to the size of the hematoma.  
B. The domain of the nine hyperparameters and the values of the best CNN. The CNN has a built-in filter increase of its depth number, which is multiplied with the increase rate.  
C. Overview of the Bayesian Optimization process that constructs a new CNN at each iteration based on the most promising location in the probabilistic model that was created out of the domain of the nine hyperparameters.
Integrating Machine Learning Pipelines into Clinical Workflows with DICOM Message Queues

V Saase1, A Junge1, H Wenz1, M MAROS1
1Medical Faculty Mannheim, Heidelberg University, Mannheim, Germany

Purpose
We present a prototype that implements a modular, distributed and parallel analysis pipeline in MRI reporting workflows of neuroradiology. The modular software architecture allows us to quickly exchange parts of the pipeline for experiments and testing while ensuring stability and performance of the remaining system. We integrate image viewing, structured reporting and monitoring by using custom user interfaces and well-established open-source software.

Materials and Methods
Our implementation comprises multiple submodules: a web-based structured reporting editor, a machine learning-based MRI perfusion pipeline, a traditional rule-based processing pipeline, a viewer application, a PACS connection and a high-performance database. We use DICOM metadata as messages for the standardized communication between modules. Modules are implemented in various programming languages, thus enabling us to choose the best tools for the specific requirements and lowering the entry barrier for less experienced developers. Modules can be distributed across the network, making use of dedicated hardware, thereby reducing the need for moving bulk data across slow connections.

Results
A pilot trial with 10 stroke reports and 10 tumor reports (Nreader=3) showed that reporting was significantly faster (p<0.05), more structured (p<0.05) and contained more repeatable quantitative measurements (p<0.05) when compared to our legacy system.

Conclusions
Flexible, standardized and open source software is the way forward in the quest to integrate machine learning workflows into clinical practice, improving quality and performance.
Purpose
To evaluate an ultrafast Sampling Perfection with Application optimized Contrasts using different flip angle Evolution (SPACE) FLAIR sequence using Wave-CAIPI encoding (Wave SPACE-FLAIR) [1] compared to standard SPACE-FLAIR for quantitative analysis of cerebral white matter lesions in a clinical setting.

Materials and Methods
Forty-six consecutive patients suspected of having multiple sclerosis (MS) or epilepsy underwent 3T brain MRI (Prisma; Siemens, Erlangen) with 20- or 32-channel receiver coils, including standard and resolution-matched ultrafast Wave SPACE-FLAIR sequences, as part of routine clinical evaluation. Patients were excluded if either set of images showed moderate to severe motion or if no white matter lesions were detected. Cerebral white matter lesions were segmented by the lesion prediction algorithm [2] implemented in the Lesion Segmentation Tool (LST) toolbox version 2.0.15 in SPM (www.statistical-modelling.de/lst.html). Segmented lesion maps generated from the standard and Wave SPACE-FLAIR images were compared using the longitudinal pipeline in LST. Pearson's correlation coefficients, absolute symmetrized percent change (ASPC), and Dice similarity coefficients were used to compare quantitative volumetric measurements between sequences.

Results
Of the 46 patients scanned, 23 patients with white matter lesions and no significant motion on their scans (11 MS and 12 epilepsy) were included in the quantitative evaluation. 56% of patients were scanned with the 20-channel coil. Scan times and acceleration factors for both coils are listed in Table 1. Standard and Wave SPACE-FLAIR sequences showed excellent correlation of lesion volumes segmented by LST (r=0.99, p<0.0001) (Figure 1). The mean Dice similarity coefficient for white matter lesions was 0.99±0.02 (range 0.91 to 1). The mean ASPC for lesion volumes between the two sequences was -0.04 ±0.21% (range -0.98 to 0.14%).

Conclusions
Quantitative white matter lesion volumes estimated in LST using ultrafast Wave SPACE-FLAIR acquired in less than three minutes showed excellent agreement with standard SPACE-FLAIR requiring over seven minutes for scanning in patients undergoing clinical evaluation for suspected MS and epilepsy. These findings may facilitate the increased use of volumetric FLAIR sequences in patients with MS and other white matter diseases.

(Filename: TCT_1759_wave_flair-figure_ASNR.jpg)

1500
1:37PM - 1:43PM

Clinical Decision Support for Visual ASPECTS Cut-Off Values in Patient Selection for Guideline-Compliant Thrombectomy Using Automated Quantification of Attenuation Changes

W Kunz

LMU Munich, Munich, Bavaria

Purpose
Large vessel occlusion (LVO) stroke leads to variable hypoattenuation in Alberta Stroke Program Early CT Score (ASPECTS) regions on non-contrast CT (NCCT). Current guidelines recommend thrombectomy for patients with visually assessed ASPECTS ≥6 in the early time window, despite issues of interobserver variability. Our aim was to test the diagnostic performance of an automated assessment of regional hypoattenuation to identify evidence-based ASPECTS cut-off values for thrombectomy.

Materials and Methods
We included 200 patients with LVO stroke of the anterior circulation undergoing NCCT on admission; to ensure unbiased attenuation measurements, patients with prior contrast administration, prior infarction or pre-existing cerebral lesions were excluded. The ASPECTS was visually determined by two expert readers in consensus. An automated software tool was used to calculate the relative Hounsfield Unit (rHU) values for ASPECTS regions compared to the non-ischemic hemisphere (Figure 1A). A composite rHU-ASPECTS, a score incorporating weighted rHU from all regions, was used for comparison with the visually assessed ASPECTS in regression analysis and receiver-operating-characteristics analysis.
Results
The 200 included patients had a median age of 74 years and a median ASPECTS of 8 (IQR: 7-10). 176 patients (88%) had an ASPECTS ≥6. We found a strong association of composite rHU-ASPECTS with visual ASPECTS in univariate regression analysis (β=-0.560, p<0.001). Visually rated early ischemic signs in ASPECTS regions could be correctly classified by rHU values for all regions except M1, M3, and M4. Highest discriminative value was found in the lentiform nucleus (area-under-the-curve [AUC]=0.892, p<0.001), the internal capsule (AUC=0.813, p=0.001), the caudate nucleus (AUC=0.779, p<0.001) and the insula (AUC=0.776, p<0.001). The composite rHU-ASPECTS showed a high discriminative value for identification of patients with ASPECTS ≥6 (AUC=0.779, p<0.001, Figure 1B).

Conclusions
Automated assessment of regional hypoattenuations identified expert-classified visual ASPECTS cut-off values and may serve as a method to standardize stroke patient selection for thrombectomy. This automated method may be further developed to support evidence-based clinical decision-making and obviate interobserver variability.


A Goncalves Filho1, M FIGUEIRO LONGO1, J Conklin1, S Cauley1, D Polak2, J Kirsch1, W Liu3, K Setsompop1, R Gonzalez1, P Schaefer1, S Huang4, O Rapalino1

1Massachusetts General Hospital, Boston, MA, 2Siemens Healthineers, Erlangen, Erlangen, 3Siemens Shenzhen Magnetic Resonance Ltd., Shenzhen, Shenzhen, 4Massachusetts General Hospital, Harvard Medical School, Boston, MA

Purpose
To compare the diagnostic performance and image quality of highly accelerated Wave-CAIPI post-contrast 3D-T1 SPACE (Wave-T1 SPACE) and standard post-contrast 3D-T1 SPACE sequences for the detection of intracranial enhancing lesions.

Materials and Methods
Sixty-five patients undergoing 3T clinical brain MRI scanning with and without contrast were prospectively enrolled. All MRI scans included a standard post-contrast 3D-T1 SPACE (R=4, acquisition time TA=4min 19s, 0.9 mm isotropic resolution) and resolution-matched post-contrast prototype Wave-T1 SPACE sequence (R=9, TA=1min 40s). The studies were performed on clinical 3T MRI scanners (MAGNETOM Prisma; Siemens Healthcare, Erlangen, Germany) with 20- or 32-channel multi-array receiver coils. The most common indications for MRI were the evaluation of primary intracranial tumors (N=26) and screening for metastatic disease (N=23). Two neuroradiologists blinded to sequence type performed a head-to-head comparison of the image. A predefined 5-point scale was used for grading of abnormal intracranial enhancement (dural, parenchymal, leptomeningeal, and ependymal), motion artifacts and noise, and overall diagnostic quality. A third reader adjudicated discrepancies.

Results
The Wave-T1 SPACE sequence showed no significant difference in the visualization of abnormal intracranial enhancement compared to the standard sequence. Wave-T1 SPACE images demonstrated slightly higher image noise and a similar degree of motion artifacts in the majority of cases, with no impact on overall diagnostic quality. A predefined 5-point scale was used for grading of abnormal intracranial enhancement (dural, parenchymal, leptomeningeal, and ependymal), motion artifacts and noise, and overall diagnostic quality. A third reader adjudicated discrepancies. The Wave-T1 SPACE sequence showed no significant difference in the visualization of abnormal intracranial enhancement compared to the standard sequence. Wave-T1 SPACE images demonstrated slightly higher image noise and a similar degree of motion artifacts in the majority of cases, with no impact on overall diagnostic quality. The balloon plot and representative examples in the figure demonstrate the comparable diagnostic quality of the standard post-contrast T1 SPACE and Wave-T1 SPACE sequences in delineating pathological enhancement.
Conclusions
The post-contrast 3D-Wave-T1 SPACE sequence allows an approximately 3-fold reduction in acquisition time with equivalent performance in identifying parenchymal, leptomeningeal, dural and ependymal enhancing lesions compared to a 4min 19s resolution-matched standard post-contrast T1 SPACE sequence. These results support the increased use of accelerated volumetric Wave-T1 SPACE over standard T1 SPACE in clinical brain MR protocols requiring contrast. This will decrease patient time on the scanner and the aggregated time savings may improve patient access.

(Filename: TCT_2033_AbstractIMG1SPACE.jpg)

Whole-Brain Brain Oxygen Metabolism in Adult Sickle-Cell Patients Using Two Different Quantitative MRI Approaches

S Chawla1, S Nabavizadeh1, P Wu1, A Rodriguez-Soto2, E Englund2, M Langham1, F Sayani1, J Russell3, F Wehrli1
1University of Pennsylvania, Philadelphia, PA, 2UCSD, San Diego, CA, 3University of Pennsylvania, Philadelphia, PA

Purpose
Quantitative MRI based methods have been employed to study oxygen metabolism in sickle cell disease (SCD) patients. T2 relaxation under spin tagging (TRUST) sequence uses spin labeling to isolate pure venous blood signals and measures its T2 value,
which is converted to venous oxygenation (Yv) with a calibration plot. However, there exists some controversy on the impact of HbS on the calibration curve and oxygen extraction fraction (OEF) parameters from TRUST MRI method. The purpose of the present study was to compute the values of OEF and cerebral metabolic rate of oxygen (CMRO2) from SCD patients using both TRUST and susceptibility-based oximetry (SBO) methods and to compare with healthy controls.

Materials and Methods
A cohort of 18 patients with SCD [males/females: 8/10; mean age: 28.52 ± 5.24 years; mean hematocrit:30.92 ± 6.73%] and 12 age-matched healthy control subjects underwent MR imaging on a 3T MR system equipped with 64 channel head phased array coil. The imaging protocol included T1-weighted 3D magnetization-prepared rapid gradient-echo (MPRAGE) sequence, SBO sequence comprising of an interleaved, high temporal resolution 2D-gradient-recalled echo images and TRUST MRI with a single slice EPI intersecting the lower superior sagittal sinus region. All data were processed using in-house developed MATLAB scripts. Using Non-parametric Mann-Whitney U tests, OEF= (Ya-Yv)/Ya and CMRO2 were compared between healthy control and SCD patients as obtained from TRUST and SBO methods. Additionally, CBF values as obtained from the SBO sequence were also compared between the two groups.

Results
Higher global CBF was observed in SCD patients compared to control (84.8 ± 16.1 vs 46.0 ± 5.6 ml/min/100g; p< 0.001). Using TRUST, higher OEF (52.7 ± 15.3 vs 35.5 ± 4.1; p< 0.001) were observed in SCD patients compared to healthy control group. On the other hand, lower OEF (26.4 ± 7.1 vs. 32.7 ± 3.3, p= 0.007) were observed in SCD patients compared to healthy controls using SBO method. CMRO2 was significantly lower in SCD patients when measured by SBO technique compared to TRUST (127.2 ± 41.6 vs. 251.8±75.4 μmol/100 g/min, p<0.000).

Conclusions
We observed opposite trends in OEF and CMRO2 in SCD patients compared to controls using TRUST and SBO methods. High OEF measured by TRUST technique lead to very high supraphysiologic CMRO2 values. SBO method that does not depend upon the morphologic and hematologic changes of sickle cell is more reliable in measuring OEF and CMRO2 in patients with SCD.

2085
Can imaging-based iterative reconstruction by SafeCT improve the visualization of the early CT sign of acute brain infarct?

A YOGI1, K Ishigami2, D Higa1, A Nakamata3, M Okuma1, S Yogi1, S Murayama2
1UNIVERSITY OF THE RYUKYU HOSPITAL, OKINAWA, Japan, 2Graduate School of Medical Science, University of the Ryukyus, Nakagami-gun, Okinawa, 3University of the Ryukyus Hospital, Nakagami-gun, Okinawa

Purpose
To evaluate the usefulness of imaging-based iterative reconstruction by SafeCT (Medic Vision, Israel) for the visualization of the early CT sign of acute brain infarct.

Materials and Methods
The study group consisted of 27 patients with 43 acute brain infarcts, who had undergone unenhanced brain CT followed by diffusion-weighted MR imaging (DWI). There were 15 male and 12 female patients. All CT examinations were performed within four hours after the onset. The interval period between CT and MRI ranged from 0.6 to 3.8 (1.6 ± 0.8) hours. The presence or absence of acute brain infarct was evaluated on DWI. CT data was reformatted to the slice thickness of 0.625 mm and thin slice CT groups (p < 0.05 and < 0.0001, respectively).

Results
Higher OEF (52.7 ± 15.3 vs 35.5 ± 4.1; p< 0.001) were observed in SCD patients compared to healthy control group. On the other hand, lower OEF (26.4 ± 7.1 vs. 32.7 ± 3.3, p= 0.007) were observed in SCD patients compared to healthy controls using SBO method. CMRO2 was significantly lower in SCD patients when measured by SBO technique compared to TRUST (127.2 ± 41.6 vs. 251.8±75.4 μmol/100 g/min, p<0.000).

Conclusions
We observed opposite trends in OEF and CMRO2 in SCD patients compared to controls using TRUST and SBO methods. High OEF measured by TRUST technique lead to very high supraphysiologic CMRO2 values. SBO method that does not depend upon the morphologic and hematologic changes of sickle cell is more reliable in measuring OEF and CMRO2 in patients with SCD.
Fast Gray Matter Acquisition T1 Inversion Recovery for Preoperative Planning of MR-guided Focused Ultrasound Thalamotomy in the Treatment of Essential Tremors: Preliminary Findings

Obusez E1, Lockwood D1, Nagel S1, Rammo R2, Ruggieri P3, Jones S1
1Cleveland Clinic, Cleveland, OH, 2Cleveland Clinic Foundation, Cleveland, OH, 3CLEVELAND CLINIC FOUNDATION, Aurora, OH

Purpose
MR-guided focused ultrasound (MRgFUS) is a new FDA-approved device used for the targeted ablation of the thalamic ventral intermediate nucleus (ViM) in the treatment of essential tremors (ET). Some studies have suggested that temporary ataxia, a relatively common adverse event, may be associated with extension of the ablation zones II (cytotoxic) and III (vasogenic) edema into the posterior limb of the internal capsule (PLIC) 1,2,3. Current sequences do not clearly delineate the thalamic-PLIC border during targeting of the ViM, hence it is difficult to ensure sufficient distance between the projected ablation and the thalamic-PLIC border, especially inferomedially. There is also sufficient human variation during targeting that indirect targeting based on standardized stereotactic coordinates alone is risky, hence direct visualization is needed. Fast Gray Matter Acquisition T1 Inversion Recovery (FGATIR) provides superior contrast to visualize the gray and white matter 4,5. We assessed the preoperative use of FGATIR compared to the standard T1MPRAGE in patients undergoing MRgFUS for ET.

Materials and Methods
12 patients underwent MRgFUS for ET and were included in this IRB-approved retrospective study. The FGATIR was acquired on the day of the procedure and uploaded into the proprietary MRgFUS application. For targeting, T1-MPRAGE was used in 6 patients and FGATIR in 6 patients, and minor millimeter adjustments were made to account for size of the projected ablation and to ensure adequate distance from the thalamic-PLIC border. FGATIRs were acquired with routine postop MRIs the day after for all patients, and distance of ablation zone II from the thalamic-PLIC border was measured for both groups. Patients with postop ataxia on exam were graded as mild, moderate or severe. Zone III edema extending into the PLIC was also subjectively graded as mild, moderate and severe.

Results
All 12 patients had resolution or near-resolution of their tremors. During preoperative targeting, the FGATIR showed superior contrast.
resolution of the thalamic-PLIC border compared to T1-MPRAGE (Representative Images A and B). 3 patients in T1-MPRAGE group had zone II extension into the PLIC and had severe ataxia. In the FGATIR group, no patients had zone II extension into the PLIC and 1 patient had severe ataxia (Table).

Conclusions
FGATIR may have helped the MRgFUS operators better visualize thalamic-PLIC boundary resulting in no extension of the Zone II into the PLIC and less severe ataxia than the T1-MPRAGE.

![Representative Images](TCT_2133_FGATIRABSTRACTPHOTO300DPI.jpg)

### Table

<table>
<thead>
<tr>
<th>PATIENT</th>
<th>PREOPERATIVE FGATIR</th>
<th>MAXIMUM DIAMETER OF LESION (MM)</th>
<th>RELATIONSHIP OF LESION MARGIN (ZONE II) WITH THE PLIC</th>
<th>DISTANCE OF THE MARGIN (ZONE II) OF THE LESION TO PLIC (MM)</th>
<th>ATAXIA</th>
<th>PERILESIONAL EDEMA (ZONE III) EXTENDING INTO PLIC</th>
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<tr>
<td>1</td>
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<td>9</td>
<td>Abuts PLIC inferiorly</td>
<td>0</td>
<td>Mild</td>
<td>Mild</td>
</tr>
<tr>
<td>2</td>
<td>No</td>
<td>10</td>
<td>Extends into PLIC inferiorly</td>
<td>-2*</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>3</td>
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<td>12</td>
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<td>Severe</td>
</tr>
<tr>
<td>4</td>
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</tr>
<tr>
<td>5</td>
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<td>Abuts PLIC inferiorly</td>
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<td>Mild</td>
</tr>
<tr>
<td>6</td>
<td>Yes</td>
<td>10</td>
<td>Extends into PLIC inferiorly</td>
<td>-1.5</td>
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<td>Severe</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>9</td>
<td>Abuts PLIC inferiorly</td>
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</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>11.8</td>
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</tr>
<tr>
<td>9</td>
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<td>9</td>
<td>Abuts PLIC inferiorly</td>
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<tr>
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<td>Within Thalamus</td>
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<tr>
<td>11</td>
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</table>

* measured in superior-inferior maximal dimension as lesion diameter is greatest in this direction.

* The negative number indicates the lesion extension into the PLIC.

(Filename: TCT_2133_FGATIRABSTRACTPHOTO300DPI.jpg)

### Prospective Motion Correction Brain MRI Using an External Tracking System

S Patel1, P Pawha1, L Fleysher1, K George1, J Stueben1, B Delman1, Z Fayad1, K Nael1

1Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose
Head motion can be a major problem in MRI acquisition, particularly when acquiring high-resolution 3D MR sequences such as magnetization-prepared radio-frequency pulses and rapid gradient-echo (MPRAGE). With recent advances in combining real-time correction with new navigator and external tracking mechanisms, rigid-body motion in all 6 degrees of freedom can be quantified (1). In this prospective study we aimed to assess the efficiency of a motion-tracking system in reducing motion-related artifact.

Materials and Methods
Patients who referred for routine brain MRI studies were prospectively imaged using a 3.0T magnet (Skyra, Siemens). Imaging
protocol included 3D MPRAGE (TR/TE/FA: 1890ms/3.25ms/9° acquisition time ~ 6 min), once routinely and once after turning on the motion tracking system consisting of a quad camera apparatus installed inside the MRI scanner above the isocenter (KinetiCor Inc.). The images obtained using the cameras were processed and motion data in 6 DOF (3 translation, 3 rotations) were calculated and transmitted in the form of network packets to the scanner. This data was then incorporated into the MRI sequence which updates the image acquisition in real time based on the most recent head position data available. MPRAGE images with and without motion correction were assessed independently by 2 board certified neuroradiologists using a 5 grade scoring scale (figure). Interobserver agreement was assessed using a weighted kappa test. Discrepancies were resolved by consensus and the difference between images quality scores with and without motion correction was tested using a Wilcoxon Rank-Sum test.

Results
A total of 69 patients were included. There was a good interobserver agreement (k=0.74, 95%CI 0.64-0.83) between 2 neuroradiologists for scoring the motion artifact. Using dichotomized image quality scores, 19 routine MPRAGE scans (27%) were deemed non-diagnostic (score 3, 4) while only 10 motion-corrected MPRAGE scans (14%) were rated non-diagnostic. The overall image quality scores were higher (p=0.022) in motion corrected studies.

Conclusions
The described motion-tracking system can be used effectively in clinical practice reducing motion artifact and improving image quality of 3D MPRAGE sequence. Described motion correction system has the potential to improve the overall image quality and increase MRI throughput by reducing motion artifact.

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Minimal</td>
</tr>
<tr>
<td>2</td>
<td>Mild</td>
</tr>
<tr>
<td>3</td>
<td>Moderate</td>
</tr>
<tr>
<td>4</td>
<td>Severe</td>
</tr>
</tbody>
</table>

0 = No Motion artifacts are not detectable
1 = Minimal Motion artifacts barely detectable, present on 1-2 slices, negligible effect on white-gray junction
2 = Mild Motion artifacts are noticeable in > 2 slices, examination remains diagnostic without obscuration of white-gray junction
3 = Moderate Motion artifacts degrade and possibly obscure underlying anatomy (white-gray junction) and pathology, (rendering a final diagnosis uncertain)
4 = Severe Motion artifacts result in markedly distorted underlying anatomy and no diagnosis can be made

(Filename: TCT_2273_5gradescoringscale.JPG)

2731
2:19PM - 2:25PM
Evaluation of intracranial vessel wall MR imaging, CT angiography, and MR angiography in patients with clinically diagnosed CNS vasculitis.

T Flood¹, D Montes¹, J Lim¹, P Schaefer¹, J Romero¹
¹Massachusetts General Hospital, Boston, MA

Purpose
Intracranial vessel wall MR imaging (VWI) has shown promising clinical utility for evaluation of mural-based CNS vasculopathies. Traditional arterial imaging methods, such as CT angiography (CTA) and MR angiography (MRA), evaluate the vessel lumen, without robust analysis of the vessel wall. CNS vasculopathies, including CNS vasculitis, result in lumenal and mural abnormalities, suggesting a potential complementary role for CTA, MRA, and VWI. However, there is a relative dearth of quantitative data comparing these modalities in CNS vasculitis. We compared CTA, MRA, and VWI in adult patients to evaluate the clinical utility of multimodal imaging in the diagnostic workup of CNS vasculitis.

Materials and Methods
A single center retrospective study was performed. Adult patients with clinically diagnosed CNS vasculitis and VWI were analyzed. VWI exams were visually inspected by a neuroradiologist (with 2 years neuroimaging experience) for evidence of vasculitis (e.g. concentric vessel wall enhancement). MRA and CTA reports were reviewed and statements describing the findings as "consistent with vasculitis" or "suggestive of vasculitis" were considered positive. Chi-square test was used to analyze the relationship between imaging modalities. Sensitivity values were calculated for each technique.

Results
33 adult patients with clinically diagnosed CNS vasculitis and VWI were analyzed. Review of VWI (n=33), MRA (n=31), and CTA (n=19) studies demonstrated evidence of vasculitis in 22, 9, and 9 exams, respectively. Chi-square analysis found a significant difference between VWI and MRA for detecting vasculitis (p = <0.5); whereas, no significant difference was found between VWI and CTA (p=0.17). Sensitivity of VWI, MRA, and CTA for vasculitis detection was 67% (95% CI [48-82]), 29% (95% CI [15-48]), and 47% (95% CI [25-71]), respectively (Fig. 1). Combining VWI-MRA and VWI-CTA improved sensitivity for detecting vasculitis, with values of 74% (95% CI [55-88]) and 90% (95% CI [66-98]), respectively. Combining VWI-MRA (versus MRA alone) and VWI-CTA (versus CTA alone) improved detection of vasculitis (p = <0.05, for both).
Conclusions
The diagnostic utility of multimodal imaging in CNS vasculitis was analyzed. Results support improved detection of CNS vasculitis with VWI relative to MRA; whereas, no significant difference was found between VWI and CTA. Combining VWI-MRA and VWI-CTA increased sensitivity and improved detection of CNS vasculitis relative to MRA or CTA alone.

Utility of Compressed SENSE MRI in Brain Imaging

N RAY\textsuperscript{1}, C Ahuja\textsuperscript{2}, P Singh\textsuperscript{3}
\textsuperscript{1PGIMER, CHANDIGARH, Chandigarh, Chandigarh, \textsuperscript{2}PGIMER, Chandigarh, Chandigarh, Chandigarh, \textsuperscript{3}Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh}

Purpose
Reducing the complexity and length of examinations has been a major direction of research in MRI in recent years. \textsuperscript{(1-3)} In this study, compressed sensing is combined with the parallel-imaging or SENSE infrastructure, i.e., Compressed SENSE (CSENSE), for accelerating anatomic MR data acquisition in human brain by exploiting the multi-element receiver coil sensitivity variation and sparsity constraining. The main aim of this study was to compare the quality of images acquired by conventional MRI and CSENSE MRI for various brain MRI sequences.

Materials and Methods
A total of 227 patients underwent brain MR examinations on 3 T MRI scanner (Philips Ingenia). The patients were divided into routine MRI group (169 patients) and MR angiography (58 patients) group. In the former group, axial T2, 3D FLAIR, pre- and post-contrast 3D T1, SWI and DRIVE sequences were acquired using conventional and CSENSE technique while in latter TOF MRA head and neck was acquired using both the techniques. The acceleration factors for different sequences and time reduction achieved are summarised in table 1. The images were evaluated based on a pre-defined scale by three blinded neuro-radiologists based on 
visualisation of different anatomical brain structures and head and neck vessels as well as for resolution, lesion conspicuity and overall diagnostic confidence. The quantitative evaluation of image quality was done by calculating the apparent contrast background deviation (CBD). Interrater agreement was evaluated using the κ test. The subjective visualization scores for each sequence and apparent CBD were assessed using the Wilcoxon signed-rank test and paired t test respectively.

Results
High inter-rater agreement was found regarding different qualitative parameters of image quality. Nonsignificant statistical difference was found between qualitative parameters of image quality as well as for apparent CBD between the two groups (Table 2).

Conclusions
CSENSE can be used as a potential tool for reducing image acquisition time without compromising the image quality. This could be of paramount significance particularly in paediatric population or patients requiring sedation or anaesthesia as it can potentially reduce the need for sedation & anaesthesia. More over because of lesser acquisition the sequences can be more useful in emergency conditions like acute stroke.

Reliability and Accuracy of Methods for Assessing Lateral Ventricles

E Shum¹, P Shah¹, A Hertzler¹, T Abildskov², C Vanier¹, A Rodriguez³, T Knoblauch⁴, T Snyder⁵
¹Touro University Nevada, Henderson, NV; ²The University of Utah, Salt Lake City, UT; ³IMGEN LLC., Las Vegas, NV; ⁴University of Nevada, Las Vegas, Las Vegas, NV; ⁵SimonMed, Las Vegas, NV

Purpose
Accuracy of assessing lateral ventricle size in research and clinical practice has implications for a variety of disorders with important diagnostic, treatment and prognostic implications. While various automated and manual methods have been proposed and utilized; a systematic study of the reliability and comparative outcomes of the various tracing methods has been lacking. This investigation examined the reliability of six different brain volumetric tracing methods used to measure the lateral ventricles and analyzed potential biases associated with each.

Materials and Methods
3T MR images were used to assess 20 (7 males; 13 females; mean age=36.5) mild traumatic brain injury (mTBI) subjects. Lateral ventricular volume (LVV) was measured for each patient utilizing 3 manual (InteleViewer; traced by 2 raters, OsiriX, and ImageJ; traced by a single rater) and 3 automated (NeuroQuant v3.0, FreeSurfer v6, and VolBrain) volumetric software tracing systems. 1.2 mm sagittal T1 sequences were used for the automated volumetric tracings, while the more clinically relevant axial 4 mm T2 images were utilized for the manual tracings. The inter-platform reliabilities for each quantification method were assessed using the intra-class correlation coefficient (ICC) based on a single-rating, consistency agreement, 2-way mixed effects model and 95% confidence intervals. Systematic (indicating the need for a scaling constant) and volume-based biases were assessed in mixed effects analysis of covariance (ANCOVA) models followed linear regression.

Results
All tracing methods had excellent inter-platform reliability (ICC>0.947) but systematic and volume-dependent biases were noted among all tracing methods. Lateral ventricle volumes of the manual tracings were all greater than the automated tracings. However, the
automated FreeSurfer and VolBrain programs under-estimated volumes relative to other methods (e.g., mean bias between VolBrain and ImageJ -2.65 (95% COI), and the bias grew larger in conjunction with the size of the structure measured (95% COI).

Conclusions
The three manual methods and NeuroQuant yield similar values when mathematically adjusted via a volume dependent scaling factor. Our results underscore the importance of careful computational consideration when comparing volumetric data from multiple tracing methods. This study is first to examine intraclass correlation between three manual and three automated tracing methods. Follow-up studies with larger sample sizes may improve estimates for scaling factors.

Scientific Abstract Session: Brain Vascular 2
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Immune-Checkpoint-Inhibitor-Associated CNS Vasculitis

S Fazeli¹, M McDonald²
¹University of California San Diego, San Diego, CA, ²N/A, N/A

Purpose
To discuss the MR findings of CNS vasculitis related to immune checkpoint inhibitor treatment.

Materials and Methods
A 67-year-old female with a history of metastatic ovarian cancer presented to the hospital with sepsis secondary to urinary tract infection one week after initiating a clinical trial, including treatment with checkpoint inhibitors cabozantinib/atezolizumab. Brain MRI performed at time of admission demonstrated stigmata of chronic left frontal operculum infarct without evidence of confluent white matter signal abnormalities or other acute findings (Figure 1A). On day four of hospitalization, the patient became progressively encephalopathic with diffuse nonspecific abnormalities noted on EEG. Lumbar puncture performed demonstrated markedly elevated total protein without leukocytosis. Given rapid change in mental status, brain MRI was performed with and without intravenous contrast for further assessment.

Results
Follow-up brain MRI performed two days after initial imaging demonstrated new, patchy T2-FLAIR hyperintensities involving the subcortical, deep, periventricular and brainstem white matter tracts with additional regions of T2 hyperintensity involving the deep gray nuclei (Figure 1B). In addition, there were innumerable punctate regions of perivascular enhancement throughout the supratentorial and infratentorial compartments (Figure 1C), in an overall miliary distribution. No dural or leptomeningeal enhancement was identified.

Conclusions
Immunotherapy is a groundbreaking treatment for many but has also resulted in a substantial increase in the risk of autoimmune diseases and autoimmune-associated adverse events. To date, various types of autoimmunity ranging from organ-specific to systemic illnesses have been associated with immunotherapy, with the recent inclusion of medium to large vessel vasculitis. In the present case, stigmata of an underlying immunotherapy-related adverse event/vasculitis was suspected given the onset of symptoms relative to the timing of treatment, although ultimately additional differential considerations included an underlying paraneoplastic phenomenon, carcinomatosis related to the patient's metastatic ovarian cancer and atypical leptomeningitis, such as referable to fungal or viral etiologies. Nevertheless, it is important for the practicing neuroradiologist to be aware of the potential autoimmune manifestations related to immunotherapeutics to enable the appropriate guidance for clinical management, which ultimately may include cessation of therapy.

S Moum1, W Mehan1
1Massachusetts General Hospital, Boston, MA

Purpose
We report the case of a patient with remote stereotactic radiosurgery who developed progressive word-finding difficulties and dysarthria secondary to intracranial intravascular papillary endothelial hyperplasia.

Materials and Methods
The patient is a 63-year-old male who presented with progressive word-finding difficulties and dysarthria. Medical history was remarkable for remote stereotactic radiosurgery for aneurysm treatment. He had no history of systemic malignancy. On physical examination, the patient demonstrated dysarthria and word-finding difficulties.

Results
An unenhanced CT of the brain demonstrated a round, mildly hyperdense mass involving the left superior temporal gyrus with marked surrounding vasogenic edema. CT angiography of the head was notable for scattered curvilinear foci of contrast-related enhancement within the mass, suggestive of internal vessels. No proximal large-vessel occlusion was seen. Contrast-enhanced MR imaging of the brain demonstrated a lobulated, enhancing mass (Figure 1A) with peripheral susceptibility-related signal (Figure 1B) centered within the left superior temporal gyrus. No intracranial restricted diffusion was identified within the mass or in the remaining brain parenchyma. There was marked abnormal vasogenic edema involving the left temporoparietal region with associated local mass effect (Figure 1C). Encephalomalacia from a prior right occipital lobe infarct was also incidentally noted. The lesion was resected. Contrast-enhanced MR imaging of the brain performed two months after surgery showed near complete resolution of the previously seen vasogenic edema and associated local mass effect. No residual abnormal enhancement was seen in the left temporal resection cavity.

Conclusions
Intravascular papillary endothelial hyperplasia (IPEH), also known as Masson tumor, is a rare reactive process that occurs due to venous stasis and organized thrombus formation. IPEH is commonly found in the head and neck and less often intracranially. In this patient, prior radiation therapy, a common association, presumably predisposed to the underlying vascular injury. Patients are often asymptomatic, although local edema may result in symptomatology as was seen in this patient. Important differential considerations for intracranial cases include high-grade glial neoplasm, malignant angiosarcoma, and metastasis. Surgical resection is often curative. While rare, IPEH is a benign differential consideration to remember for vascular intracranial mass lesions.
Risk of Aneurysm Development at Intracranial Arterial Fenestrations

W Tom\textsuperscript{1}, J Chen\textsuperscript{2}
\textsuperscript{1}University of California San Diego, San Diego, CA, \textsuperscript{2}UC SAN DIEGO HEALTH SYSTEM/SAN DIEGO VA MEDICAL CENTER, SAN DIEGO, CA

Purpose
In prior studies, aneurysms have been identified at the sites of intracranial arterial fenestrations suggesting that intracranial arterial fenestrations are a risk factor for aneurysm formation. However, prior studies being cross-sectional in design have been unable to quantify the risk of developing new aneurysms at arterial fenestrations.

Materials and Methods
We searched a database of reports of all radiology studies at our institutions of the head and neck for "fenestration," "fenestrations," or "fenestrated." After reviewing the reports, 626 patients had imaging consistent with an intracranial arterial fenestration. After excluding patients without follow-up imaging or with aneurysms at the arterial fenestrations in the initial study, 85 patients remained. Among the included patients, the mean follow-up was 3.1 years, while the maximum follow-up was 13.6 years. The total follow-up was 259.4 person-years.

Results
Within the patient cohort, the most common artery with a fenestration was the basilar artery representing 71% of the patients. Although 18% of the patients had aneurysms distant from the arterial fenestration, no patients developed aneurysms at the sites of arterial fenestrations during follow-up. Consequently, the probability of aneurysm development at an arterial fenestration is < 1.2% per year (95% CI), and the median time to aneurysm development at an arterial fenestration is > 60 years (95% CI).

Conclusions
The risk of aneurysm development at an arterial fenestration is < 1.2% per year, and the median time to aneurysm development from an arterial fenestration is > 60 years.
Pressure Drop Estimation in Vein of Galen Aneurysmal Malformation: Comparing 4D Flow MRI-Based Computational Fluid Dynamics and Intraoperative Measurement

M Aristova¹, A Vali¹, R Abdalla¹, C Sammet², D Robinson Cantrell¹, T Alden², A Shaibani¹, S Schnell¹
¹Northwestern University - Feinberg School of Medicine, Chicago, IL, ²Ann & Robert H. Lurie Children's Hospital of Chicago, Chicago, IL

Purpose
4D Flow MRI has been used in non-invasive, non-contrast assessment of hemodynamic characteristics throughout treatment in Vein of Galen Aneurysmal Malformation (VGAM) patients [1], [2]. Here we present an advanced application of computational fluid dynamics (CFD) with boundary conditions based on 4D Flow MRI, to characterize pressure drop across the malformation, and compare to intraoperative pressure measurement.

Materials and Methods
Images were obtained through an IRB-approved retrospective study. A patient with Vein of Galen Aneurysmal malformation (0.64y, M) received 4D Flow MRI (3T Skyra: Siemens, Germany) as part of a clinical protocol. 4D flow measurements were used to obtain geometry of the vasculature (Mimics: Materialise NV, Belgium) and patient-specific boundary conditions. To estimate pressure drop across the malformation transient Navier-Stokes equations were solved numerically (Fluent 19: Ansys, USA). During interventional treatment a pressure probe (arterial: Medtronic Echelon 14 microcatheter; venous: Stryker Excelsior 1018 microcatheter) was used to obtain pressure difference between the proximal arterial feeders and the interior of the aneurysmal malformation (Fig 1A-B).

Results
The pressure differential obtained from 4D Flow MRI data and measurement (Fig 1C-D) ranged from 7.86 – 13.17 mmHg over the cardiac cycle, with mean 10.93 mmHg. Direct intraoperative pressure in the proximal right PCA measured 7 mmHg and more distal in the pedicle supplying the malformation measured 6 mmHg. Direct pressure measurement in the recipient venous pouch pre-
embolization measured 6 mmHg, decreasing to 5 mm Hg post embolization of the pedicle. This indicates a 1mmHg preoperative pressure differential increasing to 2mmHg postoperatively.

Conclusions
As the patient had no evidence of venous hypertension and the measured arterial pressure was unusually low, a possible reason for pressure measurement discrepancy could be the use of a too-large catheter in the arterial intraoperative pressure measurement leading to underestimation of the arterial pressure. 4D Flow MRI can be used as the basis for fluid dynamics calculations in complex VGAM anatomy, and future work will include investigation in additional cases.

Digital Subtraction Angiography images showing locations of (A) arterial and (B) intraoperative venous pressure measurement. (C) Right anterior view of 4D Flow data, with pathlines indicating the direction of flow and color-coding indicating velocity at systolic timeframe. (D) Pressure differential between arterial and venous locations extracted from 4D-Flow based CFD simulation throughout the cardiac cycle.

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MR Vessel Wall Imaging In Spontaneous Intracranial Dissecting Aneurysms
A Mozafarykhamseh¹, R Abdalla², M Aly³, A Shaibani³, M Hurley³, B Jahromi³, M Potts¹, S Ansari⁴
Dissecting intracranial aneurysms (DIA) can present with subarachnoid hemorrhage or ischemia, and are more common in the posterior circulation. Radiographically, DIAs have similar morphological features to fusiform and dolichoectatic atherosclerotic aneurysms, with difficult diagnosis on traditional CTA and MRI/MRA cross sectional imaging. In addition, the rebleeding risk from ruptured DIA is considerably higher reaching up to 71.4% with 46.7% mortality, necessitating early diagnosis and treatment. We aimed to distinguish specific imaging features of spontaneous DIA using high resolution MR vessel wall imaging (VWI).

Materials and Methods
In a retrospective analysis of our MR VWI database between Jan 2016 and March 2019, we identified patients with suspected DIA diagnosed by clinical history, CTA/MRA imaging findings, and conventional angiography. MRI 3D TOF and MR VWI were reviewed by two neuroradiologists for imaging findings that were diagnostic for DIA including intramural hematomas, intimal flaps and double lumen. Following diagnosis on MRI/3D TOF MRA, MR VWI was serially assessed for additional findings that could aid or confirm the diagnosis.

Results
Seven patients (4M:3F) with mean age 62 +/- 13.7 were proven to have DIA, all located in the posterior circulation (6 vertebral:1 basilar) with no ruptured aneurysms. All patients presented with either severe headaches or diplopia/dizziness. There was no family history of IA and no history of any connective tissue disease but high incidence of hypertension and hyperlipidemia (30%). On MRI/3D TOF MRA, intramural hemorrhage was observed to diagnose two DIAs, which was also confirmed with intramural T1 hyperintense signal on MR VWI. Two aneurysms demonstrated fusiform morphology with intraluminal thrombus on MRI/3D TOF MRA without diagnosis, however, MR VWI identified an enhancing dissection flap and double lumen pathology for definitive DIA diagnosis. Two DIA were suspected with suggestion of intimal flap on MRI/3D TOF MRA, but improved visualization of enhancing intimal flap on MR VWI confirmed the diagnosis. One aneurysm was diagnosed based on clinical history and an associated enhancing dissection flap with tapered occlusion of the contralateral vertebral artery, but no imaging features on 3D TOF MRA or MR VWI suggested a dissecting aneurysm.

Conclusions
MR VWI is a valuable tool in confirming the diagnosis and differentiating fusiform thrombosed aneurysms from DIA with improved visualization of T1 hyperintense intramural hemorrhage.

Purpose
Risk factors for cerebral aneurysm rupture with subsequent subarachnoidal hemorrhage are well studied among industrial societies and include smoking, hypertension and excessive alcohol intake(1). The population of Mongolia has so far not been subject of a systematic analysis of lifestyle risk factors. A high number of Mongolians pursue an active nomadic living or permanently reside in
traditional tents ("gers"). The influence of such geo-environmental factors on the risk of aneurysm rupture has also not been studied. Our work aims to identify lifestyle and geo-environmental risk factors for rupture of cerebral aneurysms in Mongolia.

**Materials and Methods**

A retrospective single-center study of all intracranial arterial digital subtraction angiographies (DSA) with diagnosis of incidental or ruptured cerebral aneurysms during the two years period 2016 to 2017 (n=694) was performed. The living conditions (urban versus rural, house versus ger, resident versus nomadic) and medical history (nicotine abuse, diabetes and hypertension) of the affected patients were assessed.

**Results**

Calculation of relative risk ratios identified a significant higher probability for aneurysm rupture in Mongolian patients with a history of smoking and hypertension, but not with diabetes (figure). Of all 694 patients with cerebral aneurysms, the majority lived in rural areas (54%, n=375), with 73% residing in traditional gers and 27% in houses. Urban living was recorded in 44% (n=303) of patients, with 63% in houses and 37% in gers. Active nomads (n = 16; 2%) represented the smallest group, but showed the highest non-significant relative risk of aneurysm rupture.

**Conclusions**

While a significantly elevated risk of aneurysm rupture can be observed in Mongolian citizens with a history of smoking and hypertension, country-specific geo-environmental factors have no measurable impact on the occurrence of aneurysmal bleed.

![Figure: Risk ratios for aneurysmal rupture in patients with specific geo-environmental and lifestyle/medical factors in Mongolia.](TCT_1935_FigureRRwithlegend.jpg)
Purpose
Missense mutations in ACTA2, the gene that codes for smooth muscle actin, have recently been implicated in a multisystem smooth muscle dysfunction syndrome characterized by aortic aneurysms, patent ductus arteriosus, congenital mydriasis, and distinct cerebrovascular anomalies which predispose patients to ischemic stroke. The purpose of this excerpta is to review the unique angiographic imaging findings associated with this rare genetic disease.

Materials and Methods
An 11 year old girl with a past medical history of patent ductus arteriosus, esophageal web, gastrointestinal dysmotility, and congenital mydriasis presented after an episode of dysphasia and right upper extremity weakness followed by a second episode of dysphasia and transient left upper extremity weakness three weeks later. Physical examination failed to demonstrate a focal neurologic deficit. A lumbar puncture was performed and was noncontributory. Based on characteristic findings on MRI and MR angiography, genetic testing was pursued and demonstrated a heterozygous mutation substituting arginine for histidine at position 179 in the ACTA2 gene. The patient was placed on aspirin prophylaxis and later underwent preoperative cerebral angiography followed by bilateral pial synangiosis. Her postoperative course was complicated by large infarctions involving the bilateral anterior and middle cerebral artery territories.

Results
MRI performed at the time of initial presentation demonstrates multiple areas of restricted diffusion, T2 hyperintense signal, and enhancement involving the bilateral frontal lobes consistent with multifocal subacute infarctions. MR angiography utilizing 3D time of flight technique (Figure 1A,B) as well as conventional angiography (Figure 1C,D) demonstrates patulous dilatation of the bilateral petrous and proximal cavernous internal carotid arteries with straightening and abrupt tapering of the proximal intracranial vasculature. There is no evidence of lenticulostriate collateral formation.

Conclusions
Cerebral arteriopathy associated with ACTA2 mutation is a rare genetic disease with less than 60 confirmed cases in the literature. Its characteristic imaging appearance including absence of lenticulostriate collaterals as well as distinct clinical phenotype distinguishes it from the more common moyamoya disease. Patients currently diagnosed with moyamoya disease who also have dysfunction of smooth muscle organs may benefit from ACTA2 genotyping.
Purpose
There is little data in the literature on the characteristics and natural history of intracranial arterial infundibular dilatations (IDs) and unruptured intracranial aneurysms in children. Purpose 1: To evaluate asymptomatic intracranial aneurysms and arterial ID from brain MRA studies in children at our institution, and to describe their features with respect to location, associated pathologies and temporal evolution. Purpose 2: To evaluate the frequency of an underlying condition when an incidental intracranial aneurysm or arterial ID was detected in a child

Materials and Methods
IRB-approved retrospective review of asymptomatic intracranial aneurysms and arterial ID in children <18 years over an 18-year period. Clinical (age, sex, syndrome) and radiological (location, type, size, thrombus, mass effect) data recorded. Follow-up imaging assessed for temporal changes. ID:parent artery ratios assessed at diagnosis and last follow-up. Temporal evolution to aneurysm evaluated

Results
60 intracranial aneurysms in 51 patients (M:F=36:15, 10.5±0.5 years). Single aneurysm in 45 patients (88.2%); 2 and 3 aneurysms in 3 patients each (5.8%). Syndromic association in 43.1%, most frequently sickle cell disease (10/22 [45.5%]). 71.7% saccular (5.0±5.7 mm), remaining fusiform (6.5±2.7 mm). 51.7% aneurysms from ICA, most commonly cavernous (32.3%). Mean size change (109 patient-years): decrease of 0.6±4.2 mm (-0.12±9.9 mm/yr). Interval growth (2.0 ± 1.0 mm) in 13.3% (4 saccular, 4 fusiform). Interval decrease in size (8.3 ± 10.7 mm) in 10%. Inverse relationship between aneurysm size and growth rate (r = -0.82, p < 0.00001). One aneurysm treated endovascularly. 60 intracranial infundibula (ID) in 60 children (M:F=27:33; 9.7±5.2 years). Family history of aneurysms in 3.3%. Syndromic association in 23.3%, most frequently Sickle Cell Disease (4/14=28.6%). Mean ID size: 2.2±0.5 mm, mean ratio to parent artery: 0.5±0.2. Most common location: P1-PCA (56.7%), posterior communicating ID in 6.7%. On follow-up (86 patient-years), no significant change in ID:parent artery ratio. No IDs showed interval evolution to aneurysm

Conclusions
1. Growth and rupture are unusual in asymptomatic pediatric brain aneurysms. A small proportion can show growth and should be identified for imaging surveillance. 2. Pediatric brain ID are distinct from adults with regard to location, etiology and temporal evolution. Growth and aneurysmal formation are rare, not necessitating frequent short-term imaging surveillance.
Presence of a collateral venous sinus drainage pathway predicts outcome of anticoagulation therapy following cerebral sinus venous thrombosis (CSVT) in children

M Czarniecki1, J Murnick2, D Harrar2, J Meldau2, M Goss2, J Carpenter2, Y Diab2
1Georgetown University Hospital, Washington, DC, 2Children's National Hospital, Washington, DC

Purpose
Cerebral sinus venous thrombosis (CSVT) in children can be life-threatening and is often treated with systemic anticoagulation. Historically, duration of therapy has been extrapolated from treatment of peripheral thromboses. However, a patient's individual intracranial venous anatomy could potentially influence optimal duration of therapy. In some patients with CSVT, venous drainage from the torcular flows via a collateral pathway through the occipital sinus and a marginal sinus to the jugular bulb. We hypothesize that collateral venous drainage via an occipital-marginal pathway can influence whether a thrombosed transverse and/or sigmoid sinus recanalizes with anticoagulation.

Materials and Methods
Children who received anticoagulation for treatment of a transverse and/or sigmoid CSVT between 2010 and 2019 were identified from a thrombosis database at our institution. All patients had MRI at the time of initial diagnosis, most including MRV and post-contrast sequences. All included patients had follow-up imaging at an interval of 6-12 weeks. These images were evaluated for the
presence of an occipital-marginal collateral drainage pathway and for whether recanalization was achieved. Patients who had not recanalized on initial follow-up imaging received continued anticoagulation and additional follow-up imaging. Patients who did not achieve recanalization after a minimum of 5 months of anticoagulation were categorized as failing to recanalize. Results were analyzed using the Fisher's exact test.

Results
A total of 19 patients were included in the analysis with a median age of 15 months (range: 8 days - 17 years). An occipital-marginal collateral pathway was identified in 3 patients, none of whom demonstrated recanalization of the thrombosed transverse/sigmoid sinus following therapeutic anti-coagulation. Of the 16 patients who did not have an occipital-marginal collateral, 13 (81%) of these eventually recanalized. The presence of the occipital-marginal sinus collateral was shown to significantly correlate with failed recanalization (p=0.0103).

Conclusions
Presence of occipital-marginal collateral drainage predicts failure of recanalization of transverse/sigmoid CSVT with anticoagulation. This imaging finding may help inform duration of therapy.

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2386
2:33PM - 2:39PM

Magnetic Resonance Vessel Wall Imaging in Central Nervous System Vasculitides: a Case-Series

M Maya1, M Padrick1, Z Fan1, O Dumitrascu1, C Neurology1, K Ogami1, S Song1, Y Chodakiewitz1
1Cedars Sinai, Los Angeles, CA

Purpose
We report three patients with central nervous system (CNS) vasculitis, in which vessel wall imaging (VWI) findings were instrumental in diagnosis and subsequent management.

Materials and Methods
Case 1: A 33-year-old male presented with cerebellar infarcts and vertebral dissections. Digital subtraction angiography (DSA) demonstrated no sign of vasculopathy. VWI revealed concentric thickening and enhancement of right posterior cerebral and left anterior choroidal arteries. Serum and CSF analysis revealed high titers of Human Herpesvirus type 6. Case 2: A 56-year-old male with HSV1 encephalitis was treated and mental status improved. Surveillance neuroimaging, however, revealed ongoing pathology, including MCA territory distal hyperintense vessels. VWI revealed middle cerebral artery (MCA) concentric smooth contrast enhancement. Case 3: A 41-year-old obese female with hypertension and tobacco use presented with recurrent transient ischemic attacks. Computed topography angiography demonstrated bilateral MCA stenosis. Patient refused DSA. VWI revealed uniform enhancement and thickening of the arterial wall. A calf rash biopsy diagnosed a mixed connective tissue disease.

Results
In cases 1 and 2, VWI visualized vasculitic changes that were crucial to proper diagnoses of viral arteriopathies. In case 3, VWI findings led to a diagnosis of mixed connective tissue disease prompting immunotherapy in a patient with stenoocclusive disease that...
was initially attributed to atherosclerosis. In each case, VWI provided a noninvasive modality to track intracranial vasculopathy progression and response to treatment.

Conclusions
Etiological diagnosis of intracranial vasculopathies remains challenging. Whereas traditional angiographic modalities depict vessel lumen appearance, they provide very limited information regarding arterial wall integrity and pathology. Conversely, the underlying vasculitic process has typical imaging characteristics on VWI, as illustrated in our case-series. In order to provide targeted therapy, clinicians should take advantage of the nuanced information VWI provides.

Scientific Abstract Session: Head & Neck Skull Base
2096
1:30PM - 1:36PM

Unusual Location of Well Differentiated Liposarcoma

A GUARNIZO1, P Puac Polanco2, C Torres3
1UniverSity of ottawa, the ottawa hospital, ottawa, on, 2University of ottawa, ottawa, ontario, 3university of ottawa, ottawa, on

Purpose
To describe a rare pathology that could be considered in the differential diagnosis of lesions in the supraglottic larynx. To review the clinical presentation, epidemiology and histopathological features of liposarcoma in the supraglottic larynx.

Materials and Methods
A 54 old year woman presented with 1-year history of voice changes. Flexible laryngoscopy revealed an exophytic left vallecular polyp. CT of the head and neck showed an exophytic predominantly fat density lesion arising from the valleculae with superior extension extending to the level of the base of the tongue. The lesion demonstrated heterogeneous enhancement with some septations.
At this time a diagnosis of lipoma was considered. The lesion was removed and the pathology showed a well-differentiated liposarcoma with MDM 2 amplified by FISH ratio 4.0

Results

Axial (A), sagittal (B), coronal (C) images of a CT scan of the neck show an exophytic fat density lesion with multiple enhancing septations, arising from the vallecula causing moderate narrowing of the airway.

Conclusions

Liposarcomas of the supraglottic larynx are rare neoplasms. Only 4%-9% of all liposarcomas occur in the head and neck and of those 9% are in the larynx and in the supraglottic region. There are 4 histologic subtypes: well-differentiated, dedifferentiated, myxoid and pleomorphic liposarcomas. The well-differentiated subtype is the second most common and represents 30%-40% of the cases with low risk of metastasis. MDM 2 amplification by FISH is a sensitive method to distinguish well differentiated liposarcoma from lipoma. Surgery is the treatment of choice with long term follow up due to high potential for recurrence. Differential diagnosis includes benign polyp, lipoma and fibrovascular polyp. Radiation therapy may be used in patients with high-grade liposarcoma and local extension.

(Filename: TCT_2096_Liposarcoma.jpg)

Non-contrast T2WI for Post-operative Surveillance of Vestibular Schwannoma

S Strauss¹, S Stern Shavit¹, J Shin¹, E EBANI², J Lantos¹, S Selesnick¹, C Phillips³
¹Weill Cornell Medical Center, Manhattan, NY, ²NEW YORK PRESBYTERIAN HOSPITAL - WEILL CORNELL, NEW YORK, NY, ³Weill Cornell Medical College, New York, NY

Purpose

In the post-operative setting, imaging surveillance is usually necessary for at least 10 years after surgical resection of vestibular schwannoma 1, as reported recurrence rates range from 0.17-7.7%, depending on surgical approach (translabrynthine, retrosigmoid or middle cranial fossa) and completeness of initial resection2. In practice, the gold standard for imaging surveillance remains post-contrast T1WI of the internal auditory canal at 1, 2, 5 and 10 year time points, depending on the practitioner/institution1. The purpose of this retrospective study is to compare non-contrast SSFP images to post-contrast T1WI in the post-operative assessment of vestibular schwannoma. We hypothesize that non-contrast SSFP alone will be accurate in post-operative surveillance.

Materials and Methods

This was a HIPAA-compliant, IRB-approved retrospective cohort study of 35 patients with history of prior surgical resection of vestibular schwannoma and known residual/recurrent tumor. Post-contrast T1 weighted and non-contrast steady state free procession (SSFP) of the skull base were separately examined for each subject, and semi-automated tumor volume (mm3) calculations were performed for each subject using 3DSlicer. Paired samples t-test was performed to test for significance of difference between the volumes calculated based on the T1WI and SSFP images.

Results

Mean tumor volume measured on post-contrast T1WI was 1053.8 mm3 (range= 79.4-6289 mm3). Mean tumor volume measured on non-contrast SSFP was 1011.1 mm3 (range = 56.0-6011.7 mm3), a 4.1% difference from the gold standard (post-contrast T1WI). There was, however, a significant difference between volumes measured using the two sequences (t (34) = 3.3, p= 0.003).

Conclusions

Residual tumor volumes measured using a semi-automated technique based on non-contrast SSFP differed from post-contrast-T1WI by only 4.1%, which is less than that reported based on 2D measurements in the literature on pre-treatment surveillance literature (e.g., 10.4% reported by Forgues et al.3). These findings, if reproduced in a larger sample, suggest that an abbreviated, non-contrast examination in patients with previously resected schwannoma might be safely employed, obviating the need for contrast administration and presenting a potentially cost effective change in practice.
Utility of Separate Maxillofacial CT Imaging in Trauma Patients Already Receiving a Cervical Spine CT Exam in the Emergency Room Setting

C Baldwin¹, H Sotoudeh², A Singhal³
¹University of Alabama at Birmingham (UAB), Birmingham, AL, ²University of Alabama Birmingham, Birmingham, AL, ³University of Alabama at Birmingham, Birmingham, AL

Purpose
Facial trauma is a common indication for maxillofacial imaging in the emergency room, especially in the setting of whole body scanning. These patients often also undergo concurrent separate cervical spine CT imaging or CT Angiogram (CTA) of the neck (with cervical spine reformats), contributing to cumulative radiation exposure, including to the orbits. There is overlapping anatomy in these CT images and recent studies in the thoracolumbar spine have shown that this feature can be exploited to avoid redundant imaging and prevent excess radiation exposure. This study is to compare the detection rate of facial injuries reported from maxillofacial CT imaging with concurrently acquired CTA neck reformatted images in order to eliminate redundancy.

Materials and Methods
After IRB approval, records of 200 consecutive patients who received maxillofacial CT imaging in the UAB emergency department were reviewed. 65 patients who received cervical spine imaging with overlapping visible anatomy were selected for further analysis. The maxillofacial CT reports were reviewed to determine the type and location of facial/skull fractures reported during the initial encounter. The cervical spine CT/CTA neck studies were examined by two neuroradiologist readers separately, blinded to the findings on the maxillofacial report. Any differences between the readers were resolved by consensus.

Results
86 total fractures were identified in the subset of 28 out of the 65 selected patients. Out of 86 total fractures, 82 (95.3%) were identified on both studies and 4 (4.7%) were identified on only maxillofacial CT (Figure A). The Pearson Correlation Coefficient for overall agreement between the two studies was 0.995. In addition to bone fractures, detection of soft tissue injury and orbital injury were also compared. For both of these parameters, the cervical spine imaging was equally sensitive and specific with complete agreement. Orbital soft tissue injury was seen in 13 (20%) patients on both sets of images. The average radiation exposure as measured by Dose Length Product (DLP) per maxillofacial CT was 1064 mGy*cm. Of note, the ocular lens was included in both sets of images in all the patients.

Conclusions
Evaluation of maxillofacial structures and clinically significant maxillofacial injury is feasible with extended cervical spine imaging in the emergency room setting. Redundant scanning of maxillofacial structures with the two scans adds to cumulative radiation exposure in the patients, especially to the ocular lens.
Prevalence of Sigmoid Sinus Dehiscence/Diverticulum among adults with skull base cephaloceles.

H Sotoudeh¹, S Ghandili², O Shafiat², G Roberson³, G Elsayed⁴, J Bernstock⁵, G Chagoya⁶, P Talati⁶, A Singhal⁷

¹University of Alabama at Birmingham, Birmingham, AL, ²Johns Hopkins University School of Medicine, Baltimore, MD, ³University of Alabama at Birmingham, Birmingham, AL, ⁴University of Alabama, Birmingham, AL, ⁵Harvard Medical School, Boston, MA, ⁶Massachusetts General Hospital, Boston, MA

Table 1: Sensitivity and specificity of cervical spine CT/CTA neck reformats as compared to maxillofacial gold standard, separately on a per patient and per fracture basis.

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value(%)</td>
<td>95% CI</td>
</tr>
<tr>
<td>Patient based</td>
<td>85.71</td>
<td>67.3-96.0</td>
</tr>
<tr>
<td>analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture based</td>
<td>95.3</td>
<td>88.5-98.7</td>
</tr>
<tr>
<td>analysis</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Overall degree of agreement, with particular emphasis on the missed bone fractures.

<table>
<thead>
<tr>
<th></th>
<th>Total fractures</th>
<th>Total fractures</th>
<th>Agreement (Kappa coefficient)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>seen on Maxillofacial CT</td>
<td>seen on C-spine CT</td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mandibular Body</td>
<td>4</td>
<td>3</td>
<td>0.85</td>
</tr>
<tr>
<td>Nasal Bone</td>
<td>16</td>
<td>15</td>
<td>0.94</td>
</tr>
<tr>
<td>Sphenoid</td>
<td>3</td>
<td>2</td>
<td>0.79</td>
</tr>
<tr>
<td>Remaining bones</td>
<td>62</td>
<td>62</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Purpose
The cephalocele is a relatively rare condition caused by a congenital or acquired skull defect. The incidence of associated brain venous anomalies is not well known in this condition. In this study, we evaluated the "sigmoid sinus dehiscence and diverticulum (SSDD)" in patients with spontaneous skull base cephalocele.

Materials and Methods
Medical data from 2005 to 2018 were retrospectively searched for cephalocele. The patients with spontaneous skull base cephaloceles were included in this study. The prevalence of SSDD was calculated, and the relationship between the cephalocele variables (size, location, content, symptoms) and presence of SSDD was evaluated using the chi-squared test.

Results
Fifty-six patients were found, 12 males and 44 females. Thirty-four patients were symptomatic which of them 23 underwent surgical repair for cephalocele in our follow up. In 22 cases the cephalocele was diagnosed incidentally. After evaluation of the sigmoid sinuses, in 21 patients, evidence of dehiscence and diverticulum were noted. In 11 patients, the right sigmoid sinuses were involved, and in 7 patients the left sigmoid sinus was involved including 3 cases of diverticulum. In 3 patients evidence of bilateral SSDD was noted.

Conclusions
The SSDD is very common (37.5%) in patients with spontaneous skull base cephalocele and is probably under-diagnosed in radiologic exams. The linear regression demonstrated a negative association between cephalocele volume and the presence of SSDD. We hypothesize that skull base cephalocele and SSDD share a common physiopathology which is likely intracranial hypertension. One potential explanation could be that increased intracranial hypertension could manifest in several different forms including empty sella, prominent subarachnoid spaces around optic nerves, cephalocele formation, and SSDD. People predisposed to various anatomical constraints may have one presentation (ie, cephalocele) favored over another (ie, SSDD), leading to this possible finding.

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Sinonasal Glomangiopericytoma: Imaging Appearance & Update on a Rare Sinonasal Neoplasm

Ikuta1, A MALHOTRA2, V ZOHARBIAN3, N Das4
1YALE UNIVERSITY SCHOOL OF MEDICINE, MILFORD, CT, 2YALE UNIVERSITY SCHOOL OF MEDICINE, NEW CANAAN, CT, 3YALE SCHOOL OF MEDICINE, NEW HAVEN, CT, 4UT Health San Antonio, SAN ANTONIO, TX

Purpose
Sinonasal glomangiopericytoma is found in less than 0.1% of all sinonasal tumors. While this tumor may erode bone, it has an excellent prognosis. While treatment is surgical, knowledge that it can recur in 16% of patients should be known so as to prevent misclassification as a more aggressive neoplasm. Proper radiologic-pathologic correlation may provide reassurance to the operating ENT/neurosurgeon, and prevent the medical oncologist and radiation oncologist from inappropriately administering chemotherapy and radiation therapy. Sinonasal glomangiopericytoma is also presented because it is not well-represented in the radiology literature.

Materials and Methods
A male patient in his early 60's with a history of atrial fibrillation and prior transient ischemic attack was brought to the emergency room with new onset left arm and leg weakness/paresthesia. The patient had no prior history of cancer or any sinonasal issue. The patient quit smoking over 30 years ago, and only has occasional alcoholic beverages. While there was no stroke or acute arterial pathology on CTA, a mass was discovered in the left ethmoid sinus (imaging details in Image Findings section of abstract). The decision was made to surgically excise the tumor with a collaborative operation by ENT and neurosurgery. While there was osseous erosion, the dura remained without tumor invasion. Pathologists confirmed the diagnosis of sinonasal glomangiopericytoma by microscopic appearance and staining. No chemotherapy or radiation therapy is planned because of the improved 10-year survival without these adjuvant treatments. The patient is doing well post-operatively.

Results
CT without contrast demonstrates a mass isodense to soft tissues, without calcification. CTA demonstrates an arterially enhancing 2.5 cm mass eroding the ethmoid cribriform plate and left lateral lamella. However, there is no adjacent periosteal reaction or hyperostosis. The mass protrudes through the bone into the anterior cranial fossa. The mass is isointense to brain parenchyma on T1 and T2 sequences, no restricted diffusion, and homogenous contrast enhancement. There is no dural enhancement or dural thickening. There was only minimal mass effect, and no adjacent cerebral edema.

Conclusions
Sinonasal glomangiopericytoma is very rare amongst sinonasal tumors. Knowledge of the imaging characteristics will allow for proper radiologic-pathologic correlation, resulting in a clinical course that is distinct from other sinonasal tumors.
Rare Complication of Frontal Sinus Osteoma: Aseptic Meningitis with Pneumocephalus

S Khanpara¹, A Aein², P Rabiei², E Bonfante-Mejia³, R Riascos¹
¹The University of Texas Health Science Center, McGovern Medical School, Houston, TX, ²The University of Texas Health Science Center at Houston, Houston, TX, ³Univ. Of Texas Health Science Center, Houston, TX, ⁴Univ. Of Texas - Houston, Houston, TX

Purpose
To illustrate a case of frontal sinus osteoma with an uncommon complication of aseptic meningitis and pneumocephalus.

Materials and Methods
A 28-year-old Spanish speaking gentleman presents to the emergency department with seizure-like activity and transient loss of consciousness. He had frontal headache of moderate severity since last three weeks before this acute presentation. On physical examination, he appeared to be conscious and oriented to time, place and person with a GCS of 15. Pupils were reactive bilaterally to light. Muscle tone was normal and there was no pronator drift. The patient did not elicit any sensory or motor deficits. However, there was some neck stiffness that was not associated with photophobia, blurry vision or emesis. He did not report associated fever, chills or weakness. Kernig's and Brudzinski's signs were mildly positive.

Results
Scout image (Fig A) for the non-contrast CT demonstrates a large area of pneumocephalus (asterisk). There is an ill-defined radiopaque area in the frontal sinus region. Sagittal bone window image (Fig B) shows an osteoma located within the right frontal and anterior ethmoid sinuses (green arrow). Posteriorly, it is seen to extend through the inner table into the calvarium. There is an associated linear track of extra-axial air extending from the posterior margin of the osteoma. There is subtle area of hypodensity adjacent to the pocket of pneumocephalus (not shown here). An MRI performed later confirms the presence of the osteoma within the right frontal and anterior ethmoid sinus. The hypodensity adjacent to the pneumocephalus corresponds to an area of hyperintensity on T2-FLAIR image (Fig C) and likely represents edema (orange arrow). The postcontrast image (Fig D) demonstrates faint, patchy and linear enhancement along the anterior and inferior margins of the pneumocephalus (orange arrow) raising the possibility of meningitis (correlating with the physical examination). The absence of fever/chills, normal WBC count and inflammatory markers such as ESR and CRP suggest the presence of aseptic meningitis.

Conclusions
Aseptic meningitis and pneumocephalus are an uncommon but serious complication of paranasal sinus osteoma resulting from erosion of the underlying dura. Prevention of this life-threatening situation with sudden deterioration in clinical status is possible by timely consideration of this entity especially in cases where it is protruding into the calvarium. An elective surgery may be performed in such cases.
Intranasal Percocet Abuse: a Radiographic Subtlety in the Era of Prescription Opioid Epidemic

S Cai¹, B Branstetter²
¹University of Pittsburgh, Pittsburgh, PA, ²UPMC, Wexford, PA

Purpose
Abuse of prescription pain medication continues to be a substantial public health problem in today's society. According to the National Institute on Drug Abuse, roughly 21-29 percent of patients prescribed opioids for chronic pain misuse them and amounts to an annual cost of $51 billion in the United States. Intranasal abuse of prescription opioids, such as orally-formulated Percocet (hydrocodone-acetaminophen), has become far more prevalent given its rapid absorption through the nasal mucosa. Unfortunately the radiographic appearance is poorly described and often exceedingly subtle. A high index of clinical suspicion, hindered by a shrouded history and unreliable follow-up, is often needed to aid a radiographic diagnosis. The authors report a case series of intranasal Percocet abuse as exemplified by the following case.

Materials and Methods
A 30 year old man with no significant past medical history presented with three months of bilateral nasal congestion, hyposmia, bilateral cheek and right retro-orbital pain. He denied any antecedent infection or inhalation event at the first office visit. Physical examination and nasal endoscopy revealed white crusty debris in the bilateral nasal cavities and necrotic mucosal linings of the anterior septum, inferior and middle turbinates. He was prescribed opioid pain medication to alleviate his purportedly intense pain.

Results
CT revealed subtle ulceration and de-ossification of the anterior nasal septum and extensive debris in the nasal cavity, particularly the septum and inferior turbinates. In the operating room, patient was noted to have white powdery coating throughout the anterior nasal cavity and a green-blue hue involving the mucosa. Extensive debridement of the nasal cavity was undertaken. Surgical pathology revealed necrotic debris with non-polarizable foreign material. Cultures were positive for heavy Streptococcus viridans and...
Staphylococcus aureus, no fungus or anaerobic bacteria were cultured. On follow-up, patient endorsed several years of intranasal drug use and approximately six months of intranasal Percocet abuse. Opioid prescription was subsequently terminated.

Conclusions
In the era of prescription opioid epidemic, radiologists must remain vigilant to subtle findings of intranasal opioid abuse and maintain a high index of suspicion despite an unforthcoming patient.

On presentation, CT (top-left, top-right) shows subtle erosion of nasal septum and scattered debris in the nasal cavity. Patient underwent surgical debridement following inhalation injury (bottom-left). Endoscopic photo (bottom-right) taken from a separate publication shows the typical findings of intranasal Percocet abuse, characterized by white exudate overlying the necrotic nasal mucosa.

Giant Cell Reparative Granuloma of the Sphenoid Bone – An Unusual Cause of Headache

P Annigeri¹, A Bond², S Patel³, J Corrigan¹, B Griffith¹
¹Henry Ford Health System, Detroit, MI, ²Michigan State University College of Osteopathic Medicine, East Lansing, MI, ³HENRY FORD HOSPITAL, DETROIT, MI

Purpose
Giant cell reparative granulomas (GCRG) are rare non-neoplastic lesions that represent an inflammatory response to trauma and intraosseous hemorrhage. Despite being indistinguishable from giant cell tumors (GCT) of the bone on imaging, it is important to note that GCRGs and GCTs are distinctly different both clinically and histologically. Most reported cases of GCRGs occurred in the mandible and maxilla with some lesions occurring in other craniofacial bones and small tubular bones of the hands and feet. Unlike
GCT, GCRG tends to occur in patients in the 2nd and 3rd decades of life. This excerpt describes a case of a giant cell reparative granuloma arising in the sphenoid bone of a 24 year old patient and describes the imaging characteristics of this very rare lesion.

Materials and Methods
We present a case of a 24 year-old female who presented to the clinic with a history of headaches for four weeks. The patient also reported a history of double vision centered on the left eye with an inability to abduct the eye. Imaging demonstrated an expansile lesion centered in the sphenoid bone. The patient underwent surgical excision and has since been followed with annual MRI scans without evidence of local recurrence.

Results
Sagittal bone CT (A) shows an expansile mass causing osseous destruction of the sphenoid bone with extension into the sphenoid sinus. This mass demonstrates avid homogeneous enhancement on the axial CT angiography (B). MR imaging demonstrates a T1 isointense lesion (C) centered in the body of the sphenoid, separate from the pituitary gland, with avid enhancement on post-contrast imaging (D).

Conclusions
Giant cell reparative granulomas are non-neoplastic granulomatous lesions most commonly occurring in the mandible and maxilla. Cranial bone involvement is very rare. GCRGs are clinically and histologically different from the commonly known giant cell tumor, which is a true neoplasm. Non-specificity of the imaging findings and clinical presentation can lead to a delay in diagnosis and can therefore affect treatment and prognosis. It is important to consider GCRG in the differential for a sphenoid mass.

(Spontaneous Infarction within a Facial Schwannoma Leading to Acute Facial Paralysis in a Patient with Neurofibromatosis 2)

O Kohannim1, W Niermeyer2, R Friedman1, J Handwerker1
1UC San Diego, San Diego, CA, 2Ohio State University College of Medicine, Columbus, OH

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Purpose
To present a case of spontaneous infarction within a facial schwannoma causing acute facial paralysis

Materials and Methods
A 19-year-old male with a past medical history of neurofibromatosis type 2 (NF2) presented to the emergency room with sudden onset left facial nerve paralysis and neck pain. Physical examination revealed left facial nerve palsy without additional cranial nerve deficits. The patient had recently undergone a right vestibular schwannoma excision with auditory brainstem implant placement via a translabyrinthine approach.

Results
A contrast-enhanced brain MRI was performed due to his new symptoms and he was found to have an enhancing tubular lesion along the mastoid segment of the left facial nerve, consistent with a facial nerve schwannoma. Of note, when this study was compared to a prior brain MRI from a year ago, this lesion had developed a new, non-enhancing component below the level of the left stylomastoid foramen, suggestive of necrosis or auto-infarction within the schwannoma. Corresponding to the inferior, non-enhancing portion, there was increased signal on diffusion weighted imaging and corresponding low apparent diffusion coefficient, compatible with infarction. Multiple additional enhancing masses compatible with his history of NF2 were unchanged.

Conclusions
It is hypothesized that the new, likely spontaneous infarction within the left facial schwannoma led to patient's development of acute left facial paralysis. Given lack of symptomatic improvement, the patient underwent transmastoid decompression of the mastoid segment of the facial nerve down to the stylomastoid foramen. The tumor was left in situ to protect the facial nerve. Few have reported torsion and infarction within schwannomas in the literature, predominantly in the spine. Its occurrence in the facial nerve leading to acute symptoms or confirmation of infarct with diffusion weighted imaging within a schwannoma have not been previously reported in the literature.

Venous Channels at the Craniocervical Junction Could Mimic Masses

A Nayate

1University Hospitals of Cleveland, Cleveland, OH
Purpose
To demonstrate that non-pathologic enhancing lesions in the craniocervical junction (CCJ) are veins connecting the suboccipital cavernous sinus (SCS) and the anterior condylar vein (ACV).

Materials and Methods
A 66 year old female with history of primary melanoma of the nasal cavity underwent resection and chemoradiation. Patient had multiple CT and MRI of the face and brain which revealed stable enhancing nodules in the CCJ over 4 years.

Results
Figure A. Conglomeration of 3 enhancing nodules in the left spinal canal at the level of C1-C2. Figure B. Blue and red arrows show enhancing nodules in the right and left spinal canal at the level of C1-C2. The right nodule is abutting the adjacent dura. Figure C. Blue arrow shows a vein extending into the right SCS. Red arrow shows another nodule in the left spinal canal. Figure D. Red arrow shows a vein extending into the left SCS.

Conclusions
Differential considerations for intradural extramedullary enhancing lesions in the CCJ include schwannoma, meningioma, aneurysm, and meningeval diseases. McGuinness B. et al. recently described that enhancing lesions in a characteristic location related posterior to the intradural vertebral artery and distal to the dural penetration at the foramen magnum are often benign and could represent a varix or a ganglion. Antonucci MU et al. subsequently described that these lesions are most likely venous in etiology. Our case demonstrates two unique findings not mentioned in previous reports in regards to these lesions. First, there were 3 intradural extramedullary enhancing lesions in a vertical column along the left lateral spinal canal at the level of C1-C2. The prior studies described these lesions as being single. Second, the lesion in the right spinal canal abuts the dural surface while in the prior cases, the lesions were described as being separate from the dura. In our case, the lesions in the left spinal canal were interconnected by a thin venous channel and connected into the left suboccipital cavernous sinus inferiorly and the left anterior condylar venous confluence superiorly. A similar connection was also seen in regards to the lesion in the right spinal canal. A similar drainage pattern was seen in cases in the study conducted by McGuinness B. et al. In summary, non-pathologic enhancing lesions in the foramen magnum and CCJ are venous in etiology. Our case also demonstrates unique findings that, to our knowledge, have not been previously detailed.
Purpose
The 8th edition of the American Joint Committee on Cancer Cancer Staging Manual incorporates the depth of invasion (DOI) of oral cavity cancers as an independent prognostic factor in addition to tumor thickness (TT)(1). Currently, preoperative evaluation of tumor extent relies on CT/MRI, which may not delineate the tumor reliably, and by manual palpation. Palpation, especially for intraoperative guidance, can be subjective and limited for deeper tumors. The gold standard for determination of TT and DOI is histologic assessment of frozen and permanent sections, which can only be performed after tumor resection. We investigated whether ultrasound (US) is a feasible modality for intraoperative assessment of tumor extent and validated its accuracy by comparing it with histologic evaluation.

Materials and Methods
26 patients with tongue squamous cell carcinomas were prospectively identified. They underwent tumor resection by a single surgeon between 3/31/2016 and 4/26/2019. Intraoperative US was performed with a broadband compact linear array transducer (L15-7tio, Phillips) using B-mode and Doppler. Still images and cine clips were obtained in planes longitudinal and transverse to the long axis of the tumor. All US were performed by a single radiologist with the surgeon and an US technologist. Among this cohort, 22 patients had archived images in PACS that allowed measurements to be made sonographically (uTT, uDOI). Two patients had dysplasia and were excluded. Of the remaining 20 patients, all had both histologic TT and DOI (hTT, hDOI) measured by a single pathologist (Table 1). Consensus measurements of uTT and uDOI from two head and neck radiologists were analyzed. uTT was measured from the tumor surface to the deepest point of invasion (Fig 1). uDOI was measured from the level of the projected normal epithelial surface near the tumor to the point of deepest invasion of tumor (Fig 1). Pearson correlation was used to determine the degree of correlation between US and histologic assessment.

Results
Mean uTT (+/- standard deviation) was 7.5 mm +/- 3.5 mm and mean hTT was 7.0 mm +/- 4.2 mm. Mean uDOI and hDOI were 6.6 mm +/- 4.2 mm and 6.4 +/- 4.4 mm, respectively. There was excellent correlation between sonographic and histologic measurements for both TT and DOI with Pearson correlation coefficients (95% confidence interval) of 0.95 (0.87 - 0.98) and 0.95 (0.87 - 0.98), respectively (Fig 2).

Conclusions
Intraoperative US can provide reliable, real-time assessment of the extent of tongue tumors.
Materials and Methods
The study cohort included 154 patients with OPSCC who received chemoradiation therapy with curative intent. Pretreatment FDG-PET was performed in all patients. They were divided into training (102 patients) and test (52 patients) sets. The diagnosis of local failure and progression-free survival (PFS) rate were obtained from patients’ medical records. In deep learning analyses, three different architectures (AlexNet [1], GoogLeNet [2] and ResNet [3]) were respectively assessed with axial slice, coronal slice and these two slices combination use. In training set, FDG-PET images were analyzed after data augmentation process for the diagnostic model creation. The test set data were subsequently analyzed for confirmation of diagnostic accuracy. Assessment of PFS rates using deep learning-based prediction model were also performed. For the comparison to deep learning model, T-stage (I-IVb) and clinical stage (I-IVc) which was clinically determined with visual inspection and multi-modality imaging approach were assessed as conventional methods.

Results
Training sessions were successfully performed with accuracy rate of 74-89% and loss rate of 1.0-4. In test sets, receiver operating characteristic (ROC) curve analyses revealed area under curve (AUC) of 0.61-0.85 by deep learning model, whereas 0.62 by T-stage and 0.59 by clinical stage (Fig. 1). The highest AUC was obtained with the combination use of axial and coronal slices with deep learning analysis of ResNet architecture (AUC=0.85), with the diagnostic accuracy of 0.83. In the Kaplan-Meier analysis, although the PFS rate was significantly greater in all groups of patients with lower T-stage (p<0.05), lower clinical stage (p<0.05) and low risk group of deep learning-based classification (p<0.001), deep learning-based classification clearly divided the patient’s PFS rate the most.

Conclusions
A deep learning-based diagnostic model using pretreatment FDG-PET images predicts treatment outcome and PFS rate in patients with OPSCC who underwent definitive chemoradiation therapy with 0.83 accuracy in this pilot study.
In-Utero Tractography of the Cerebellum in the Third Trimester of Pregnancy.

F Machado-Rivas¹, C Velasco-Annis¹, S Khan¹, B Marami¹, A Gholipour¹, C Jaimes¹
¹Boston Children’s Hospital, Boston, MA

Purpose
To explore cerebellar white matter (WM) connectivity in a population of third trimester typically developing fetuses using deterministic tractography.

Materials and Methods
HIPPA compliant and IRB approved study. Healthy women with previous normal 2nd trimester ultrasound were recruited prospectively for 3T MRI. Fetal brain structural images were acquired in multiple planes using SSFSE-T2w sequences. A previously validated motion-corrected super-resolution reconstruction technique [1] was used to generate isotropic images. DWI comprised 2–8
scans of the fetal head in orthogonal planes with 1-2 b=0s/mm² images, and 12 diffusion-sensitized images at b=500s/mm². A slice motion correction and DTI reconstruction algorithm [2] was applied. Deterministic tractography was performed with Trackvis using a FACT algorithm. We placed ROIs using structural and diffusion images to outline the middle cerebellar peduncle (MCP) and the superior cerebellar peduncle (SCP) pathways. We measured volume, fractional anisotropy (FA) and apparent diffusion coefficient (ADC), and tested for differences between anatomic pathways using a Wilcoxon signed-rank test. Multiple linear regression analyses were performed to find relations between tracts, volume, FA and ADC with gestational age (GA) and the anatomic pathway type. Rate of change for each variable was estimated.

Results
59 subjects (34 male and 25 female) were analyzed. GA range was 29.3 to 38.1 weeks (w), mean of 33w (SD 3w). We could perform tractography of MCP in 45 subjects (76%), and of both MCP and SCP in 32 subjects (54%) (Fig 1a). MCP Volume, FA and ADC were significantly different from SCP (all P<.001). We found that both GA and tract were predictors of volume (P<.001 and P<.001, respectively) and FA (P<.001 and P<.001, respectively). Only GA was a predictor of ADC (P<.001). For MCP, volume increased at .194 ml/w (95% CI .122 -.266) (Fig 1b), FA increased at .00616 /w (95% CI .00324 -.00909) (Fig 1c) and ADC decreased at -.0000254 (mm²/s)/w (95% CI -.0000403 -.0000105) (Fig 1d). For the SCP, volume increase and ADC decrease with GA did not reach significance (P>.05). Only FA increase was significantly associated with GA (P.005).

Conclusions
Fetal cerebellar WM connectivity can be explored in-vivo by seed-based deterministic tractography based on diffusion tensor model parameters estimated by a slice-level fetal motion correction algorithm [2]. Our analysis shows that the MCP volume and diffusion metrics significantly changed with gestational age.
K Cecil, T Beckwith, K Brunst, K Yolton, P Ryan
1CINCINNATI CHILDREN’S HOSPITAL MED. CTR., CINCINNATI, OH, 2Cincinnati Children’s Hospital Medical Center, Cincinnati, OH, 3University of Cincinnati, Cincinnati, OH

Purpose
Traffic-related air pollution (TRAP), a complex mixture of particulate matter, metals, elemental and organic carbon is strongly associated with cardiopulmonary health effects[1]. Evidence suggests the developing brain may also be a target organ for these particles due to translocation either from the respiratory system or through the olfactory nerve [2]. Using an epidemiological cohort with extensive longitudinal exposure assessment since infancy, we tested the hypothesis that exposure to TRAP during critical windows of brain development is significantly associated with changes in brain chemistry, structure and organization. Our imaging study design targeted recruitment of participants from the cohort with the highest and lowest quartiles of exposure at time of birth.

Materials and Methods
Participants (n=147, mean age 12.1 ± 0.7 years, 56% male) from the Cincinnati Childhood Allergy and Air Pollution Study (CCAAPS) completed a high-resolution imaging and single voxel, short echo spectroscopy protocol with a 32-channel head coil at 3 Tesla. We evaluated brain chemistry with LCModel software, volume and cortical thickness using the Computational Anatomy Toolbox for SPM 12 software running in Matlab. We derived diffusion metrics (fractional anisotropy (FA), mean (MD), axial (AD) and radial (RD) diffusivity) by employing a 32-direction, diffusion tensor imaging sequence. Analyses were performed using DTI Studio and custom software. Exposure to TRAP at birth was estimated using a previously developed land use regression model [3]. One-way ANOVA and multiple linear regression analyses were used to investigate the relationship between neuroimaging metrics with TRAP exposure at specific timepoints (birth, early life, average childhood, 12 years), respectively. Potential confounders and covariates were included in the analytical models.

Results
Children with high TRAP exposure levels at time of birth were associated with reductions at 12 years of age in brain volume and cortical thickness, especially in the cerebellum, pre- and post-central gyri, and changes in diffusion metrics compared with children with low TRAP exposure (Figure 1). Recent exposure to high levels of TRAP was associated with significant increases in myo-inositol (β=0.26; 95%CI 0.01, 0.51) compared to low TRAP exposure.

Conclusions
Children with higher exposure to TRAP demonstrate differences in chemical, structural and organizational neuroimaging outcomes compared with their lower exposed peers.

(Filename: TCT_1800_Figure_CCAAPS.jpg)
Scientific Abstract Session: Brain Infection/Inflammation

1074

3:30PM - 3:36PM

The Central Vein Sign and Iron Rims: Insights From a Large Cohort of Patients with Multiple Sclerosis and Mimicking Disorders

M Clarke¹, D Pareto¹, L Pessini Ferreira¹, G Arrambide², M Alberich³, F Crescenz², S Cappelle⁵, M Tintoré¹, C Auger⁶, X Montalban⁷, N Evangelou⁸, A Rovira⁹

¹Hospital Vall d’Hebron, Barcelona, -- SELECT --, ²Centre d’Esclerosis Múltiple de Catalunya, (Cemcat), Hospital Universitari Vall d’Hebron, Universitat, Barcelona, Catalunya, ³Vall d’Hebron Research Institute, Barcelona, Catalunya, ⁴University of Verona, Verona, Verona, ⁵University Hospital Leuven, Leuven, Flemish Brabant, ⁶Hospital Vall d’Hebron, BARCELONA, Barcelona, ⁷Centre d’Esclerosi Múltiple de Catalunya, (Cemcat), St Michael’s Hospital, University of Toronto, Barcelona, Catalunya, ⁸University of Nottingham, Nottingham, Nottinghamshire, ⁹Hospital Universitari Vall d’Hebron, Barcelona, Spain

Purpose

Susceptibility-weighted imaging (SWI) is an MRI technique that allows in vivo visualisation of venous blood & iron deposits. This technique enables identification of iron rims (IR) surrounding some white matter lesions (WMLs) and also the presence of the central vein sign (CVS), both of which have been proposed as MS-specific biomarkers. Previous studies have found that WMLs with IRs are more likely to enlarge, fail to remyelinate and appear to be absent in non-MS disorders. Large cohort studies are needed to further establish the role of IRs and CVS in MS. We aimed to assess the frequency of the CVS and IRs, detected on clinical, 3T SWI images, in a large cohort of patients with clinically isolated syndrome (CIS), relapsing-remitting (RR), progressive MS (PMS) and MS-mimicking disorders.

Materials and Methods

We retrospectively identified 622 patients scanned as part of routine, clinical assessment at the Vall d’Hebron University Hospital in Barcelona, Spain between September 2010 and March 2019. Our sample included three main groups of patients: CIS patients scanned within 6 months of the first attack, MS patients with an already established diagnosis and patients with MS imaging mimicks. We identified supratentorial lesions, which were at least 3mm on 2D/3D FLAIR and used co-registered 2D SWI to assess the frequency of CVSs and IRs. We ran a negative binomial regression to predict the number of lesions with IRs in CIS & MS patients based on clinical and demographic characteristics.

Results

112 CIS, 103 relapsing-remitting (RR), 49 progressive MS (PMS) and 35 non-MS patients were included. 2624 WMLs were analysed, including 1357 WMLs with CVS and 392 WMLs with IRs. 48% of CIS, 59% of RR and 39% of PMS patients had at least one IR and none of the non-MS patients had any IRs. RR patients had more IRs (median=1, range:0-22) than PMS patients (median=0,range: 0-10) and CIS (median=0,range:0-8). Median number of WMLs with CVS was 2.5 for CIS, 6 for RR, 3 for PMS and 1 in non-MS. None of the non-MS patients exceeded the 40% threshold of WMLs with CVS. WMLs with IRs and CVS were most common around the ventricles (58% of all WMLs with IRs and 39% of all WMLs with CVSs). CVSs were also common in subcortical WMLs (36.9% of all WMLs with CVSs). The incidence rate of WMLs with IRs in females was 0.6x that in males (p< 0.001). CIS phenotype was predictive of a decreased number of IRs, compared to RR (p< 0.001), but not in PP (p=0.38).

Conclusions

IRs and CVS can be successfully visualised on clinical, 3T SWI images and appear to be highly specific to MS WMLs. Our results show that IRs numbers peak in RRMS and decrease with longer disease duration. Future longitudinal analyses, currently being undertaken at our centre, will help determine their contribution to disease progression and disability accumulation.
Differentiation of Multiple Sclerosis from Neuromyelitis Optica Spectrum Disorders and MOG Antibody Disorder Based on Brain Lesion Distribution

A Pires¹, G Fatterpekar¹, J Patel², E Charlson², I Kister², A Derman¹
¹New York University Langone Health, Department of Radiology, New York, NY, ²New York University Langone Health, Department of Neurology, New York, NY

Purpose
While no radiologic finding is pathognomonic for Multiple Sclerosis (MS), brain lesions in MS tend to occur in characteristic locations as outlined in the McDonald criteria. Some lesion types are more specific than others and determining their frequency in different demyelinating-inflammatory disorders may be of benefit in differentiating each disease from each other. Our purpose is to compare the frequency of brain lesions considered typical for MS based on the 'MS Lesion Checklist' (Kister 2018) in a cohort of patients with MS, Neuromyelitis Optica Spectrum Disorders (NMOSD), and MOG Antibody Disorder (MOGAD).

Materials and Methods
Retrospective chart and brain MRI review was performed in a cohort of patients with MS (n=51), NMOSD (n=23), MOGAD (n=8), who were referred to the NYU MS Care Center (New York) for evaluation. One neuroradiologist and one neuroradiology fellow independently reviewed the cohort's brain MRIs while blinded to the clinical diagnosis. They scored the number of lesions on each MRI based on lesion location (middle cerebellar peduncle, brainstem surface, brainstem ependymal surface, central brainstem, cerebellar, abutting temporal horn, Dawson finger/periventricular, subcortical white matter, callososeptal interface, other corpus callosum, U-fiber, and other juxtacortical). Frequency of lesions in each location in the three diseases were compared using Fisher's exact test (p<0.05 considered significant).

Results
Of all the lesion locations scored, only lesions abutting the temporal horn demonstrated a statistically significant difference in MS when compared to both NMOSD and MOGAD (MS 73%, NMOSD 22% (p<0.001), MOGAD (p< 0.01). Cerebellar lesions were more common in MS (53%) than NMO (26%) with p<0.04, but cerebellar lesions were not significantly different between MS and MOGAD. Additionally, Dawson's fingers and callososeptal interface lesions were significantly more common in MS when compared to MOGAD (p<0.0005 and p<0.006, respectively), but there was no difference in the occurrence of these lesions between MS and NMOSD.

Conclusions
Data suggest a relatively high degree of overlap in the distribution of lesions in inflammatory demyelinating disorders. Of all the locations categorized, only lesions abutting the temporal horn were shown to be significantly more common in MS than NMOSD or MOGAD.
MOGAD. While other lesions were significantly different between MS and one of the other two disorders, they could not differentiate MS from both, reinforcing the importance of clinical findings.

**Diffusional Kurtosis Imaging helps to differentiate MS lesion types**

C Thaler¹, A Kyselyova¹, T Faizy², S Jespersen³, B Hansen³, J Fiehler⁴
¹University Hospital Hamburg-Eppendorf, Hamburg, Hamburg, ²Stanford University, STANFORD, CA, ³Aarhus University, Aarhus, Aarhus, ⁴University Medical Center Hamburg-Eppendorf, Hamburg, AK

**Purpose**

Diffusional kurtosis imaging (DKI) is a novel MRI technique measuring the leading deviation from Gaussian diffusion. Mean kurtosis (MK), one of the parameters derived from DKI, has shown increased sensitivity to tissue microstructure in several neurological disorders, including Multiple Sclerosis.

**Materials and Methods**

Thirty-seven patients with relapsing-remitting MS and eleven healthy controls (HC) were enrolled in this study and received brain imaging on a 3T MR scanner. The MR protocol included a sagittal 3-dimensional FLAIR sequence, a T1w MPRAGE sequence before and after Gadolinium injection and a fast DKI sequence, recently introduced by Hansen et al [1]. Subsequently, MK and mean diffusivity (MD) were measured in the white matter of HC, normal-appearing white matter (NAWM) of MS patients, contrast-enhancing lesions (CE-L) and FLAIR lesions (FLAIR-L).

**Results**

Overall 1526 lesions were analyzed, including 30 CE-L and 1496 FLAIR-L. Results are displayed in Figure 1 and 2. For MK, we found significant differences between all groups (p<0.05) except between WM of HC and NAWM (p=0.06). For MD, we only found significant differences between HC and CE-L and FLAIR-L as well as between NAWM and FLAIR-L (p<0.05). A detailed overview is given in Table 1.

**Conclusions**

MK showed good prognostic value to differentiate between the different lesion categories without the use of gadolinium. Furthermore, the fast DKI sequence used in our study can be easily integrated in clinical routine and provides further information about diffuse white matter injury, lesion microstructure and damage.

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**Prevalence of thalamic and cortical lesions in multiple sclerosis on 3T clinical MRI**

D Thongkham¹, G Sadigh², A Saindane³, R Bakshi⁴, J Allen², R Hu²

(Filename: TCT_1693_ASNR_Grafik2.jpg)
Purpose
Gray matter involvement, including the thalamus, has become increasingly recognized for its association with many clinical manifestations of multiple sclerosis (MS). While there have been reports describing thalamic lesions on 7T research magnets, this has not been replicated in the clinical setting. We thus sought to evaluate the detectability of cortical and thalamic lesions using Double Inversion Recovery (DIR) and Fluid Attenuation Inversion Recovery (FLAIR) on 3T clinical studies.

Materials and Methods
172 patients with a clinical diagnosis of MS, who underwent brain MRI using an MS protocol that included volumetric 3D DIR (sagittal acquisition with 1mm axial reformats) and 2D T2 FLAIR (axial acquisition, 3mm slices) on the same Siemens 3T MR unit between September 2016 and April 2018 were selected for recruitment. Two board certified neuroradiologists independently reviewed all exams and identified thalamic and cortical lesions. Adjudication was provided by a third neuroradiologist when necessary. Statistical analysis was performed using JMP (SAS 2018), with significance defined as p < 0.05.

Results
The median age was 42 (IQR 32 – 50), and 131 (76%) were women. 160 (93%), had relapsing-remitting, 5 (3%) had primary-progressive, and 7 (4%) had secondary-progressive MS. Thalamic lesions were detected in 56 (32.6%) on DIR compared to 25 (14.5%) on FLAIR (p < .001), while cortical lesions were detected in 51 (29.7%) on DIR compared to 27 (15.7%) on FLAIR (p = 0.003). For patients with cortical lesions, the average number of lesions identified per patient was 1.75 (SD = 0.91, Range 1-5) and 1.30 (SD = 0.78, Range 1-3) on DIR and FLAIR respectively (p < .001). For patients with thalamic lesions, the average was 1.57 (SD = 0.93, Range 1-6) and 1.28 (SD = 0.54, Range 1-3) respectively (p = .004). There was a correlation between the presence of thalamic and cortical lesions on DIR (p < .001) and suggestion of correlation on FLAIR (p = .067).

Conclusions
Our patient population demonstrated a relative high prevalence of both thalamic and cortical lesions at clinical 3T MRI, albeit at lower rate than is reported at 7T (Zurawski 2019). DIR detected more of both types of lesions than 2D FLAIR, which could be due to its higher contrast or smaller slice thickness in our clinical protocol. Our results show that both thalamic and cortical involvement in MS can be detected using routine MRI techniques. Future work is needed to evaluate how this information can be used to prognosticate and guide therapy in MS.
Purpose
To present a deep-learning approach for the automated classification of different central nervous system diseases presenting with brain white matter (WM) hyperintense lesions on MRI and to compare the performance of the model with that of two expert neuroradiologists blinded to patients' diagnosis. The diagnostic work-up of patients with suspected multiple sclerosis (MS) may be challenging due to the frequency of WM hyperintensities in a variety of neurological conditions. Using MRI data, a great effort is ongoing to allow an automatic and reliable diagnosis for patients with different diseases mimicking MS. The accuracy of deep-learning-based imaging diagnostics is reaching or is going beyond the level of clinical experts by using information directly driven by raw or minimally processed data.

Materials and Methods
Two hundred sixty-eight brain T1-weighted and T2-weighted MRI scans, acquired on a 1.5T and 3T MR Philips scanners, were collected from patients with migraine (n=56), MS (n=70), neuromyelitis optica spectrum disorders (NMOSD) (n=91) and CNS vasculitis (n=51). The model architecture, trained on 178 images, was based on a cascade of four 3D convolutional neural network layers followed by a fully dense layer after features extraction. The ability of the final algorithm to correctly classify the diseases in an independent test set of 90 MRI was compared with that of 2 expert neuroradiologists.

Results
In the test set, the deep learning algorithm showed higher classification accuracy (92.2% vs 59% for migraine, 98.8% vs 78% for MS, 88.6% vs 4.4% for NMOSD, 92.1% vs 51% for vasculitis) and higher specificity (97.1% vs 88.4% for migraine, 98.4% vs 75.5% for MS, 92.9% vs 92% for NMOSD, 93.2% vs 72.6% for vasculitis) compared with the two neuroradiologists (p=0.01). The inter-rater agreement was about 84.9% (Cohen's kappa=0.78, p<0.001).

Conclusions
The classification performance of the deep-learning algorithm on brain MRI exceeded that of 2 expert neuroradiologists, thus suggesting that artificial intelligence may be a powerful and useful paraclinical tool in the diagnostic work-up of diseases mimicking MS.

Retrospective, Dual-Center Review of Imaging Findings In Neurosarcoidosis At Presentation: Prevalence And Imaging Subtypes

G Bathla1, C FREEMAN2, N Soni3, T MORITANI4, J Song5, S MOHAN6
1Univ. Of Iowa Hospitals & Clinics, Iowa City, IA, 2HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA, 3University of Iowa hospitals and Clinics, IOWA CITY, IA, 4UNIVERSITY OF MICHIGAN, ANN ARBOR, MI, 5University of Pennsylvania, Philadelphia, PA, 6UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA

Purpose
Neurological involvement in sarcoidosis is well recognized. However, the imaging manifestations in Neurosarcoiotosis (NS) have only been assessed in small case series. The purpose of the present study was to assess the prevalence of various imaging manifestations in NS patients at presentation and to explore if specific imaging findings may cluster in different sub-groups.

Materials and Methods
We performed a retrospective, dual-institution, systematic imaging review of MRI findings in one hundred consecutive NS patients who presented over a 15-year period. Clustering analysis (k-mode) was performed to evaluate co-occurrence of imaging findings and also their correlation with clinical presenting symptoms.

Results
Periventricular white matter changes (PVWM) were the most common imaging abnormality (56%), followed by leptomeningeal (47%) and pachymeningeal (32%) involvement. Other common manifestations included cranial nerve involvement (30%), parenchymal granulomas (27%), Hypothalamic-Pituitary-Adrenal axis involvement (26%) and hydrocephalus (14%). Additionally, we noted a higher prevalence of perivascular enhancement (23%), cerebrovascular events [including ischemic and hemorrhagic events] (17%) and ependymal involvement (20%) than previously recognized. Additional k-mode analysis showed that the imaging findings could possibly be divided into disease sub-sets of four groups, each with varying distribution of imaging manifestations and clinical manifestations.

Conclusions
Overall, PVWM involvement and meningeal involvement are the most common imaging manifestations of NS. The prevalence of perivascular enhancement, cerebrovascular events and ependymal involvement is likely higher than previously reported. Additionally, different imaging findings in NS may cluster together and imaging subtypes in NS possibly exist.
Neurosymptomatic CSF HIV Escape

B Sawatzky¹, H Rowley², L Eisenmenger³
¹University of Wisconsin, Madison, WI, ²Univ. of Wisconsin, Madison, WI, ³University of Wisconsin - Madison, Madison, WI

Purpose
The purpose of this talk is to present a rare case of neurosymptomatic human immunodeficiency virus (HIV) escape and review the imaging findings essential to making this challenging diagnosis.

Materials and Methods
54-year-old male with a history of HIV on highly active antiretroviral therapy (HAART) presented with progressive gait difficulty over the course of one year with accelerated instability and memory loss over the past two months. An extensive workup demonstrated no signs of viral, tuberculous, or fungal infection and no findings of CNS lymphoma. The serum HIV viral RNA load was 160 cp/mL; however, cerebral spinal fluid (CSF) HIV viral RNA load was 1390 cp/mL, consistent with neurosymptomatic CSF HIV escape.

Results
MRI from one year prior was consistent with HIV encephalopathy with confluent areas of T2 and T2/FLAIR hyperintensity in the subcortical and deep cerebral white matter, sparing the short association fibers and demonstrating no abnormal enhancement or diffusion restriction. New MRI shows worsening diffuse areas of T2 and T2/FLAIR hyperintensity in the subcortical and deep cerebral white matter now with stippled enhancement in a perivascular distribution.

Conclusions
Combination antiretroviral therapy (CRT) that successfully suppresses systemic infection usually suppresses CNS HIV infection as well; however, rarely the virus becomes sequestered within the CSF demonstrating higher CSF than serum HIV concentrations, referred to as CSF HIV escape. Even more rarely, CSF HIV escape presents with neurological decline, called neurosymptomatic escape. While confluent white matter hyperintensity is non-specific in the setting of HIV, the key to diagnosis of CSF HIV escape is recognizing the abnormal perivascular enhancement in the setting of patchy and confluent white matter disease. This pattern of enhancement is not present in HIV encephalopathy, progressive multifocal leukoencephalopathy, and typical CNS infections. CSF sampling should be obtained to confirm the diagnosis and exclude other possible etiologies including atypical infections or lymphoma. With the increasing use of CRT in HIV patients, it is essential for radiologists to recognize this entity and appropriately recommend lumbar puncture.
Mean Kurtosis in the Corpus callosum is associated with clinical impairment in Multiple Sclerosis patients

C Thaler¹, A Kyselyova¹, T Faizy², S Jespersen³, B Hansen⁴, J Fiehler⁵
¹University Hospital Hamburg-Eppendorf, Hamburg, Hamburg, ²Stanford University, STANFORD, CA, ³Aarhus University, Aarhus, Aarhus, ⁴Aarhus University, Aarhus, Aarhus N, ⁵University Medical Center Hamburg-Eppendorf, Hamburg, AK

Purpose
Clinical-radiological correlations are in general low in Multiple Sclerosis (MS). Recent studies, that focused on diffusional kurtosis imaging (DKI), have shown that mean kurtosis (MK) is sensitive to diffuse white and gray matter injury in MS and might improve clinical-radiological correlations.[1]

Materials and Methods
Fourteen patients with relapsing-remitting MS received brain imaging on a 3T MR scanner at baseline and again after 12 months. Scan protocols included a sagittal 3-dimensional FLAIR sequence and a fast DKI sequence, recently introduced by Hansen et al.[2] Subsequently, MK was measured within the corpus callosum (CC), which was automatically segmented using FreeSurfer, and within
a FLAIR lesion mask which was manually outlined for each patient. Additionally, imaging results were correlated with clinical impairment using the Expanded Dis-ability Status Scale (EDSS), the 9-Hole Peg Test (9H-PT), the Symbol Digit Modalities Test (SDMT) and Timed 25-foot Walk (T25-FW).

Results
At baseline, significant correlations were obtained between MK within the CC and all obtained clinical test scores (see Figure1). No correlations were found for MK within the FLAIR lesion mask and any clinical test score. Comparing the baseline and follow-up data, we found a significant correlation between relative changes in MK within the CC and relative changes in the 9H-PT (see Figure2).

Conclusions
MK within the CC correlates well with clinical impairment in MS patients and might improve the detection and evaluation of diffuse white matter injury. The fast DKI sequence used in our study can be easily integrated in clinical routine and provides a novel imaging biomarker that might close the clinical-radiological gap. At the time of abstract submission, further regions of interests were investigated.

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4:26PM - 4:32PM

Immune-Reconstitution Inflammatory Syndrome (IRIS) or Paradoxical Reaction (PR) is Also Seen in Non-Immunocompromised Patients During Treatment for Tuberculosis

L Nagae1, T Massini1, D Watson1, J Rees1, M Lauzardo1
1University of Florida, Gainesville, FL

Purpose
to report a case of Immune-Reconstitution Inflammatory Syndrome (IRIS) or Paradoxical Reaction (PR) during treatment for tuberculosis in a non-immunosuppressed patient.

Materials and Methods
20 year-old, non-HIV previously healthy female, presented with seizures, back pain and headache. Imaging revealed miliary lesions throughout the brain, lungs, liver, and L1-L2 vertebral body osteomyelitis with epidural and psoas abscesses. Percutaneous sampling of the psoas abscess confirmed tuberculosis. Treatment with isoniazid, rifampin (later changed to rifabutin), pyrazinamide, ethambutol and, additionally, prednisone, was implemented. A follow-up brain MRI correlated with overall clinical improvement of the patient during prednisone tapering. Overall decrease of all brain lesions was seen, except for new post-contrast enhancement along the hypothalamus and infundibulum, as well as a sub-centimeter enhancing nodule along the left Sylvian fissure, concerning for a pseudo aneurysm. Follow-up CTA demonstrated the nodular enhancement along the left Sylvian fissure to represent a granuloma rather than a pseudo aneurysm. All new lesions were, therefore, interpreted as IRIS or PR. Prednisone tapering was held momentarily and the patient continuously improved.

Results
Edema and post-contrast enhancement involving L1 and L2 vertebral bodies continuously and the ventral epidural space, with only minimal enhancement of the intervening disc, compatible with the known tuberculous spondylitis (Fig 1). An enhancing nodule is seen in the conus medullaris (Fig 1) along with additional similar spinal cord lesions (not included). Miliary lesions were identified in
the brain (Fig 1), lungs and liver. Overall improvement of brain lesions during treatment and development of new enhancing lesions interpreted as IRIS or PR (Fig 2).

Conclusions
IRIS or PR are known to occur in the setting of HIV or medical immunosuppression, such as lymphocyte-targeted antibody treatment used for immune-mediated conditions, such as multiple sclerosis. IRIS and PR are thought to be, however, more common than usually documented, also in non-immunosuppressed population during tuberculosis treatment, and more likely during tapering of prednisone. These findings have to be recognized so to avoid confusion with lack of response to treatment, which would require change in clinical management.

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4:33PM - 4:39PM

Susceptibility-Weighted Imaging as an Alternative to Contrast-Enhanced T1w Imaging for Detecting Acute Multiple Sclerosis Lesions

A Rovira¹, L Pessini Ferreira¹, M Clarke¹, A de Barros¹, A Salerno¹, M Tintoré¹, D Pareto¹, C Auger¹
¹Hospital Vall D’Hebron, Barcelona, 08035, Spain

Purpose
Multiple sclerosis (MS) is a chronic neuroinflammatory disease with spatiotemporal dissemination of lesions within the central nervous system. Gadolinium (Gd) enhancement of focal lesions indicates active inflammation, and represents a marker of acute disease activity. Susceptibility-weighted imaging (SWI) is an MRI technique that allows in vivo detection of magnetic susceptibility effects in tissues. Prior studies using quantitative susceptibility mapping (QSM) have demonstrated a significant increase in magnetic susceptibility of MS lesions as they evolve from a Gd-enhancing to a non-enhancing stage. We hypothesize that in Gd-enhancing lesions, no susceptibility effect is demonstrated on SWI, while in non-enhancing new T2 lesions a susceptibility effect is clearly shown. Therefore, the purpose of this study is to assess the value of SWI for detecting enhancing MS lesions.

Materials and Methods
We retrospectively reviewed a set of 57 relapsing MS patients, who had undergone a baseline and a follow-up 3T MRI (mean interval: 9.4 months), in whom new T2 lesions were identified. The SWI data was visually analyzed by two observers, blinded to the Gd-enhancement status, in order to detect the absence or presence of rim-like or dot-like hypointensities within each new lesion. Hypointensities attributable to a central vein sign were disregarded from the analysis. Two different observers analyzed the pre- and post-Gd images, also in a blinded manner. The results were exported into a SPSS spreadsheet for statistical analysis.

Results
We evaluated a total sample of 173 new T2 lesions (24.8% enhancing and 75.2% non-enhancing lesions). Hypointense rims were identified in 49 (28.3%) lesions (95.9% were non-enhancing). Dot-like hypointensities were seen in 93 (53.7%) lesions (97.8% were non-enhancing). Finally, 39 (22.5%) lesions were isointense or slightly hyperintense on SWI, of which 97.4% showed enhancement after Gd administration. Based on the absence of signs indicating susceptibility effect within the lesions (hypointense rim or dot, not attributable to a central vein), sensitivity, specificity, positive predictive value, negative predictive value and accuracy of SWI for predicting Gd-enhancement were 97.7%, 90.7%, 96.7%, 92.9% and 95.9%, respectively. On the other hand, the presence of signs
indicating susceptibility effect, sensitivity, specificity, positive predictive value, negative predictive value and accuracy for predicting absence of Gd enhancement were 88.4%, 99.2%, 97.4%, 96.3% and 96.5%, respectively.

Conclusions
The absence of magnetic susceptibility on SWI seems to be a useful marker of active inflammation in new MS brain lesions. SWI could be considered as an imaging biomarker and an alternative to Gd-enhanced MRI, for assessing disease activity in the monitoring process of MS patients.

Scientific Abstract Session: Brain Tumor 3
2192

Eye tracking for brain metastasis localization, longitudinal follow-up and deep learning image labeling: a proof of concept

J STEMBER1, D Stember2, A Holodny3, N Swinburne1, R Young1, D Gutman1, A Ballangrud1, N Moss1, E Krupinski4
1Memorial Sloan Kettering Cancer Center, New York, NY, 2New York University School of Medicine, New York, NY, 3MEMORIAL SLOAN KETTERING CANCER CENTER, NEW YORK, NY, 4Emory University School of Medicine, Atlanta, GA

Purpose
Brain metastases are increasing in prevalence as new therapies prolong survival (1). Increasingly, stereotactic radiosurgery is gaining acceptance over whole brain radiation to treat multiple lesions (2). Initial annotation of multiple lesions (up to 40) is tedious and time-consuming. Following so many lesions is challenging especially when one resolves, but later recurs. These may be misconstrued as new metastases. Additionally, inadequate annotated data hampers progress in deep learning to localize, measure and classify lesions. We have recently demonstrated feasibility of Eye Tracking (ET) to label lesions for deep learning (3). Extracting labeled metastases automatically from ET, in the routine clinical setting, could vastly improve the convolutional neural networks. In this proof-of-principle work, we hypothesize that ET can accurately localize and annotate metastases.

Materials and Methods
Five publicly available (4) image slices of postcontrast T1 weighted brain MRIs containing 14 metastases were viewed by a radiology researcher with eye tracking software and hardware (Tobii T60XL). Gaze plot heat maps (Fig 1B) were generated, with red regions corresponding to longer gaze times. The user was instructed to look longer (~2 seconds) at metastatic lesions than normal structures. All lesions were traced with hand annotated (HA) regions of interest (ROIs) in Matlab v2016b, with the remaining image processing employing Python v3.7. Regions of prolonged gaze were extracted by color selection for the red areas (Fig 1B) yielding ET ROIs.

Results
86% (12/14) of lesions were correctly predicted (i.e. nonzero overlap) by ET. Fig 1 displays one sample image (1A), its gaze plot (1B), the HA ROIs (1C) and the ET ROIs (1D).

Conclusions
We have demonstrated as proof-of-principle that ET can accurately localize metastatic lesions. They can thus be used as "seed points" to easily tag metastatic lesions for longitudinal follow-up and for deep learning applications to automatically detect lesions via for example a bounding box algorithm. Future work will extend the modest sample size, employ three-dimensional image sets and use the seed points for longitudinal image tracking and convolutional neural network training.

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2092

Stratified vascular growth pattern in vessel architectural imaging differentiates early tumor progression from pseudoprogression in glioblastoma

M Kim1, J Park2, H Kim3, K Emblem4, A Bjørnerud4

(Filename: TCT_2092_pptProcessedScreenShotImages1.jpg)
Purpose
To investigate difference in vascular growth pattern between early tumor progression and pseudoprogression in post-treatment glioblastoma and to demonstrate diagnostic performance in the enlarging contrast enhancing mass using vessel architectural imaging.

Materials and Methods
Sixty patients with enlarging contrast-enhancing mass in post-treatment glioblastoma underwent dual spin- and gradient-echo (SE-GE) dynamic susceptibility contrast imaging. Conventional relative cerebral blood volume (rCBV) and vessel architectural parameters including vessel size and time shift between SE and GE bolus signal peaks (peak shift), vortex area, and vortex direction between SE-GE relaxation rates were calculated and compared between two conditions. The area under the receiver operating characteristics curve (AUC) and cross-validation were used to compare the diagnostic performance of the CBV with the performance obtained with the addition of vessel architectural parameters.

Results
Early tumor progression showed higher rCBV (1.90 ± 0.81, P = .02) and trend towards larger vessel sizes (101.29 ± 37.28, P = .079) compared to that of pseudoprogression. SE-GE relaxation rate curves revealed lower peak shift (0.02 ± 0.51, P = .022) with early tumor progression indicating a more aggressive vascular growth pattern. Combined peak shift and rCBV showed higher diagnostic performance (AUC 0.73, 0.59-0.86) for distinguishing two conditions than rCBV alone (AUC 0.63, 0.49-0.79).

Conclusions
Vessel architectural imaging may help stratify patients based on their vascular growth patterns and vessel type and thereby serve as an early identifier of disease progression in post-treatment glioblastoma.
Results
Craniopharyngioma and Rathke cleft cysts were located at midline and did not demonstrate fluid-fluid level. Feature of ≥2mm thickness of contrast enhancing wall was only seen in pituitary adenomas. The presence of an intracystic nodule was only with Rathke cleft cysts. Although can be seen in all three, a hypointense rim on T2-weighted images and septations were more common with pituitary adenomas. Statistical analysis revealed that cystic pituitary adenomas, craniopharyngiomas and Rathke cleft cysts can be distinguished on MRI features including an off-midline location, presence of an intracystic nodule, a fluid-fluid level, ≥2mm thickness of contrast enhancing wall, septations and a hypointense rim on T2-weighted images (for all p <0.05)

Conclusions
MRI features of seems helpful in differentiating pure cystic lesions of pituitary region.

1714

Ganglioglioma of the Pituitary Stalk Mimicking Neurohypophysitis

D Helmy1, A Ozturk2, O Raslan3, J Chang3, R ASSADSANGABI4, V Ivanovic3, M Bobinski3, N Pham5
1UC Davis Medical Center, Sacramento, CA, 2University of California, Davis Medical Center, Sacramento, CA, 3UC Davis, Sacramento, CA, 4UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA, 5UC Davis Health, Sacramento, CA

Purpose
To illustrate an extremely rare pituitary stalk tumor mimicking neurohypophysitis.

Materials and Methods
A 51-year-old woman presented to her primary care physician with polyuria and polydipsia that started "all of the sudden" 3 months ago. She was found to have low urine sodium, urine osmolality, and serum ADH, and was diagnosed with central diabetes insipidus. MRI brain with and without contrast showed uniform thickening and enhancement of the pituitary stalk, absence of the posterior pituitary bright spot, and remodeling of the dorsum sellae. With the suspicion for neurohypophysitis, she was referred to neurosurgery for biopsy. During surgical biopsy, the pituitary stalk was markedly enlarged and associated with a white, firm, relatively avascular mass. Pathology showed disorganized, atypical astrocytes and dysmorphic ganglion cells in a neuropil-rich stroma and an immunohistochemical profile consistent with WHO Grade I ganglioglioma, an exceedingly rare benign tumor in this location. No further surgical intervention was recommended. She was started on nightly desmopressin with significant improvement in her symptoms and is doing well 6 months later.

Results
Preoperative MRI brain with and without contrast. Sagittal (A) and coronal (B) precontrast T1 weighted sequences show thickening of the infundibulum and absence of the posterior pituitary bright spot. Sagittal (C) and coronal (D) postcontrast T1 weighted sequences with fat saturation show diffuse enhancement of the infundibulum and posterior pituitary.

Conclusions
Ganglioglioma is an exceedingly rare tumor of the neurohypophysis, with only 2 previously reported cases in the literature. The normal neurohypophysis contains the axons of neurons originating in the hypothalamus, specialized glial cells called pituicytes, and fenestrated capillaries. The origin of a ganglioglioma in the neurohypophysis is therefore unclear. Theories include the presence of ectopic ganglion cells, maturation of precursor cells, and metaplasia of existing cells. More common primary masses of the neurohypophysis are pituicytomas, granular cell tumors (also known as choristomas), and pilocytic astrocytomas; however, all of these tumors are still very rare. The clinical presentation and imaging findings of pituitary stalk ganglioglioma can mimic neurohypophysitis, as in this case of a 51-year-old woman who presented with diabetes insipidus.
23Na-MRI as a biomarker of tumor heterogeneity and survival

F Zaccagna\(^1\), F Riemer\(^2\), J Grist\(^1\), M McLean\(^1\), J Kaggie\(^1\), R Schulte\(^3\), S Hilborne\(^1\), T MATYS\(^1\), C Watts\(^4\), S Price\(^1\), J Gillard\(^1\), M Graves\(^1\), F Gallagher\(^1\)

\(^1\)University of Cambridge, Cambridge, United Kingdom, \(^2\)University of Bergen, Bergen, Norway, \(^3\)GE Global Research, Munich, Germany, \(^4\)University of Birmingham, Birmingham, United Kingdom

Purpose
Sodium is a biomarker of cell integrity and proliferation known to be increased in gliomas. MRI can non-invasively quantify both the total sodium concentration and the intracellular sodium concentration. The purpose of this study was to evaluate sodium distribution within glioma and explore its capability for assessing tumor heterogeneity, viability and predicting survival.

Materials and Methods
Sixty-five treatment-naïve patients were recruited in this prospective, ethically approved, study. Sodium MRI was performed on a 3T clinical scanner (GE Healthcare, WI, USA) using a Rapid Biomedical (Rimpar, Germany) dual-tuned 23Na/1H birdcage head coil. The Intracellular-weighted sodium concentration (IW-SC) was obtained by inversion recovery. 3D-T2WI and post-gadolinium 3D-T1W FSPGR were used for co-registration. Differences in total sodium concentration (TSC) and IW-SC between tumor, basal ganglia and white matter were tested using the paired and unpaired samples t-test; significance for multiple comparisons was assessed using the Benjamini-Hochberg procedure. Kaplan-Meier survival analyses were performed for the clinical and imaging-derived biomarkers using the best threshold defined by the Youden's index.
Results
Sixty patients (55.7% male, 55.3±17.2 years) successfully completed follow-up. Thirty-six lesions were high-grade gliomas (HGG), 19 lower-grade primary CNS tumors (LrGG), 3 metastases (high-grade serous carcinoma, renal cell carcinoma and lung cancer) and 2 were undetermined at pathology. TSC and IW-SC in the HGGs were higher than in the LrGGs (58±13 mmolL⁻¹ vs. 55±1.5 mmolL⁻¹, p = 0.54, and 27±15 vs. 21±7, p = 0.04, respectively). TSC and IW-SC in the basal ganglia and in the normal appearing white matter were not significantly different between LrGG and HGG (p=0.29). Several imaging-derived biomarkers were able to significantly predict survival. The strongest prognostic predictors were the ratio between the TSC of the lesion and the necrotic component (p<0.001) and the ratio between the IW-SC in the enhancing component and the basal ganglia (p<0.001).

Conclusions
Sodium MRI is a reliable technique to measure both the total sodium and the intracellular sodium concentrations. The quantification of the intracellular fraction could help in grading gliomas and in early detection of malignant transformation. Furthermore, sodium MRI significantly correlates with survival and could be potentially used for early response assessment and prognostication.

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An Unusual Cause of Spontaneous Pneumocephalus due to a Calvarial Osteoblastoma

J Kang¹, A Wong¹
¹Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA

Purpose
Although osteoblastomas are common benign primary bone tumors of the axial skeleton, case reports in the calvarium are extremely rare. Osteoblastomas, as well as other benign tumors such as osteomas, involving the calvarium have been associated with a number of complications, such as headache, mechanical obstruction of the nasal cavity and paranasal sinuses, neurological deficits, and intracranial extension. We present the first known instance of spontaneous pneumocephalus caused by intracranial extension of a calvarial osteoblastoma. Two different pathophysiological mechanism have been proposed: a ball-valve mechanism and inverted bottle mechanism.

Materials and Methods
A 27-year-old female presented with several months of frontal headache, sinus congestion, and feeling unwell. Symptoms acutely worsened 2 days prior to initial presentation. There were no complaints of frank CSF rhinorrhea, trauma, seizures, or neurological deficits. Brain imaging demonstrated pneumocephalus and a complex left anterior cranial fossa bony mass eroding into the frontal and ethmoidal sinuses, as well as the roof of the left orbit. A bifrontal craniotomy with orbito-frontal osteomy of the skull base was performed to resect the osseous mass extending into the dura. Histopathology was consistent with osteoblastoma. An autologous pericranial graft was necessary due to dural incompetence.

Results
Initial non-contrast cranial CT demonstrated a lobulated heavily calcified and partially corticated osseous lesion extending from the left frontal calvarium into the left frontal convexity, frontal and ethmoidal sinuses, as well as the roof of the left orbit. This was associated with a large amount of pneumocephalus along the left frontal convexity, and interhemispheric fissure causing mass effect on the subjacent brain surface and slight rightward midline shift. MRI revealed the osseous mass to be intrinsically hypointense on T1W images, and of intermediate to low signal intensity on T2W/FLAIR sequences. The mass avidly enhanced on post-gadolinium sequences and demonstrated no diffusion restriction. No underlying cerebral edema was seen.

Conclusions
Although osteoblastomas are benign, there are a number of potential complications that can occur when they involve the skull. In this example, we present the first reported case of spontaneous pneumocephalus as a complication from a frontal calvarial osteoblastoma eroding into the sinuses and cranial vault.
Differentiation of glioblastoma multiforme and single brain metastasis by the distribution pattern of intratumoral susceptibility sign derived from susceptibility-weighted imaging

H Kang¹, Y Kim¹
¹Seoul Veterans Hospital, Seoul, Korea, Republic of

Purpose
The aim of this study is to determine whether the distribution pattern of intratumoral susceptibility sign (ITSS) derived from susceptibility-weighted imaging (SWI) could differentiate glioblastoma multiforme (GBM) and single brain metastasis.

Materials and Methods
58 intracranial brain neoplasm patients (55 male and 3 female, age 69.8 ± 8.2 years (mean ± SD), 42 brain metastases and 16 with GBMs) were enrolled in this study. These patients underwent examinations that included SWI in addition to conventional magnetic resonance (MR) sequences on a 3T. Two radiologists investigated the distribution patterns of ITSS of the tumors and applied an ITSS grading system based on the degree of the ITSS. Then, we compared the grade of the visibility of ITSS in the central portion of tumors; the inner three quarters area of tumor volume (CITSS) and in the tumor capsular area; the outside one quarter area of tumor volume (PITSS) on SWI.

Results
The mean visibility scores of the CITSS is higher than PITSS in GBM (p < 0.001) and the mean visibility scores of the CITSS is
lower than PITSS in brain metastasis (p < 0.001). Wilcoxon rank sum test showed that the CITSS in GBM was statistically higher than brain metastasis (p < 0.001) and the PITSS in GBM was statistically lower than brain metastasis (p < 0.001). We found that the CITSS is more frequently seen in GBM than brain metastasis, and the PITSS is in brain metastasis than GBM.

Conclusions
Our findings suggest that there were different characteristics of ITSS between GBM and brain metastasis on SWI due to the profound difference in histologic feature of capillary between the two tumor types. The CITSS within the GBM represents the complex immature neovascularity and blood leakage and PITSS in the metastasis represents the mechanical disruption of the BBB lack capillaries and prominent feeding or draining vessels. So, differentiation could be achieved between GBM and brain metastasis using the ITSS distribution pattern of the brain tumors.
Figure 1. Graphical illustration of the relative grading score of the visibility of the ITSS in the central portion of the tumors: 1. Glioblastoma multiforme, 2. Brain metastasis.

Figure 2. Graphical illustration of the relative grading score of the visibility of the ITSS in the tumor capsular area of the tumors: 1. Glioblastoma multiforme, 2. Brain metastasis.

Figure 3. 82 year old male patient with Glioblastoma Multiforme. A: Postcontrast T1 shows intratumoral heterogeneity (arrow). Strong enhancement sharply delineates the margins of the lesion (excellent degree). B: SWI precontrast shows Grade 4 CITSS indicates more than 10 dot-like or linear low intensity structures (arrow head) and Grade 2 PITSS.

Figure 4. 66 year old male patient with renal cell cancer brain metastasis. A: Postcontrast T1 shows strong enhancement sharply delineates the margins of the lesion (excellent degree). B: SWI precontrast shows Grade 2 CITSS indicates 1-5 dot-like or linear low intensity structures (arrow head) and Grade 4 PITSS.

Table 1. The mean score and standard deviation of the visibility of the ITSS in the central portion of the tumor and tumor capsular area.

<table>
<thead>
<tr>
<th>Histologic type of Tumor</th>
<th>numbers</th>
<th>CITSS</th>
<th>PITSS</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glioblastoma multiforme</td>
<td>9</td>
<td>3.89±0.40</td>
<td>1.33±0.51</td>
<td>3.22±0.98</td>
</tr>
<tr>
<td>NSCLC metastasis</td>
<td>10</td>
<td>1.70±0.67</td>
<td>3.60±0.84</td>
<td>0.50±0.23</td>
</tr>
<tr>
<td>RCC metastasis</td>
<td>9</td>
<td>1.44±0.52</td>
<td>3.44±0.72</td>
<td>0.45±0.25</td>
</tr>
</tbody>
</table>

ITSS: Intratumoral susceptibility sign. GBM: Glioblastoma multiforme. NSCLC: Non small cell lung cancer. RCC: Renal cell cancer. *= ITSS in the central portion of the tumor, #: ITSS in the tumor capsular area. *: CITSS/PITSS. The grading system is as follows: 1 = not visible, 2 = poor, 3 = good, and 4 = excellent.

Table 2. Comparison of the score of the visibility of the ITSS in the central portion of the tumor and tumor capsular area (p < 0.05, Wilcoxon signed rank test).

<table>
<thead>
<tr>
<th>Mean score of the grading of the CITSS vs PITSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>P value</td>
</tr>
<tr>
<td>GBM 0.006</td>
</tr>
<tr>
<td>NSCLC 0.007</td>
</tr>
<tr>
<td>RCCM 0.010</td>
</tr>
</tbody>
</table>

The Role of Dual-phase 18-FDG PET/CT in the Diagnosis and Follow-up of Brain Tumors

C Ozutemiz¹, E Neil², M Tanwar³, N Rubin², K Ozturk¹, Z Cayci¹
¹University of Minnesota, Minneapolis, MN, ²University of Minnesota, Minneapolis, MN, ³University of Pittsburgh, Pittsburgh, PA

Purpose
F18-FDG-PET/CT imaging of the brain is limited by background activity. Dual-phase (DP) F18-FDG-PET/CT with MRI-fusion is a method to eliminate this limitation and discriminate viable intracranial tumors from non-viable. This method isn't currently standardized. Primary aim is to assess the diagnostic capability of DP-F18-FDG-PET/CT qualitatively and quantitatively in brain tumor imaging. Second objective is to determine specific cut-off values for DP-F18-FDG-PET/CT.

Materials and Methods
Retrospectively, a total of 51 primary and secondary brain tumors were evaluated with DP-F18-FDG-PET/CT between 5/2017 and 2/2019 in 32 (23 female) patients. Acquisitions were performed in 30-minutes (t1) and 3-hours (t2) after 10mCi F18-FDG intravenous administration and 6-hour fasting. PET was fused with MRI in 46. Two observers independently evaluated the lesions qualitatively. Interrater reliability and accuracy were studied by weighted Cohen's Kappa. Quantitatively, MaxSUV was measured from the lesions (L), contralateral deep-white-matter (CWM), contralateral caudate-nucleus-head (CCH) and unilateral cerebellar-cortex (UC). Ratios including L/CWM, L/CCH, L/UC at t1 and t2 were calculated. ROC analysis was used to determine optimum cut-off values, and area-under-the-curve (AUC) ratios were compared. Lesion outcome was determined by pathology (available in 15), lesion stability on serial MRIs (representing non-viable tumor) or decreased tumor size on serial MRIs after new treatment (representing viable tumor).

Results
37 viable, 14 non-viable lesions were evaluated. Qualitatively, the diagnostic accuracy (first observer: from κ=0.45 to κ=0.59, second observer: κ=0.41 to κ=0.66) and interrater reliability (κt1=0.51, κt2=0.83) improved with addition of delayed imaging. Viable tumors showed increasing trend for all DP-F18-FDG-PET/CT derived parameters with delayed imaging compared to non-viable. AUC and ROC analysis showed comparably high sensitivity, specificity and accuracy profile for early and delayed DP-F18-FDG-PET/CT. Proposed cut-off values/AUC/accuracy/sensitivity/specificity are as follows; LMaxSUVt1=7.2/92%/88%/89%/86%, LMaxSUVt2=7.8/88%/90%/97%/71%, L/CWMt1=2.05/89%/82%/78%/93%, L/CWMt2=2.36/89%/82%/81%/86%, L/CCHt1=0.68/89%/82%/78%/93%, L/CCHt2=0.61/91%/84%/87%/79%, L/UCt1=0.89/87%/82%/81%/86%, L/UCt2=1.07/87%/80%/84%/71%.

Conclusions
DP-F18-FDG-PET/CT with MRI-fusion improves lesion detection and diagnostic accuracy in primary and metastatic brain tumors.
Pattern analysis of dynamic susceptibility contrast-enhanced MR imaging demonstrates tumor acidity in glioblastoma

S Nabavizadeh¹, H Akbari¹, A Fathi Kazerooni¹, J Ware¹, S Guiry¹, C Raymond², J Yao², B Ellingson², C Davatzikos¹

¹University of Pennsylvania, Philadelphia, PA, ²University of California, Los Angeles, Los Angeles, CA

Purpose
The high metabolic demand of tumor in patients with glioblastoma (GBM) can lead to acidification of the tumor microenvironment. In this study, we investigated the utility of principal component analysis (PCA) of dynamic susceptibility contrast-enhanced (DSC) imaging and machine learning to quantify tumor acidity in patients with GBM as determined by pH-sensitive amine chemical exchange saturation transfer echo-planar imaging (CEST-EPI).

Materials and Methods
21 treatment naïve and post-treatment GBM patients were imaged with structural and DSC-MRI, and pH-weighting was obtained using CEST-EPI estimation of the magnetization transfer ratio (MTR) asymmetry at 3 ppm. We employed PCA to distill the DSC-MRI time series down to a few principal components that capture the temporal dynamics of blood perfusion. Enhancing tumor (ET),
non-enhancing core (NEC), and peritumoral T2 hyperintensity (namely, edema, ED) were used to extract principal components (PCs) and to build support vector machines regression (SVR) models to predict MTR values using PCs.

Results
A feature vector consisting of the first five PCs was sufficient to capture more than 99% of the variance in the perfusion signal for all tissue types and all patients. Our predicted map correlated with MTR values with Pearson r equal to 0.44, 0.34, 0.61, 0.543, in NEC, ET, ED, and overall, respectively (p<0.0000).

Conclusions
PCA analysis of DSC imaging data can provide information about tumor pH in GBM patients. The strongest correlation belongs to the peritumoral region. In addition to well-known role of DSC imaging in evaluating tumor perfusion, it can also be used to monitor tumor pH in patients with GBM especially in the peritumoral T2 hyperintensity.

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2203 4:33PM - 4:39PM

T2-FLAIR Mismatch sign as an imaging biomarker for IDH-mutant, 1p/19q non-codeleted lower-grade gliomas. Initial experience utilizing contrast-enhanced FLAIR acquisition

O Arevalo¹, Y Munir¹, C Soto², L De Alba¹, S Khanpara¹, R Riascos¹
¹The University of Texas Health Science Center at Houston, Houston, TX, ²National University of Colombia, Bogota, TX

Purpose
Lower-grade gliomas (LGG) have been classified into molecular subtypes with different prognosis based on the IDH1/2 mutation status and 1p/19q codeletion status. The T2-FLAIR mismatch has been proven to be a highly specific imaging biomarker for the IDH-mutant, 1p/19q non-codeleted genotype; however, this conclusion has been drawn from studies utilizing non-contrast FLAIR images. The signal intensity in FLAIR sequences depends on both T1 and T2 relaxation times, and contrast-enhanced FLAIR (ceFLAIR) has been proven to increase the conspicuity of certain cerebral and meningeal lesions. We aimed to investigate whether the T2-FLAIR mismatch sign utilizing ceFLAIR images rendered a comparable diagnostic performance.

Materials and Methods
Preoperative MR scans of 18 adult patients with pathological diagnosis of LGG (WHO grade II and III) with known IDH1/2 status, 1p/19q codeletion status, and ceFLAIR images were included (6 IDH1/2-Mut, 1p/19q codeleted; 8 IDH1/2-Mut, 1p/19q non-codeleted; 4 IDH1/2-WT). The MR scans were evaluated to assess the presence of the T2-FLAIR mismatch sign by two blinded neuroradiology trainees and one blinded neuroradiologist. A consensus decision was made in regards to the presence or absence of the sign.

Results
The T2-FLAIR mismatch sign was present in 3/8 cases of 8 IDH1/2-Mut, 1p/19q non-codeleted LGG. The sign was not seen in the remaining 5 patients with IDH1/2-Mut, 1p/19q non-codeleted, 6 individuals with IDH1/2-Mut-1p/19q codeleted, and 4 subjects with IDH1/2-WT LGG. The T2-FLAIR mismatch sign utilizing ceFLAIR had a positive predictive value of 100%, negative predictive value of 66% (95% CI = 53.90-77.38), a sensitivity of 37.5% (95% CI = 8.52-75.51), and a specificity of 100% (95% CI = 69.15-100.00).

Conclusions
The T2-FLAIR mismatch is a highly specific imaging marker for IDH1/2-Mut, 1p/19q non-codeleted LGG, which concur with the results published in prior studies. T2-FLAIR mismatch sign utilizing ceFLAIR images renders similar diagnostic performance when compared with studies done with standard non-contrast FLAIR acquisitions.
Table

Low grade gliomas with preoperative ceFLAIR images (n = 18)

<table>
<thead>
<tr>
<th>Tumor</th>
<th>Negative T2-ceFLAIR mismatch</th>
<th>Positive T2-ceFLAIR mismatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffuse Astrocytoma (WHO grade II) IDH1/2-Mut, 1p/19q non-codeleted</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Anaplastic Astrocytoma (WHO grade III) IDH1/2-Mut, 1p/19q non-codeleted</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Diffuse Astrocytoma (WHO grade II) IDH1/2-WT</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Anaplastic Astrocytoma (WHO grade III) IDH1/2-WT</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Oligodendroglioma (WHO grade II) IDH1/2-Mut, 1p/19q codeleted</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Anap. Oligodendroglioma (WHO grade III) IDH1/2-Mut, 1p/19q codeleted</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure

MR of the brain from a patient with a right temporal Anaplastic Astrocytoma (WHO grade III) IDH1/2-Mut, 1p/19q non-codeleted. Note the homogeneously hyperintense signal of the mass in the T2-weighted image (left panel), which is significantly supressend on the ceFLAIR image (right panel), consistent with the T2-FLAIR mismatch sign.

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Scientific Abstract Session: Interventional/Stroke

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Cost-effectiveness of endovascular thrombectomy in patients with low ASPECTS (<6) at presentation

A Malhotra¹, X Wu², M Khunte³, S Payabvash², C Matouk², D Gandhi⁴, P Sanelli⁵

¹Yale University School of Medicine, New Canaan, CT, ²Yale University School of Medicine, New Haven, CT, ³Yale School of Medicine, New Haven, CT, ⁴University of Maryland School of Medicine, Baltimore, MD, ⁵Northwell Health NSUH, Manhasset, NY

Purpose

Purpose: The utility of endovascular thrombectomy (EVT) in patients with acute ischemic stroke due to with large vessel occlusion (LVO) and low ASPECTS (Alberta Stroke Program CT score) remains uncertain. The purpose of this study is to determine the health outcomes and cost effectiveness of EVT versus medical management in patients with ASPECTS <6.

Materials and Methods

A decision-analytic study was performed with Markov modeling to estimate the lifetime quality-adjusted life years (QALY) and associated costs of EVT-treated patients compared to best medical management. The study was performed over a lifetime horizon with a societal perspective in the Unites States setting. The base case calculations were performed in 2 age groups- 55 and 65 years old. Economic outcome measures included short term (90-day) and long-term (life time) costs.

Results

The incremental cost-effectiveness ratios were $412,411/QALY and $1,022,985/QALY for 55- and 65-year-old groups in the short-term model. EVT was the long-term cost-effective strategy in 96.16% of the iterations, and resulted in difference in health benefit of 2.21 QALYs and 0.79 QALYs in the 55- and 65-years age groups respectively, equivalent to 807 days and 288 days in perfect health. EVT remained the more cost-effective strategy when the probability of good outcome with EVT was above 16.9% whereas medical management became the more cost-effective strategy when the proportion of good outcome with it was higher than 24.1%. EVT remained cost-effective as long as the good outcome associated was at least 1.6% higher in absolute value than that of medical management. EVT remained cost-effective even when its cost exceeded $50,000 (threshold was $108,036). Although the cost-effectiveness decreased with age, EVT was cost-effective for 75-year-old patients as well. Varying the direct costs and indirect costs associated with mild and moderate disability up to 20-fold of their base-case values did not affect the final conclusion.

Conclusions

Our study suggests EVT to be the more cost-effective approach compared to medical management in patients with ASPECTS <6 in the long-term (life-time horizon), considering the poor outcomes and significant disability associated with non-reperfusion. Faster and improved reperfusion techniques would increase the relative benefit of EVT even further in these patients.

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What Predicts Poor Outcome After Successful Thrombectomy?

J Heit¹, M Mlynash², S Christensen², S Kemp², M Lansberg², M Marks³, G Albers⁴

¹Stanford University, Stanford, CA, ²Stanford, Stanford, CA, ³Stanford Univ. Med. Ctr., Stanford, CA, ⁴Stanford University Medical Center, Palo Alto, CA

Purpose

Thrombectomy for acute ischemic stroke treatment leads to improved outcomes in early and late time windows, but not all thrombectomy patients achieve a good outcome. A better understanding of factors that predict outcome after successful thrombectomy
will identify targets for new stroke therapies. We determined clinical and imaging factors that predict clinical outcome after successful thrombectomy with thrombolysis in cerebral ischemia (TICI) 2b-3 revascularization in the Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke (DEFUSE 3) trial.

Materials and Methods
DEFUSE 3 was a randomized trial that compared medical therapy to thrombectomy in AIS patients with a target mismatch profile on perfusion imaging who were treated 6 to 16 hours after last seen normal. DEFUSE 3 patients who underwent thrombectomy with TICI 2b-3 revascularization were included. The primary outcome measure was a good clinical outcome at 90-days (modified Rankin Scale score 0-2).

Results
Patients who had poor outcomes despite TICI 2b-3 perfusion were older (73.5 versus 66.5 years; p=0.01), more likely to be female (68% versus 39%; p=0.02), had higher NIHSS scores at randomization (20 versus 13; p<0.001), and had poor collaterals as measured by the hypoperfusion intensity ratio on CT or MR perfusion (median 0.45 versus 0.38; p=0.03). Following thrombectomy, poor outcome patients had larger core infarctions (median 59.5 versus 29.9 ml; p=0.01), more core infarction growth (median 33.6 versus 13.4 ml; p<0.001), and more asymptomatic (65% versus 50%; p=0.02) and symptomatic (18% versus 0%; p=0.01) reperfusion hemorrhage. In a logistic regression analysis, age (OR 1.1 [95% CI, 1.03-1.11], p=0.004), higher NIHSS at randomization (OR 1.25 [95% CI, 1.07-1.41], p=0.002), time from imaging to femoral artery puncture (OR 5 [95% CI, 1.16-16.67], p=0.03), and the presence of any reperfusion hemorrhage (OR 3.3 [95% CI, 1.67-5]; p=0.001) independently predicted poor outcomes.

Conclusions
In DEFUSE 3, factors associated with poor outcomes despite successful reperfusion included older age, higher NIHSS, and increased time from imaging to femoral artery puncture. Both symptomatic and asymptomatic reperfusion hemorrhage were associated with poor outcomes. These findings raise the possibility that adjunctive therapies that prevent reperfusion hemorrhage might improve outcomes from thrombectomy.
logarithmic relationship is assumed, despite evidence that ischemic lesion growth appears to be variable. Indeed, the effects of endovascular thrombectomy (ET) on final infarct volume differ among patients presenting within similar time windows, with conflicting results regarding efficacy in specific subgroups. While it is not feasible to calculate true growth rates, it is possible to gain an impression of the initial progression from symptom onset to primary imaging. In our study, we sought to tease apart the outcome effects of ET, as mediated by the early infarct growth rate (EGR). In contrast to others, our approach does not dichotomize our collective, but will rather examine lesion growth as a continuous variable. We hypothesize that EGR has a modifying effect on ET regarding outcome and lesion progression.

Materials and Methods
We present an ongoing, single center retrospective analysis of patients who underwent ET for acute stroke with anterior circulation (AC) LVO from Jan 2015 to Aug 2017. Each received initial CT imaging, as well as follow-up scans within 24 hours of ET. Initial infarct growth rates and final infarct growth were measured. Extensive clinical information was documented at preset timepoints with the goal of exploring the time-versus-outcome relationship.

Results
Early results of 41 patients with ACLVO stroke treated with ET show a good outcome (mRS≤2) in 54% of cases, with a mortality rate of 0% at discharge. The median EGR was 6.38 ml/h (range 0.15-115.14). For patients with faster EGR, a modifying effect on outcome following ET was observed (β-coefficient 0.03, 95%CI 0.0004–0.058; p=0.04). In addition, an association (albeit not significant) was observed between EGR and final infarct volume (β-coefficient 17, 95%CI -2.8–36.5, p=0.08).

Conclusions
Although in its preliminary stages, this is one of the few studies that will include endovascularly treated patients presenting with acute stroke in ACLVO, regardless of initial infarct core size. By widening the inclusion criteria and thereby strengthening the number of such patient collectives, we may finally begin to gain a better understanding on the infarct growth curve. This, in turn, could aid in a paradigm shift from standardized time frames to individualized ones.

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Improved Detection of Immediate Post Thrombectomy Parenchymal Enhancement with Spectral CT Correlates With Final Infarct Burden

A Erdfarb1, S Lee2, A Brook3, D Altschul1, N Haranhalli1, R Zampolin1
1Montefiore Medical Center, Bronx, NY, 2Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY, 3N/A, N/A

Purpose
To assess the sensitivity of dual-energy CT imaging compared to conventional CT in the detection of parenchymal enhancement and its association with eventual infarct distribution in post-thrombectomy patients.

Materials and Methods
35 post-thrombectomy patients with immediate post-procedural detector-based spectral CT imaging and follow-up CT and/or MR imaging acquired at least 24-hours post-procedure were reviewed. Conventional, iodine density, and 140 keV images underwent consensus review by two neuroradiologists to determine the extent of enhancement on conventional versus spectral imaging. The distribution of enhancement using each method was then compared to the extent of demarcated infarct on follow-up imaging.

Results
Infarct was demonstrated in 34 of 35 cases. 15/34 (44.1%) cases with infarct demonstrated no enhancement on conventional or spectral imaging. Conventional CT imaging demonstrated some degree of enhancement in 11/34 (32.4%) cases. In 3 of these 11 cases only partial enhancement of the affected territory was demonstrated, however the remaining parenchyma was correctly delineated on spectral imaging. An additional 8 cases of enhancement were identified using spectral imaging, for a total of 19/34 (55.9%) cases. Overall, enhancement on conventional imaging corresponded to final infarct distribution in 8 cases (8/34 cases, 23.5% sensitivity), spectral imaging identified these 8 cases and added an additional 10 cases (18/34 cases, 52.9% sensitivity), and neither method demonstrated enhancement corresponding to final infarct burden in the remaining 16 cases. McNemar's test demonstrated a statistically significant difference in the sensitivity of conventional versus spectral imaging to detect the final distribution of infarct (29.4% difference, 95% CI: 14.1 – 44.73%, p=0.002).

Conclusions
Although lack of enhancement does not preclude demarcation of infarct on follow-up imaging, the extent of enhancement, when present, correlates with final infarct distribution. Detector-based spectral imaging is more sensitive for the detection of immediate post-thrombectomy enhancement corresponding to the final extent of infarct than conventional CT imaging. Given this ability to better delineate post-thrombectomy infarct burden, consideration should be given to incorporating routine utilization of spectral imaging into the evaluation of post-thrombectomy patients.

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The weekend effect on outcomes of Endovascular thrombectomy in Comprehensive stroke centers after the 2015 AHA/ASA guidelines

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Purpose
The weekend effect has been established to affect the outcomes of acute ischemic stroke treatment among several other diseases. In 2015, Multiple randomized control trials established endovascular thrombectomy (EVT) as the standard of care for anterior circulation ELVO within 6 hours and was later extended to 24 hours as per the AHA/ASA guidelines. To ensure effective and consistent delivery of treatment, the Joint commission partnered with the AHA/ASA and established certification requirements and guidelines for stroke centers to become comprehensive, and mandated tracking of multiple stroke metrics for maintenance of certification. No trials evaluated the weekend effect on EVT after the 2015 guidelines. We aim to evaluate the weekend effect on EVT since 2015 at 3 affiliated comprehensive stroke centers (CSCs).

Materials and Methods
A retrospective analysis of our EVT database from 2015 to 2018 was conducted. Baseline demographics, stroke risk factors and time metrics, as well as technical and functional outcomes were analyzed. We compared the weekday group (WD), defined as EVT performed between 7 am and 7 pm on business days, versus the weekend group (WE), defined as EVT performed from 7 pm to 7 am on business days, on weekends, and in official vacations.

Results
216 patients underwent EVT (110 (50.9%) on WD vs 106 (49.1%) on WE). No significant difference in baseline demographics, risk factors, and stroke severity was observed. Patients presenting on the WE had significantly longer median onset to presentation times (130 vs. 72.5 minutes, p=0.04) with a trend towards lower rates of IV rtPA administration (44.3% vs 58.2%, p=0.06). Even though presentation to groin times were significantly higher in the WE group (Median 104.5 min vs 86 min, p=0.007), groin to revascularization time (51.5 vs 48 min; p=0.40) and successful recanalization rates (TICI 2b/3 90.6% WE vs 90% WD; p=0.99) were similar between both groups. There was no significant difference in rates of sICH (10.4% vs. 7.3%; p=0.48) and 90-day functional outcomes (mRS ≤2, 47.2% vs 41.8%; p=0.50) between the WE vs WD groups, respectively.

Conclusions
Despite the weekend effect persisting, with delayed presentation to groin times, in our multi-center CSC analysis, those delays did not affect the favorable technical and clinical outcomes in the WE compared to the WD group. This study points to possible areas of improvement in modern CSCs to optimize care for acute ischemic stroke patients, regardless of the presentation time.

Stroke Thrombectomy Time of Day or Night Does Not Impact Patient Outcomes

G JINDAL1, A Wessell2, H De Paula Carvalho3, G Cannarsa4, T Miller3, D Gandhi5
1UNIVERSITY OF MARYLAND MEDICAL CENTER, BALTIMORE, MD, 2University of Maryland, Baltimore, MD, 3University of Maryland, BALTIMORE, MD, 4University of Maryland Medical Center, Baltimore, MD, 5University of Maryland School of Medicine, Baltimore, MD

Purpose
The influence of time of day or night during which stroke thrombectomy procedures are performed has not been extensively evaluated. We assess the impact of time of day or night of stroke thrombectomy on peri-procedural details and functional outcomes.

Materials and Methods
We retrospectively analyzed all patients undergoing anterior cerebral circulation stroke thrombectomy at our institution from April 2012 to February 2019. Daytime cases were defined as arteriotomy time between 0700 and 1859 hours; nighttime cases comprised the remaining cases. Successful revascularization was defined as TICI ≥ 2B. Good functional outcomes were defined as mRS scores of 0-2 at 90 days after thrombectomy.

Results
A total of 325 patients were eligible for the analysis. Nine patients with missing data were excluded. Of the remaining 316 patients, 196 underwent thrombectomy during daytime hours, while 120 cases were performed at night. Nighttime patients were older (67.5 vs 63.9 years of age; (p=0.024)) and had higher NIHSS scores (18.8 vs 17.1; (p=0.011)) in comparison to daytime cases. There was no significant difference in patient gender, vessel occlusion site, medical comorbidities, last known well to endovascular treatment time, thrombectomy procedure time, revascularization grade, number of thrombectomy passes, first pass recanalization rates, nor good outcomes between daytime and nighttime thrombectomy cases. Higher age, higher presenting NIHSS, lack of revascularization, and history of diabetes were independently associated with poor outcomes.

Conclusions
Time of day or night during which stroke thrombectomy was performed did not affect peri-procedural details, revascularization status, nor functional outcomes.
Real World Evidence for Acute Stroke Thrombectomy in the Posterior Circulation from the NVQI Registry

D Robinson Cantrell1, R Abdalla1, A Shaibani1, M Hurley1, M Potts1, B Jahromi1, S Ansari1, N NVQI Investigators1

1Northwestern University - Feinberg School of Medicine, Chicago, IL

Purpose
The role of mechanical thrombectomy (MT) for anterior circulation (AC) large vessel occlusions (LVOs) has been established by multiple randomized controlled trials (RCTs) [1]. However, no RCTs have yet to assess the benefits of MT in the posterior circulation (PC). We aim to evaluate the real-world evidence for MT in PC LVOs using the NeuroVascular Quality Initiative (NVQI) registry.

Materials and Methods
Data from the NVQI registry was analyzed to assess AC vs. PC acute ischemic stroke outcomes treated with MT in 23 US centers (17 states) from February 2015 to October 2019. Mann Whitney and Fischer exact tests were used for continuous and categorical variables, respectively.

Results
MT was performed in the posterior circulation in a minority of 9.2% (284/3103) of patients compared to the anterior circulation. LVO sites were predominantly basilar artery occlusions (68% basilar trunk and 19.4% basilar apex/PCA) with fewer vertebral artery occlusions (12.7%). Mean age was 66±15.5 years PC vs. 68.8±15.4 years AC, p=0.004. Mean NIHSS at presentation was 17±10.2 PC vs. 15.8±6.8 AC, p=0.007. CT/CTA was performed in 94% of cases whereas MRI was performed in 19% of cases (vs. 14% AC, p=0.03). Successful recanalization was achieved in 84.5% (TICI 2b/3) vs. 84% AC (p=0.87) with 50.4% reporting single pass recanalization and 3.9% technical failures (3.2% access related). Intraprocedural complications were reported in 4.9% of cases (0.7% vessel perforations, 0.4% hemorrhagic transformations, 1.4% non-target embolization, and 1.8% iatrogenic dissections). Mean post-operative length of stay was 9.5±9.5 days, with 24.6% in-hospital mortality vs. 11.2% AC, (p<0.001). Clinical 90-day follow up mRS was reported in 64.2% of cases with independent mRS≤2 achieved in 40.4% vs. 37.3% AC, (p=0.31). 90-day mortality was reported in only 0.9% of cases. Missing data was most common in technical failure, intraprocedural complications, and 90-day mRS, amounting to 16.5%, 17.3% and 35.8% of cases, respectively.

Conclusions
Real world evidence from the NVQI procedural registry suggests PC stroke patients present at a younger age with a higher NIHSS compared to AC LVOs. Given the historically high morbidity and mortality of PC LVOs [2], these results provide strong evidence for the benefit of posterior circulation thrombectomy, with 3-month functional outcomes that are nearly identical to what is observed in the anterior circulation.
Volumetric Analysis of Mechanical Thrombectomy-Related Subarachnoid Hemorrhage and Correlation with Patient Outcomes

P Brown¹, S Wolfe¹, K Fargen¹, C Whitlow¹
¹Wake Forest Baptist Medical Center, Winston-Salem, NC

Purpose
Endovascular management of stroke has become the mainstay treatment for intracranial emergent large vessel occlusion (ELVO). As mechanical thrombectomy (MT) indications expand, associated complications may also be expected to increase in number and frequency. One of these is MT-associated subarachnoid hemorrhage (SAH). While ischemic hemorrhagic transformation (HT) has been well-studied, the classification, mechanisms, and associated effects of MT-related SAH are less well understood. Current classifications methods generally break SAH into trace, focal, and diffuse SAH. We describe our use of automated segmentation in an attempt to correlate hemorrhage volumes with patient outcomes in an attempt to develop a more functional classification of MT-related SAH.

Materials and Methods
We conducted a retrospective review of our single-center experience of procedure-related SAH after mechanical thrombectomy for ELVO from January 2015 to July 2019 with regards to hemorrhage volume and patient outcome. Automated segmentation software was utilized to calculate hemorrhage volumes (sample image provided). These volumes were correlated with mRS at long-term follow-up.

Results
We report twenty-seven cases of thrombectomy-related SAH during the evaluation period. One of these patients was lost to follow up. Functional outcomes were seen in 30% of cases of diffuse SAH, 16.7% of focal SAH, and 25% of trace SAH.

Conclusions
After widespread publication of expanded indications for MT, particularly after January 2018, practitioners have increasingly adopted more aggressive approaches in procedural management of ELVO, our institution included. Rates of functional independence in the most recent studies approach 50%. Our data suggest overall poorer-than-expected outcomes after development of MT-related SAH; however, in our population these outcomes are poorly correlated with SAH volumes. Further exploration is warranted with larger groups of patients, potentially in a multicenter setting.

Primary Aspiration And Vascular Anatomy: Vessel Diameter May Affect Clot Aspiration
A Kyselyova, J Fiehler, J Buhk, A Frölich
1University Hospital Hamburg-Eppendorf, Hamburg, Hamburg

Purpose
ADAPT (a direct aspiration first pass technique) is considered to be an efficient, safe, cost-effective and fast thrombectomy technique. We evaluated anatomical and thrombus' characteristics associated with success of the aspiration component as part of the ADAPT technique.

Materials and Methods
106 cases of acute carotid-T, basilar and MCA occlusion undergoing endovascular treatment with ADAPT were retrospectively assessed for "successful primary aspiration", defined as TICI score ≥ 2b after primary aspiration with 5F or 6F aspiration catheters.
We evaluated patient age, aortic arch type (1-3), vessel diameter at the thrombus' proximal end on CTA, access vessel tortuosity on DSA and CTA counting the number of reverse curves, clot density and clot length in non-contrast CT and CTA as well as clot perviousness (increase in HU on CTA compared with non-contrast CT).

Results
Successful primary aspiration was seen in 38 cases (35.8%). Cases with successful primary aspiration had smaller vessel diameters at the proximal thrombus' end (0.25±0.07mm vs. 0.32±0.14mm; p=0.006) (Fig.1). No significant differences were observed regarding aortic arch type, clot perviousness, clot density and clot length. Patients with successful primary aspiration were younger (65.5±15 versus 71.2±16).

Conclusions
Vessel diameter at the aspiration site seems to affect the effectiveness of thrombus aspiration. The relation between aspiration catheter and thrombus diameter may influence aspiration success and should be further assessed.

(W Kunz)
1LMU Munich, Munich, Bavaria

Purpose
The AURORA meta-analysis (Analysis of Pooled Data from Randomized StUdies of ThROmbectomy MoRe than 6 hours After Last Known Well) included patients that were randomized to endovascular thrombectomy (EVT) or to medical management (MM) presenting with large vessel occlusion stroke beyond 6 hours of symptom onset or last known to be well. Based on five pooled trials, EVT showed clear clinical benefits. We aimed to determine the cost-effectiveness of EVT in this context.

Materials and Methods
A decision model based on Markov simulations estimated lifetime costs and quality-adjusted life years (QALY) associated with EVT or MM (Figure 1). The analysis was performed in a United States setting from a societal perspective. Input parameters for the model were based on most recent and best available evidence (Table 1), including pooled outcome data from patients randomized in five trials.
trials (DAWN, DEFUSE 3, ESCAPE, REVASCAT, POSITIVE, Figure 2). Probabilistic sensitivity analyses (PSA) were performed using 10,000 Monte Carlo simulations to estimate uncertainty. Incremental costs (IC), incremental effectiveness (IE), and incremental cost-effectiveness ratios (ICER) were derived. Cost-effectiveness acceptability rates were determined for varying willingness-to-pay (WTP) thresholds.

Results
Based on outcome data of 458 patients randomized within the AURORA meta-analysis, the base-case analysis identified EVT as the strategy that resulted in incremental QALYs and cost-savings over the projected lifetime compared to MM (IC: -$17,902; IE: +1.71 QALYs; ICER: EVT dominant). Adjusting for all input parameter uncertainty in PSA, EVT was the preferred strategy with acceptability rates of >99.9% at all WTP thresholds ranging from $10,000 to $150,000 per QALY (Figure 3). Simulations led to 94.46% dominant/cost-saving iterations (Figure 4).

Conclusions
EVT is projected to provide considerable long-term clinical benefit whilst also leading to considerable long-term cost-savings in the management of patients with large vessel occlusion stroke presenting beyond 6 hours of symptom onset or last known to be well.
Purpose
The NINDS CDE SCI project was designed to harmonize data collection for NIH funded clinical studies in spinal cord injury (SCI).
The featureset consists of a composite of categorical as well as ordinal (direct measurements) of SCI based upon features developed in prior published work. The purpose of this study was to determine if categorical representations of SCI on MRI outperform absolute measures in a multi-reader blinded evaluation.

Materials and Methods
This study specifically focused on a subset of 18 of 52 NINDS CDE elements directly related to the injured spinal cord. Features included: length/location of cord edema/hemorrhage, absolute measures of canal/cord and lesion length and BASIC score. Four neuroradiologists and one spine neurosurgeon from five institutions were recruited as independent readers. 35 SCI MRI studies from twelve different centers were pre-selected from a collection of over 120 studies. Anonymized exams were loaded into a cloud-based viewer platform. After a single training session, all 35 exams were scored independently by the five experts at their own pace. The exam order was randomized and then re-scored for a second round. Inter- and intra-rater assessment was performed using kappas for categorical items and intraclass correlation coefficient (ICC) for ordinal measures at 95% CI.

Results
Inter-rater agreement for all features in round one evaluations ranged from poor 0.22 (0.06, 0.37) to excellent 0.99 (0.99, 1.00). Highest inter-rater agreement was found for categorical features of edema/hemorrhage length/location relative to anatomic reference (ICC range 0.69 - 0.99) whereas lower inter-rater ICCs were found for absolute measures (ICC range 0.22 - 0.83). There was good agreement for measures at the level of injury (ICC range 0.73 - 0.83). Only minor differences in agreement were observed overall between the two reading sessions. Intra-rater ICCs overall ranged from good to excellent (ICC range 0.78 to 1.00) without removal of outliers. There was no significant difference in performance between experienced neuroradiologists and the spine surgeon.

Conclusions
Categorical measures of SCI are more reliable and reproducible than absolute measures in clinical practice. The devised NINDS SCI MRI CDE instrument provides a uniform method for capturing reliable quantitative and categorical data for SCI investigational work and clinical trials. Multi-center SCI clinical trials should adopt categorical measures of SCI on MRI because of their better reproducibility overall.
Hangman’s Fracture: Clinical and Imaging Experience At Our Institute In 58 Patients

S Khanpara¹, O Arevalo², A Aein¹, R PATEL³, R Riascos⁴
¹The University of Texas Health Science Center, McGovern Medical School, Houston, TX, ²The University of Texas Health Science Center at Houston, Houston, TX, ³UNIVERSITY OF TEXAS HEALTH SCIENCE CENTER, HOUSTON, HOUSTON, TX, ⁴Univ. Of Texas - Houston, Houston, TX

Purpose
Traumatic spondylolisthesis of C2 with bilateral pars interarticularis fracture is colloquially termed as Hangman's fracture. Initially believed to be rare and seen in judicial hanging, the detection rate of Hangman's fracture has gone up with increased use of cross-sectional imaging. It comprises about 4-5% of all cervical fractures. In this study, we report our clinical and imaging experience in hangman's fracture.

Materials and Methods
This study is an IRB approved retrospective review of 58 patients diagnosed as having hangman's fracture over a period of 4 years. Primordial report database was searched for various terms such as "hangman's fracture", "traumatic spondylolisthesis of C2" and "pars interarticularis fracture". A review of these images and the charts were performed by a neuroradiology fellow.

Results
Based on the Levine and Edwards classification, type I Hangman's fracture was the most common type of fracture (n=40) with type II,
Ila and III being less common (n= 6, 9 and 3 respectively). Out of the total 58 patients, 33 were females and 25 were males. The mean age at the time of presentation was 62.3 years. 7 patients presented with transient or incomplete neurological deficits with rest having an intact neurological examination. Motor vehicle accidents (MVA) (n=30) was the most common cause of hangman's fracture followed by fall. Hyperflexion injuries were the most common injury mechanism followed by hyperextension (n=14). The foramen transversarium was involved in 43 patients with 21 patients having a blunt cerebrovascular injury (BCVI), most being low-grade injuries. The incidence of BCVI was not related to the involvement of the foramen transversarium. Spinal cord injuries were only seen in 3 patients (2 - type I injury and 1 - type III injury) with posteriorly displaced fracture fragments compromising the spinal canal. Two patients died due to multiple abdominal injuries and hypoxic-ischemic injury respectively. Rest of the patients recovered with conservative or surgical management. 13 patients required surgical fixation (anterior or posterior spinal fusion) with 45 patients managed by cervical orthosis.

Conclusions
Hangman's fracture without translation (3 mm) or angulation (10 degrees) is the most common type. Though believed to be benign in nature, it can be associated with cord and vascular injury requiring surgical intervention. On the contrary, types II and IIa are not always unstable injuries requiring surgical management.

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Associations Between Visceral Injuries, Lumbar Spine Fractures, And Their Detection.

M Shahriari¹, D Yousem², B Franck³
¹Christiana Care Hospital, Wilmington, DE, ²JOHNS HOPKINS MEDICAL INSTITUTION, OWINGS MILLS, MD, ³Christiana Care Hospital, Newark, DE

Purpose
Missed traumatic spine fractures could result in adverse patient outcome and malpractice lawsuits. The purpose of this study was to retrospectively evaluate the rate of overlooked traumatic lumbar spine fractures. We also sought to determine whether the presence of abdominopelvic findings would lead to a reduced detection rate of all traumatic spinal fractures and lumbar transverse process fractures in particular.
Materials and Methods
We retrospectively reviewed the images and reports of 150 post-traumatic chest/abdomen/pelvis CT scans from our tertiary care institution in one calendar year. 75 with and 75 without acute abdominopelvic injuries were classified for overlooked traumatic lumbar spine fractures.

Results
28% (21/75) of patients with acute abdominopelvic injuries also had lumbar spine fractures, including 72% (15/21) with transverse process fractures and 28% (6/21) with vertebral compression fractures. In the no abdominopelvic injury group, we found 18% (14/75) lumbar spine fractures with 79% (11/14) transverse process fractures and 21% (3/14) vertebral compression fractures. 33% (5/15) of transverse process fractures were overlooked in the presence of acute visceral injuries as opposed to 27% (3/11) in the other group. None of the vertebral compression fractures were missed with and without concurrent abdominopelvic injuries.

Conclusions
Transverse process fractures are the most common and also the most commonly missed traumatic spinal fractures. Overlooked transverse process fractures may cause continuous pain without a certain reason, increased rate of return to the hospital for evaluation, and additional costly work ups. By knowing this pattern radiologists should remain alert to these fractures same as vertebral fractures. The rate of overlooked transverse process fracture was higher in patients with concurrent acute visceral findings (33% versus 27%) however this might be underestimated since major forces necessary for visceral injuries usually result in displaced transverse process fracture. In our opinion dedicated spine CT with magnified views in soft tissue and bone algorithm as opposed to traditional abdominopelvic CT protocols can decrease the rate of overlooked spine fracture and increase the quality of patient care.

Emphysematous Osteomyelitis of the Spine - CT and MRI Appearance and Associated Artifact

Z Farooqi1, D Cohen-Addad1, Z CHAUDHRY2
1SUNY Downstate Health Sciences University, Brooklyn, NY, 2STANFORD UNIVERSITY MEDICAL CENTER, STANFORD, CA

Purpose
Emphysematous osteomyelitis is a rare, life threatening entity with few reported cases in the literature. Presence of gas within the bone creates a unique problem for MR imaging as these small foci of gas result in numerous gas/bone interfaces. These interfaces result in substantial spatial variations in the local magnetic field causing susceptibility artifact. The unique imaging characteristics caused by this phenomenon have not been previously discussed in the literature in the context of emphysematous osteomyelitis. The purpose of this case report is to discuss the clinical and radiological features of emphysematous osteomyelitis, the artifacts associated with it, and its possible explanation.

Materials and Methods
A 66 year old female with a past history of poorly controlled diabetes and hypertension presented to the emergency department with flank pain. She was febrile and tachycardic with a WBC count of 12000 and glucose of 500. A transthoracic echocardiogram did not show any vegetation. CT guided drainage of the psoas abscess as well as blood cultures revealed growth of Citrobacter Koseri. The patient was managed with intravenous antibiotics.

Results
CT abdomen & pelvis images showed intradiscal, intravertebral and epidural foci of gas in the region of L3 and L4 vertebral body and the adjacent psoas musculature. MRI lumbar spine demonstrated heterogeneous, granular, low STIR signal within the L3 and L4 vertebral bodies instead of the usual high STIR signal associated with osteomyelitis. Corresponding low T1 signal and low signal on contrast enhanced images was also noted. These findings were thought to be secondary to susceptibility artifact created by local magnetic field inhomogeneity secondary to multiple gas/bone interfaces. Adjacent foci of gas with microabscesses were again seen within the psoas musculature and epidural space. On repeat MRI after starting treatment, relatively higher STIR signal was seen within the involved vertebral bodies with increased enhancement thought be due to partial resolution of vertebral body emphysema and associated susceptibility. Improved STIR signal and enhancement on repeat imaging also argued against bone necrosis as the cause for low STIR signal and enhancement seen on initial MR images.

Conclusions
Emphysematous osteomyelitis is a rare life threatening condition associated with a dramatic CT appearance and peculiar MR characteristics owing to the susceptibility artifact created by the numerous gas/bone interfaces.
A fractured and migrated inferior vena cava filter strut penetrating a vertebral body.

S Khalil1, A Aein1, L De Alba1, E Bonfante-Mejia1, R Riascos1

1Department of Diagnostic Radiology and Interventional Radiology, McGovern Medical School, UT Health, Houston, TX

Purpose
To present a case of a fragmented inferior vena cava filter with the struts penetrating a vertebral body.

Materials and Methods
A 27-year-old female with past medical history of Factor V Leiden deficiency and multiple episodes of deep vein thrombosis and pulmonary embolism treated with an inferior vena cava filter presents with worsening low back pain.

Results
Abdominal x-ray demonstrated an IVC filter in place with the proximal most tip at L1-L2 level. There is fragmentation of the IVC filter with the posterior most strut penetrating the L3 vertebral body. Sagittal T2-weighted and post-contrast MR images showed bone marrow edema and enhancement surrounding the embedded fractured IVC filter in the right anterolateral aspect of the L3 vertebral body.
Conclusions
Inferior vena cava (IVC) filters have been utilized in the management of patients with venous thromboembolism (VTE) when anticoagulant therapy is contraindicated or fails to protect them from developing recurrent VTE amongst other indications. The complications of IVC filters include thrombus formation, infection, bleeding, tilting, strut fracture, penetration, and migration (1%). The risk of IVC filter fragment migration to the spine compared to other locations is 9%. To our knowledge, the chance of penetration and migration is extremely low and only a few cases have been reported in the literature. Thus, we bring to awareness the imaging manifestations of IVC filter complications with a case of a fractured and migrated IVC filter strut penetrating the vertebral body.

Lumbar Pseudomeningocele with Facet Joint Fistula and Nerve Root Herniation

M Bottene Villa Albers¹, B Branstetter²
¹UPMC, Pittsburgh, PA, ²UPMC, Wexford, PA

Purpose
Posterior pseudomeningocele of the lumbar spine is a rare finding that is classified according to etiology as idiopathic, traumatic or post-operative. The first report of iatrogenic lumbar pseudomeningocele dates to 1986 when 3 cases were described following laminectomies of the lumbar spine. The range of symptoms described in case series ranged from asymptomatic to debilitating progressive sensory or motor deficits. We present the first case of postoperative lumbar pseudomeningocele with fistula to the facet joint and associated nerve root herniation.

Materials and Methods
A 59 year-old man presented with lumbar pain radiating to both lower extremities. He had low back pain for more than 30 years and had undergone left facet ablation at L3-L4, L4-L5 and L5-S1 six years ago with partial improvement of the pain. One year prior to presentation, he had L4-L5 laminectomies done at an outside institution. Despite the surgery, his symptoms did not improve and he had persistent lumbar pain with radiculopathy, but no motor or sensory deficits.

Results
CT Myelogram of the lumbar spine revealed diffuse disc bulges at L3-L4, L4-L5 and L5-S1 with right L4-L5 posterolateral pseudomeningocele. The S2 nerve was herniated through the dural defect. Contrast extended from the pseudomeningocele into the adjacent facet joint. The patient underwent surgical correction of the lesion with L3-L4, L4-L5 and L5-S1 posterior decompression with dissection and reduction of the S2 root and closure of the dural defect. This resulted in partial improvement in his low back pain, but substantial improvement in his radiculopathy.

Conclusions
We report the first known case of a postoperative lumbar pseudomeningocele with fistula to the facet joint, accompanied by herniation of a nerve root through the dural defect. Despite the presence of synovial fistula, the treatment and outcome of this rare condition was similar to previously described post-operative pseudomeningoceles without joint communication.
Spontaneous Pneumorrhachis

B Branstetter

UPMC, Wexford, PA

Purpose
Pneumorrhachis (air in the spinal column) is a rare event, with only scattered case reports or small case series in the literature. It is most frequently the result of trauma, but barotrauma, respiratory conditions, and recent surgery have also been implicated. We report a case of spontaneous pneumorrhachis in a patient with none of the typical causative factors.

Materials and Methods
A 29-year-old male presented with crepitus in the lower neck. He had a history of severe erosive esophagitis, presumably from gastroesophageal reflux disease. He had undergone several prior esophageal dilations, but none within the past few weeks.

Results
CT of the neck and chest was performed in the emergency department, revealing gas tracking through the fascial planes of the neck and chest. Additional gas was identified in the epidural space of the spinal canal, extending from the cervico-medullary junction to the lumbar spine. The degree of central canal compression was mild. Upon directed physical examination, no neurologic symptoms were identified. A subsequent pharyngoesophagram revealed no contrast extravasation. The patient was treated conservatively.

Conclusions
Pneumorrhachis is a concerning radiologic finding, especially when it occurs without a clear precipitating event. Spontaneous pneumorrhachis is an extremely rare diagnosis, with only two published cases. Our patient presumably had a self-limited rupture of his esophagus related to his chronic esophagitis, with gas tacking along spinal nerve sheaths into the epidural space. We categorize the differential diagnosis for causes of pneumorrhachis and discuss the factors requiring treatment.
Tumor Thrombus from Metastatic Chordoma – A Rare Cause of SVC Syndrome

T Li1, J Corrigan1, M Stone1, D McVinnie1, S Patel2, B Griffith1
1Henry Ford Health System, Detroit, MI. 2HENRY FORD HOSPITAL, DETROIT, MI

Purpose
Chordoma is an uncommon malignant neoplasm arising from notochord remnants and carries a poor prognosis. Despite a high local recurrence rate, metastatic disease is rare, most frequently affects the lungs, soft tissue/bone, and liver. Hematogenous spread of disease is exceedingly rare and to our knowledge this is the only reported case of chordoma tumor thrombus in the literature. This excerpt describes a case of metastatic chordoma presenting with SVC syndrome and how this alters patient management.

Materials and Methods
We present a case of a 73-year-old male with history of chordoma who initially underwent wide local excision with proton therapy. Following surgical debulking and SBRT for recurrent disease, the patient developed symptoms of SVC syndrome with internal jugular vein thrombosis. After anticoagulation therapy failed to resolve the presumed bland thrombus, the patient presented to our institution for thrombectomy. However, during workup concern was raised for tumor thrombus and an ultrasound guided biopsy revealed dedifferentiated intravascular chordoma. Ultimately, endovascular stenting was required to relieve the patient's symptoms.

Results
Figure A: Imaging at initial presentation demonstrates a destructive left paraspinal mass involving the vertebral body with extension into the neuroforamen and epidural space. Figure B: Contrast enhanced coronal CT demonstrates expansion of the right internal jugular vein and SVC with intraluminal low-density thrombus extending into the proximal right atrium. Figure C: Contrast enhanced axial CT shows increased enhancement of the quadrate lobe (hot quadrate sign) supporting the diagnosis of SVC syndrome. Figure D: Venography shows complete occlusion of the left brachiocephalic vein with numerous chest wall and cardiac collaterals. Following deployment of a wall stent and balloon angioplasty, brisk flow was restored into the right atrium.

Conclusions
Chordomas are locally aggressive neoplasms that carry a poor prognosis. This case describes a unique presentation of chordoma manifesting as tumor thrombus causing SVC syndrome and pulmonary metastases due to hematogenous spread of disease. As treatment of SVC syndrome depends on the etiology, it is important not to presume bland thrombus and obtain a pathologic diagnosis. Initial presumption of bland thrombus would have shifted management to anticoagulation, thrombolysis, angioplasty or thrombectomy, but tumor thrombus typically requires endovascular stenting.
Primary Diffuse Leptomeningeal Melanomatosis: Review of Neuroimaging Findings.

R Ourfalian¹, S Sampson², J Kang¹, F Torres³
¹Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA, ²Kaiser Permanente LAMC Radiology, LOS ANGELES, CA, ³Kaiser Permanente, Los Angeles Medical Center, Los Angeles, CA

Purpose
Primary leptomeningeal melanomatosis is an extremely rare disease with a very poor prognosis. We present a case to review the unique neuroimaging findings throughout the brain and spine of a patient with this disease.

Materials and Methods
A 20-year-old African American male presented to small community hospital with a few months of nausea and vomiting in the early mornings and more recent frontal headaches and diplopa. A head CT and laboratory analyses were unremarkable. A lumbar puncture was then performed, and extensive testing of the CSF was noncontributory. Initial MRI imaging of the brain demonstrated T2 FLAIR hyperintense signal in the subarachnoid spaces concerning for meningitis. Leptomeningeal enhancement was also identified; however, laboratory exams did not identify an infectious, neoplastic or inflammatory culprit. The patient was subsequently referred to our tertiary care center for brain biopsy. H&E stains revealed fragments of dura and brain with pigmented tumor cells diffusely involving the leptomeninges and brain. Tumor cells were positive for HMB-45 and Melan-A, supporting melanocytic origin of the neoplasm. Findings were over all consistent with leptomeningeal melanomatosis (diffuse meningeal malignant melanocytic proliferation) with brain invasion. Extensive workup revealed no other possible primary site of melanoma. Patient passed away 7 months after the onset of initial symptoms.

Results
Precontrast T1 weighted imaging of the spine (A,B) demonstrated extensive intrinsic T1 hyperintense signal uniformly covering the dorsal aspect of the spinal cord within the subarachnoid space and likely abutting both components of the leptomeninges; the pia mater and arachnoid mater. Precontrast T1 weighted imaging of the cerebrum (C,D) demonstrated similar diffuse intrinsic T1 hyperintense signal along the leptomeninges of the brain.
Conclusions
Primary leptomeningeal melanomatosis is exceedingly rare yet highly malignant. The tumor is derived from leptomeningeal melanocytes, which have a neuroectodermal origin, and subsequently spreads throughout the subarachnoid spaces. MR imaging appearance may suggest a melanocytic leptomeningeal process by the characteristic shortening of T1 and subsequent hyperintense signal on precontrast T1 weighted sequences, thereby aiding the neuroradiologist in the diagnosis of this deadly disease.

Extraneural Metastatic Glioblastoma

S Khalil\(^1\), P Rabiei\(^1\), A Aein\(^1\), A Kamali\(^1\)
\(^1\)Department of Diagnostic Radiology and Interventional Radiology, McGovern Medical School, UT Health, Houston, TX

Purpose
To present a case of an extraneural metastatic glioblastoma.

Materials and Methods
A 59-year-old man with a history of glioblastoma status post second resection and chemoradiation presents with progressive low back pain.

Results
Axial T1-weighted post-contrast image demonstrated a rim-enhancing, centrally necrotic infiltrating mass in the right temporal lobe with extensive surrounding vasogenic edema. Sagittal CT of the abdomen and pelvis demonstrated a pathologic fracture of L2 with a mixed sclerotic and lucent lesion and mild bulging of the posterior cortex. Sagittal T2-weighted image showed heterogeneous hyperintensity and sagittal T1-weighted post-contrast image showed heterogeneous enhancement in the L2 vertebral body. Histopathologic examination was consistent with Glioblastoma.

Conclusions
While glioblastoma has a high tendency for local invasion, the incidence of its extraneural dissemination is less than 2%, with osseous involvement even being less common. The most frequent location of osseous metastasis is the vertebrae. Review of the literature has also shown that the supratentorial glioblastoma tend to be less disseminative through cerebrospinal fluid compared to the infratentorial glioblastoma. To the best of our knowledge, isolated glioblastoma vertebral metastasis is rare and only a few cases have been described in the literature.
Is Neuroradiology Becoming More or Less Specialized? Trends in Specialization of Radiologists Interpreting Neuro MRI Studies

E Calabrese¹, B Trinh², H Forman³, B Haas²
¹UCSF, San Francisco, CA, ²University of California San Francisco, San Francisco, CA, ³Yale, New Haven, CT

Purpose
Neuroradiologists have advanced training in interpreting imaging studies of the head, neck, and central nervous system. In particular, MRI studies of the brain, face, and neck (neuro MRI) likely benefit from special expertise due to the complexity of the anatomy, subtlety of abnormal imaging findings, and large number of disease processes. However, neuro MRI is not always read by specialized neuroradiologists. The purpose of this study is to use publicly available Medicare claims data to assess specialization within neuro MRI over a 6-year period.

Materials and Methods
We accessed the Medicare Physician and Other Supplier Public Use File for calendar years 2012-2017 and identified all radiologists who submitted claims for interpreting at least one neuro MRI study (MRI of the brain, face, orbits, skull base, and neck). To assess specialization, we calculated the percentage of each radiologist's total wRVU derived from all neuroradiology studies (both MR and non-MR). Using previously published thresholds for identifying subspecialists, "neuroradiologists" were defined as radiologists that derived >50% of their annual wRVU from any neuroradiology related Current Procedural Terminology (CPT) code. The primary end point for assessing specialization was the percent of neuro MRI studies interpreted by neuroradiologists. We also calculated the total number of neuro MRI studies interpreted by each radiologist and the total work relative value units (wRVU) derived from these studies.

Results
From calendar year 2012-2017 there was a 12% increase in the total number of neuro MRI studies interpreted (2,074,794 to 2,313,007) while the total number of radiologists interpreting neuro MRI studies increased by only 2% (13,725 to 13,953); this corresponds to a 10% increase in the average number of neuro MRI studies interpreted per radiologist (151 to 165). There was also a corresponding 19% increase in the number of neuroradiologists (3,110 to 3,702). The percentage of all neuro MRI studies (by wRVU) interpreted by neuroradiologists rose from 50% to 58%.

Conclusions
Longitudinal analysis of Medicare reimbursement data from calendar year 2012-2017 shows progressive increases in specialization within neuroradiology with both a higher proportion of neuro MRI studies interpreted by neuroradiologists and an increasing average number of neuro MRI studies interpreted per radiologist. This increase in specialist interpretation reflects the radiology community's commitment to delivering high quality specialized care.
Healthcare Price Transparency: The Show Where Everything is Made Up and the Points Don't Matter

N Coleman¹, J Hirsch¹
¹Massachusetts General Hospital, Boston, MA

Purpose
To highlight some of the limitations of current price transparency initiatives in guiding patient decision-making while also emphasizing the necessity of further efforts to equip patients with pricing information. Specifically, we will provide a brief review of the literature regarding impediments to price transparency in healthcare and radiology, highlight current attempts at equipping patients with pricing information, and suggest points of emphasis for future initiatives.

Materials and Methods
A review was performed of both scientific literature and lay press to ascertain patient perspectives on healthcare pricing and review the limitations facing patients and physicians in trying to obtain that information. Additionally, review was also made of various price transparency initiatives that have been implemented around the country, including corresponding cost, patient satisfaction, or outcomes data when available.

Results
There is a wide variation in patients' out-of-pocket costs depending on their payer and setting of care. One study estimates that hospital-based prices grew 42 percent from 2007-2014 for inpatient care versus 25 percent for outpatient hospital-based care, while physician prices alone increased 18 percent and 6 percent respectively. Pricing tools alone appear to have minimal impact on patient decision-making, with one review showing 12 percent of a large insured population using such a tool and only 1 percent of patients who received advanced imaging performing a price search. Other papers suggest that high deductible plans demonstrate reduced utilization of 13-18%, but do not appear to encourage price-shopping. More comprehensive interventions, such as Children's Hospital of Philadelphia's Radiology Department's recently created Patient Cost Estimation Department, resulted in higher patient satisfaction scores while simultaneously decreasing the number of hospital-wide self-pay adjustments by 63% over one year.

Conclusions
The primary challenge in establishing price transparency in radiology is that patients will ultimately pay variable out-of-pocket prices for same services rendered, with variation by payer and setting of care. Superficial transparency measures have demonstrated limited impact on patient decision-making. More robust efforts have shown some promise, however. Upcoming attempts at providing price transparency and empowering patient decision-making include direct care models and various pricing-disclosure legislation.

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H Kim¹, A Pereira¹, E Shamim¹, W Chang¹, V Dam¹, N Desai¹, G Kori¹, A Crawley¹, C Wilson², A MacLean¹
¹MidAtlantic Permanente Medical Group, Rockville, MD, ²Kaiser Permanente Mid-Atlantic States, Rockville, MD

Purpose
The purpose of this study is to measure the efficacy of incorporating standardized, patient-friendly language into neuroradiology reports to facilitate discussion of imaging abnormalities when patients receive next business day radiology reports, via a patient portal.

Materials and Methods
Within our large integrated medical group providing care across DC, MD and VA for the patients of Kaiser Permanente of the Mid-Atlantic States, neuroradiology worked closely with our referring colleagues to establish standardized reports, guidelines and patient-directed verbiage derived from peer reviewed literature and ACR white papers. Concurrently, we began releasing all neuroradiology MR and CT reports directly to patients the next business day following report finalization via our patient portal. The goal was to achieve a language within radiology reports that is both useful to the clinician and patient friendly. For example, in brain imaging, we instituted multiple sclerosis templates, as well as follow up guidelines for incidental pituitary lesions. For spine imaging, we placed an interdepartmental statement in all spine reports acknowledging that anatomic abnormalities may not be symptomatic/clinically relevant, as well as an interdepartmental statement addressing heterogeneous marrow on MR. For neck imaging, we standardized the follow up recommendations for incidental thyroid nodules detected on CT or MR. Once these standardized reports and guidelines had been in place for at least several months, we distributed a single-question, online survey to clinicians in several departments (neurology, orthopedics, and oncology). The question was: "Does the use of standardized verbiage and patient-directed messaging within our neuroradiology brain and spine MR reports assist you when discussing results with patients?" The responses were collected and the result was then derived from the responses.

Results
We had a response rate of 50%, with the vast majority of our responding referring providers (82%, 9 out of 11) reporting that the presence of carefully constructed clinician and patient friendly language within our radiology reports is valuable in image-related patient discussions.

Conclusions
Within our large integrated health care system performing just under 800,000 exams annually, use of interdisciplinary evidence-based patient friendly language in neuroradiology imaging reports is helpful in guiding patient discussions, particularly when directly releasing reports to patients the next business day. Further investigation into this topic and its impact on physician time spent on image-related patient concerns, reduction in patient anxiety, frequency and appropriateness of follow up imaging should be considered.
The Anterior Chamber of the Eye: An Overlooked Entry of the Natural Excretion pathway of Gadolinium Based Contrast Agents?

A Radbruch¹, K Deike-Hofmann²
¹University Hospital Essen, Essen, Germany, ²German Cancer Research Center, Heidelberg, Baden-Württemberg

Purpose
Recently it has been reported that gadolinium based contrast agents (GBCAs) enter the eye 3-24 hours after intravenous injection (1). In the current study, we investigated if GBCAs can be detected in the anterior chamber (AC) of healthy infantile eyes on T1-weighted MRI promptly after injection?

Materials and Methods
This retrospective study was approved by the ethical committee and encompassed MRI of 200 healthy eyes of children suffering from retinoblastoma of the contralateral eye. MRI was performed with an orbital coil with the children in a state of general anesthesia. MRI of 102 boys and 98 girls with a mean age of 22 (1-91) months were assessed. Orbital MRI prior to and closely following injection of a standard dose of a macrocyclic Gadolinium-based contrast agent (Dotarem®, Guerbet, 0.1 ml/kg body weight, mean (standard deviation) p.i. time = 12:24 (± 2:31) min) were compared. Differences of signal intensity ratios (∆SIRs) of the AC to the lens were determined between pre and post contrast-enhanced T1 weighted images.

Results
A highly significant signal intensity increase was found in the AC of healthy eyes 12 min after GBCA injection (median ∆SIR (interquartile range) = +0.08 (0.05-0.12), p < 0.0001). A slight enhancement adjacent to the ventral iris with a maximum in the iridocorneal angle could be observed in 40 out of 200 cases (20%). In addition, gadolinium-enhancement showed a strong negative correlation with children's age in multivariate analysis with adjustment for p.i. time (p < 0.0001).

Conclusions
GBCA leakage into the AC of healthy infantile eyes was found promptly after injection. The negative correlation between patient age and GBCA-enhancement might be explained by a maturation process of the blood-aqueous barrier or Schlemm’s canal. Future studies should assess the duration and potential diagnostic applications as well as possible safety concerns of gadolinium presence in the AC.

Optic nerve imaging in multiple sclerosis and neuromyelitis optica spectrum disorders cohorts

O OUTTERYCK¹
¹Lille University Hospital, LILLE, France

Purpose
Optic nerve involvement may observed in multiple sclerosis (MS) and neuromyelitis optica spectrum disorders (NMOSD). It may be hard distinguish these two pathologies. Optic nerve imaging may be of help (MRI and optical coherence tomography [OCT])

Materials and Methods
Retrospectively, we included patients suffering from CIS (clinically isolated syndrome; n=130), MS (n=148) and NMOSD (n=19) and analysed their optic nerve MRI characteristics (symptomatic/asymptomatic, lesion length, topography) on 3D-Double Inversion Recovery (DIR) sequence and their OCT (peripapillary retinal nerve fiber layer thickness [pRNFL]) characteristics. All MRI and OCT had been performed more than 3 months after optic neuritis (ON).

Results
Asymptomatic lesion was more frequently observed in CIS (21.6%) and MS (44.8%), than in NMOSD (16.7%, p<0.001). Symptomatic lesions in NMOSD were longer (27.5mm, p=0.0014) and involved more frequently canalicular (91.7%, p=0.0209) and prechiasmatic (75%, p=0.0209) segments than in CIS and MS (16mm, 63.93%, 36.07%). In CIS and MS, symptomatic lesions were longer (18mm) than asymptomatic lesions (11.6mm, p=0.001). We found significant association between lesion length and pRNFL thickness whatever the lesion was symptomatic (beta coeff= -0.72 ± 0.12, p<0.001) or asymptomatic (beta coeff= -0.45 ± 0.10, p<0.001).

Conclusions
Optic nerve imaging may be of help to distinguish MS and NMOSD associated optic nerve lesion. Lesion length is a biomarker of retinal axonal loss.

Evaluating the Utility of Post-contrast Imaging in Assessment for Optic Neuritis

ASNR20 Virtual Proceedings Page 752
M Bhatt¹, V Timpone¹, M Borges¹, J Honce¹
¹University of Colorado, Aurora, CO

Purpose
Optic Neuritis (ON) is a non-infectious optic neuropathy characterized by inflammation of the optic nerves and often associated with demyelinating conditions. Frequently a clinical diagnosis, ON can be imaged with MRI, typically prior to and following gadolinium administration. Given recent interest in CNS gadolinium deposition, efforts have been made to reduce or eliminate gadolinium from follow-up of various entities, such as vestibular schwannoma, meningioma and multiple sclerosis where clinically feasible. Our purpose is to assess the accuracy of non-enhanced orbital MRI in comparison to gadolinium-enhanced studies in the assessment for optic neuritis.

Materials and Methods
Retrospective analysis of 46 orbital MRI examinations from 2018 to 2019 which included both normal exams and cases of optic neuritis. A board certified neuroradiologist, who was not blinded, individually reviewed each case and provided an interpretation of each optic nerve, which served as the control for the study. Examinations were randomized and independently reviewed by two board certified neuroradiologists. Reviewers were blinded to the positivity of the cases and clinical history, and were only shown the axial T2-weighted and coronal STIR images. They documented the presence or absence of abnormal signal and involved optic nerve segment.

Results
92 optic nerves were individually assessed with 33 abnormal and 59 normal optic nerves based on non-blinded assessment. Sensitivity and specificity for diagnosis of optic neuritis on non-enhancing images were 87.9% and 89.8% respectively for Interpreter 1 and 84.8% and 89.8% for Interpreter 2. The calculated inter-observer variation was 0.55, correlating with moderate agreement between the two interpreters.

Conclusions
Optic neuritis is often imaged with contrast-enhanced MRI. Given the trend of reducing unnecessary gadolinium administration, we evaluated the accuracy of non-contrast imaging for the diagnosis of ON. This study suggests gadolinium may not be necessary in evaluation of some cases of ON, but further research is needed. By avoiding the routine use of gadolinium in patients with ON, the additional cost and side effects of gadolinium may be eliminated.
Comparative outcomes of bridging treatment with direct mechanical thrombectomy after large-vessel ischemic stroke: an updated meta-analysis

Y Wang¹, X Wu², C Zhu³, A Malhotra⁴
¹Sichuan Provincial People's Hospital, Chengdu, Sichuan, ²Yale University School of Medicine, New Haven, CT, ³University of Washington, Seattle, WA, ⁴Yale University School of Medicine, New Canaan, CT

Purpose
The reported benefits of routine bridging treatment (intravenous thrombolysis (IVT) prior to mechanical thrombectomy (MT), BT) for clinical outcomes remain inconsistent and controversial even in previous meta-analyses. This study aims to compare the outcomes of BT with direct mechanical thrombectomy (dMT) after large-vessel ischemic stroke based on the most up-to-date evidence.

Materials and Methods
MEDLINE, EMBASE, Scopus, and the Cochrane Library from 2017 January to 2019 May were searched for studies that directly compared the outcomes of the two treatment strategies. Methodological quality was assessed using the Quality in Prognostic Studies (QUIPS) tool. Combined estimates of odds ratios (ORs) of BT versus dMT were derived. Multiple subgroup analysis were performed, especially for IVT-eligible patients.

Results
Twenty-seven studies involving 6670 patients in the BT group and 4313 patients in the dMT group were included. No truly randomized trials comparing BT and dMT were found. Compared to patients in the dMT group, patients in the BT group had lower mortality at 90 days (OR=0.65, 95% CI 0.59–0.71), and significantly better clinical outcomes at 90 days, measured either by functional independence as defined as mRS 0-2 (OR=1.42, 95% CI 1.31–1.55), and by excellent clinical outcome as defined as mRS 0-1 (OR=1.46, 95% CI 1.31-1.63). Compared to patients in the dMT group, patients in the BT group achieved higher successful recanalization (defined as mTICI 2b-3) rate (OR=1.26, 95% CI 1.15–1.39), but similar complete recanalization (defined as mTICI 3) rate (OR=1.07, 95% CI 0.95-1.21). No significant difference was detected in the occurrence of symptomatic intracranial hemorrhage between two groups (OR=0.98, 95% CI 0.83–1.16). The above results remained similar after adopting propensity score matched data. Most of the benefits of BT remained robust in the IVT-eligible patients, except that the recanalization rates became similar between two treatment groups. Except for the analysis of successful recanalization rate in IVT-eligible patients, no substantial statistical heterogeneity was found in other analysis.

Conclusions
Compared to dMT, bridging therapy led to better clinical outcomes, lower mortality at 90 days, and higher successful recanalization rates, without increasing the risk of near-term hemorrhagic complications.
Multimodal Cerebral AVM Treatment: A 12 Year Cohort and Comparison to Key Outcomes of the ARUBA Trial

J Rabinov¹, A Patel¹, J Hirsch¹, C Ogilvy²
¹Massachusetts General Hospital, Boston, MA, ²BIDMC, Boston, MA

Purpose
Curative treatment of unruptured cerebral AVMs remains controversial after the only randomized controlled trial, ARUBA, was halted because interim analysis revealed superiority of the medical management group. We reviewed treatment algorithm and outcomes of ARUBA eligible patients at our institution.

Materials and Methods
We retrospectively analyzed 318 consecutive adult patients with cerebral AVMs treated at our institution with embolization, surgery, and/or proton-beam radiosurgery. Analysis was performed on 142 ARUBA eligible patients (baseline mRS 0-1, no history of hemorrhage), and results were compared to primary and secondary outcomes from ARUBA, as well as to natural history cohorts.

Results
Annualized stroke rate (hemorrhagic or ischemic) in our cohort was 1.8%, 4.9% in the first 12 months, and 0.8% after the first 12 months, lower than natural history studies and the ARUBA medical management arm (p=0.001). A primary ARUBA endpoint (symptomatic stroke) was reached in 13 patients (9.2 %), which compares favorably to the ARUBA intervention arm (39.6%, p=0.0001) and is similar to the ARUBA medical management arm (9.2%, P=1.0). The secondary ARUBA endpoint (mRS ≥2 at 5 years follow-up) was reached in 14.3% of patients compared to 40.5% in the ARUBA intervention arm (p=0.002) and 16.7% in the ARUBA medical management arm (p=0.6).
Conclusions
The multimodal approach to brain AVM patient selection and treatment at our institution yields good clinical outcomes with key safety endpoints (stroke, death and mRS 0-1). Results show statistical improvement over the ARUBA intervention arm and are similar to the ARUBA medical arm at 5 years follow-up. Meta-analysis of other treatment and medical observation cohorts are reviewed in the context of lifetime event risks.

Scientific Abstract Session: Adult Brain Infection/Inflammation
2351
5:05PM - 5:11PM
GABA-a Receptor Antibody-Associated Encephalitis: A Unique but Characteristic Imaging Presentation Among Autoimmune Encephalitides
T Richards¹, K Salzman²
¹University of Utah School of Medicine, Salt Lake City, UT, ²University of Utah, Salt Lake City, UT

Purpose
The primary purpose of the abstract is to present the unique imaging presentation of GABA-a receptor antibody-associated encephalitis, which primarily involves the cortical gray and white matter and typically spares the limbic structures which is the hallmark of most other forms of autoimmune encephalitis. Additional diagnostic clues including typical clinical presentation and common associations will also be discussed, so that the radiologist may assist the referring clinicians by suggesting the disease in the appropriate imaging and clinical context.

Materials and Methods
A 61 year old Asian male with past medical history including prostate cancer and multiple myeloma status post autologous peripheral stem cell transplant presented to the emergency department with subacute cognitive impairment and progressive visual defects over the course of a week. Initial brain MRI, demonstrated multifocal areas of gyriform diffusion restriction with associated FLAIR signal abnormality without enhancement in the left frontal, right temporal, and bilateral occipital lobes. At that time, the differential diagnosis was very broad including subacute ischemia, vasculitis, atypical PRES, autoimmune etiologies, among others. Lumbar puncture and vessel wall MRI were initially relatively unremarkable. EEG demonstrated subclinical seizure activity. Repeat brain MRI was performed which showed worsening of the cortical and subcortical FLAIR hyperintense, diffusion restricting lesions. Brain biopsy of a temporal lobe lesion demonstrated rarefied white matter with myelin loss and astrogliosis. Repeat lumbar puncture was performed and the CSF was sent out for additional studies including GABA-a receptor antibody which came back positive. The patient was treated with corticosteroids and IVIG and slowly improved over time.

Results
MRI of the brain with gadolinium 2 weeks after initial presentation demonstrated new and worsening cortical and subcortical supratentorial lesions involving the bilateral cerebral hemispheres with areas of cortically based diffusion restriction and sulcal enhancement.

Conclusions
GABA-a receptor antibody-associated encephalitis classically presents with cortical and subcortical lesions with relative sparing of the limbic system which differs from other forms of autoimmune encephalitis. This diagnosis is important to consider as radiologists given that the disease can be lethal if patients go into status epilepticus. Early diagnosis leads to appropriate treatment and better outcomes in these patients.
Multi-Agent Molecular MRI Targeting Macrophage Functions Revealed Immunological Effects of D-mannose Treatment in Experimental Neuroinflammation

J Chen¹, J Wang¹, N Jalalimotlagh¹, C Wang¹, C Chau¹, J Linnoila¹, R Narsimhan¹, Z Yao²
¹Massachusetts General Hospital, Boston, MA, ²Huashan Hospital, Shanghai, Shanghai

Purpose
To use multi-agent molecular MRI targeting different macrophage functions to determine the immunological response of D-mannose treatment on experimental autoimmune encephalomyelitis (EAE), a commonly used mouse model for multiple sclerosis.

Materials and Methods
The protocol for animal experiments was approved by the institutional animal care committee. 24 female C57BL/6 mice (6-10 weeks of age) were induced with EAE with myelin oligodendrocyte glycoprotein 35-55 peptide (200 µg/mouse) and were randomly assigned to PBS-control and D-mannose treatment groups (n=12 per group). Three mice were sham-induced as additional control. Clinical scores and weights were recorded daily and blinded to the treatment method. Molecular MRI were performed to asses oxidative stress (targeting myeloperoxidase (MPO) using MPO-Gd, T1-weighted) and phagocytosis (using cross-linked iron oxide (CLIO) nanoparticle, T2-weighted) MRI on day 15 post induction. After imaging, spinal cords were harvested for flow cytometric evaluation. In vitro phagocytosis experiments were performed using macrophages from wildtype and mannose-receptor knockout mice at 4 concentrations of D-mannose (0, 1mM, 10mM, 50mM). Statistical analysis was performed. P<0.05 was considered statistically significant.

Results
D-mannose improved EAE symptoms (P<0.001 for clinical score, P=0.0023 for weight) and reduce mortality (P=0.019) compared to PBS-control mice. Flow cytometric analysis found that D-mannose-treated EAE mice exhibited significantly fewer infiltrating macrophages/microglia than those of PBS-control EAE mice (P=0.032), among which pro-inflammatory macrophages/microglia were greatly reduced (P=0.0028) while anti-inflammatory macrophages/microglia increased (P=0.034). MPO-Gd MRI demonstrated that D-mannose treated mice had significantly smaller total MPO+ lesion area than that of PBS control mice (P=0.0017), consistent with decreased MPO-mediated oxidative stress. CLIO MRI showed that D-mannose administration blocked phagocytosis, resulting in the lack of CLIO-related T2-weighted signal loss seen in PBS-treated mice (Fig. a vs. b). In vitro data from wildtype and mannose-receptor knockout mice further confirmed that D-mannose treatment blocked macrophage phagocytosis in a dose-dependent manner.
Conclusions
D-mannose treatment in EAE improved clinical symptom and reduced mortality by suppressing the oxidative (MPO-mediated) macrophage/microglia response and blocking mannose-receptor-mediated phagocytosis.

Concomitant Herpes Simplex Virus Types 1 and 2 Encephalitis Following Neurosurgery: Case Report

D Vasconcellos¹, R Fava², C Cavalcante², F Souza², L Feltrin², R Rossini², A Mamere²
¹Barretos Cancer Hospital, Barretos, São Paulo, ²Barretos Cancer Hospital, Barretos, SP

Purpose
To report a rare pathology-proven case and to show the imaging findings of concomitant herpes simplex virus types 1 and 2 encephalitis following neurosurgical procedure for treatment of craniopharyngioma.

Materials and Methods
A 18-year-old male patient underwent a neurosurgery to treat a cystic craniopharyngioma, with significant compression of the optic chiasm, by insertion of an Ommaya reservoir system and aspiration of the cyst. On the 5th postoperative day, he presented with seizures and decreased level of consciousness. Magnetic resonance imaging (MRI) scan was performed and brain lesions were observed, which were initially suspected of brain injury secondary to status epilepticus. The patient then developed clinical worsening, requiring decompression craniectomy. Cerebrospinal fluid analysis showed 60 cells/mm³ (99% lymphocyte). Another MRI scan was performed showing worsening of the imaging findings, with an increase in the bilateral brain lesions, and herpetic encephalitis was then suspected. Brain biopsy confirmed intense encephalitis associated with foci of necrosis. Herpes simplex virus types 1 and 2 positive. He was treated with acyclovir and evolved with persistent neurological sequelae. Late MRI scans showed areas of encephalomalacia and gliosis in the previously affected ones.

Results
T2-weighted and T2 fluid-attenuated inversion recovery (FLAIR) images showed asymmetric areas of hyperintensity in bilateral frontal, insular and temporal lobes, with involvement of white and gray matter, restricted diffusion, mass effect and post contrast leptomeningeal enhancement. No parenchymal enhancement was observed.

Conclusions
Herpetic encephalitis following neurosurgery is a rare but serious and life threatening well-known complication, with about 40 cases described in the literature. The exact underlying mechanism is unknown. It is hypothesized that procedure-related factors such as direct manipulation, trauma to nerves, steroid therapy and stress may be involved in this mechanism, permitting the viruses to escape immune surveillance. On average, symptom onset occurs from 4 to 8 days postoperatively. In some cases, the latency period can be greater than 10 days. The most common symptoms are fever, seizures, altered mental status and psychiatric disorder. Imaging findings
are similar to those of non-neurosurgical herpetic encephalitis. It is important to remember the possibility of this postoperative complication, as early treatment with acyclovir significantly decreases mortality.

Vessel Wall Imaging of Baylisascaris procyonis Encephalitis

L Hahn¹, A Mlikotic¹

¹HARBOR UCLA, Los Angeles, CA
Purpose
The purpose of the abstract is to share the imaging findings of Baylisascaris procyonis induced encephalitis in an adult, especially MR vessel wall imaging of Baylisascaris procyonis encephalitis.

Materials and Methods
24 year old male with past medical history of methamphetamine use, homelessness, and history of psychosis not otherwise specified, reported suicidal attempts and self harm presents with altered mental status in front of a convenience store. Initial Glasgow coma scale score was 4-4-6. Initial lumbar puncture demonstrates increased eosinophils but no other significant findings including negative cultures.

Results
The non contrast CT of the head that was taken 4 month prior to presentation was unremarkable. The most current MRI of the brain demonstrated nonspecific punctate T2 Flair hyperintensities in the bilateral thalamus, centrum semi ovale, and corona radiata which demonstrated associated mild enhancement on post contrast images. There was also irregular patchy both T1 and T2 Flair hyperintensity in the bilateral cerebellar white matter which demonstrates mild enhancement. There was no abnormal susceptibility artifact or diffusion restriction within the brain parenchyma. No abnormal leptomeningeal or pachymeningeal enhancement was seen. MR vessel wall imaging was subsequently performed, which revealed multiple areas of short segmental concentric and eccentric small vessel wall enhancement (yellow arrow). There was no larger vessel wall enhancement.

Conclusions
The CSF sample that was sent to CDC came back positive for anti-Baylisascaris antibodies. Baylisascaris procyonis, also known as raccoon roundworm, is a roundworm nematode that is found ubiquitously in raccoons, which are the definitive hosts. Baylisascaris procyonis infection is often found in pediatric population while ingesting racoon fecal material or playing in soil that may be contaminated by it. The affected individual ingests eggs of B. procyonis, where the larvae undergo migration and enter a variety of somatic tissues, including the CNS. Patients with B. procyonis encephalitis usually present with CSF eosinophilia and diffuse white matter disease. The usual imaging findings are T2 prolongation of the cerebral white matter with a predilection for a periventricular distribution. CNS infection by B. procyonis can cause severe morbidity and mortality in humans.
Isolated Neuro-sarcoidosis Manifesting as Gyriform Punctate Calcifications and Cerebral Venous Engorgement

O Arevalo¹, C Soto², S Khanpara¹, E Supsupin¹
¹The University of Texas Health Science Center at Houston, Houston, TX, ²National University of Colombia, Bogota

Purpose
To present a case of isolated neuro-sarcoidosis manifesting as gyriform calcifications with a rare clinical presentation as acute focal neurologic deficit simulating a transitory ischemic attack.

Materials and Methods
54-year-old African American female patient that presented complaining of headache, and insidious onset of auto limited right hemiparesis and expressive aphasia 48 hours before admission. Past medical history relevant for Hypertension and DM type 2.

Results
Extensive gyral swelling and vasogenic edema in the left temporoparietal lobes extending to the peri-Rolandic cortex. SWI shows multiple tiny serpiginous calcifications superimposed upon the areas of gyral swelling. There are multiple dilated medullary veins in
the left hemisphere some of which radiate towards the abnormal areas in the left temporal and parietal lobes. No definite areas of restricted diffusion were seen concerning for acute ischemic stroke. There is also asymmetric enhancement and fullness of the left cavernous sinus that extends to the left Meckel's cave.

Conclusions
Sarcoidosis is an idiopathic systemic granulomatous disease, characterized by the presence of non-caseating granulomas in affected tissues. Central nervous system involvement by sarcoidosis has a wide range of imaging findings. A broad spectrum of masslike and non-masslike enhancing lesions can be seen affecting the leptomeninges, cranial nerves, pituitary gland, and virtually any central nervous system structure. Concurring with the diversity of the CNS manifestations, this entity may course with a myriad of different neurological deficits, sometimes not concordant with the ones expected for the anatomic location of the lesion. Although leptomeningeal involvement is the most common presentation, the presence of coarse gyriform calcifications and venous engorgement, thought to be secondary to pial venous congestion, is uncommon. The resultant hemodynamic abnormality may explain the acuteness of the patient symptoms.

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Ventricular Entrapment Secondary to Isolated Intraventricular Aspergillus Infection – An Unusual Manifestation of Intracranial Fungal Infection

P Patel\textsuperscript{1}, S Patel\textsuperscript{2}, D Noujaim\textsuperscript{1}, J Corrigan\textsuperscript{1}, B Griffith\textsuperscript{1}
\textsuperscript{1}Henry Ford Health System, Detroit, MI, \textsuperscript{2}HENRY FORD HOSPITAL, DETROIT, MI

Purpose
Intraventricular aspergillus infections are a rare manifestation of fungal infections of the central nervous system (CNS) and have most commonly been identified in immunocompromised patients. Spread to the CNS can occur hematogenously (usually from pulmonary infection) or directly from the paranasal sinuses. Clinical diagnosis is difficult, as symptoms are nonspecific, but imaging can help create a more accurate differential. This excerpt describes a rare case of isolated intraventricular aspergillus infection in an immunocompromised patient presenting with ventricular entrapment.

Materials and Methods
We present the case of a 59-year-old male with a history of renal transplant on immunosuppressive therapy presenting with right-sided weakness and speech difficulty. Of note, the patient had recently completed a 12-week course of antifungal therapy for acute invasive pulmonary aspergillosis. Imaging revealed a complex mass in the left lateral ventricle with ventricular entrapment. After placement of an external ventricular drain for hydrocephalus, surgical biopsy of the lesion demonstrated numerous uniform, septate, fungal hyphae with rare acute angle branching consistent with aspergillus.

Results
Initial non-contrast CT of the head (not shown) demonstrated a complex cystic mass within the left lateral ventricle with asymmetric ventricular enlargement. CT of the head with contrast demonstrated a complex lesion within the left ventricle with peripheral enhancement and enlargement of the ventricle (Fig 1A). MRI demonstrated a cystic lesion within the left lateral ventricle with a hyperintense FLAIR component anteriorly (Fig 1B) with restricted diffusion (Fig 1C). Post-contrast MRI showed enhancement at the periphery of the complex lesion. (Fig 1D). There was also entrapment of the left lateral ventricle.

Conclusions
Isolated intraventricular aspergillus infection is a rare manifestation of CNS fungal infection, most commonly seen in immunocompromised patients. Given the nonspecific clinical symptoms of this diagnosis, imaging can localize and narrow the vast differential for these CNS lesions. Diagnosed patients require immediate, long-term, and systemic antifungal therapy. Given the time sensitive nature of diagnosis for patient outcome, recognizing key imaging features early in the disease course is critical.

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Ischemic and Hemorrhagic events in Neurosarcoidosis: Exploring Imaging Based Markers of Increased Risk

G Bathla\textsuperscript{1}, C FREEMAN\textsuperscript{2}, N Soni\textsuperscript{3}, T MORITANI\textsuperscript{4}, J Song\textsuperscript{5}, S MOHAN\textsuperscript{6}, C Derdeyn\textsuperscript{7}

\textsuperscript{1}Univ. Of Iowa Hospitals & Clinics, Iowa City, IA, \textsuperscript{2}HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA, \textsuperscript{3}University of Iowa hospitals and Clinics, IOWA CITY, IA, \textsuperscript{4}UNIVERSITY OF MICHIGAN, ANN ARBOR, MI, \textsuperscript{5}University of Pennsylvania, Philadelphia, PA, \textsuperscript{6}UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA, \textsuperscript{7}University of Iowa, St. Louis, MO
Purpose
To determine if the MR imaging findings in Neurosarcoïdosis (NS) patients presenting with ischemic or hemorrhagic events (IHE) at presentation differ from NS patients without IHE.

Materials and Methods
Retrospective, dual-center, cohort study, identified 100 NS patients (definite NS (18), probable (72) and possible NS (10) as defined under Zajicek criteria). Dedicated imaging review was performed and prevalence of various imaging variables (including leptomeningeal, cranial nerve, perivascular enhancement (PVE), white matter lesions, and parenchymal lesions) on index MRI were determined. The association between various imaging findings and IHE was investigated using Chi-square tests.

Results
The mean age at presentation was 45 years (range 14-75 years, standard deviation 12.6; F: M::63:37). IHE were noted in 17 patients (11 ischemic, 4 hemorrhagic and 2 with both). Most ischemic lesions were seen in corpus striatum, corpus callosum, periventricular white matter (PVWM) and pons. Most hemorrhagic lesions were in the PVWM and subcortical regions. Only 2/9 patients had positive angiogram studies. Seven patients were worked-up for a cardioembolic etiology, none of which was positive. The frequency of imaging variables between the IHE and non-IHE groups are as follows: Imaging variable IHE (n=17) Non-IHE (n=83) P value Mean age (yrs) 42 45.6 PVE 9 14 0.001 PVWM lesions 14 42 0.01 Leptomeningitis 11 36 0.10 Cranial nerve enhancement 3 27 0.22 Parenchymal enhancing lesions 5 22 0.80 Hydrocephalus 5 9 0.10 Pachymeningitis 3 29 0.16

Conclusions
IHE are more common in NS than previously reported and appear to be significantly associated with PVE and PVWM lesions. These usually involve smaller vessels and angiography studies are often negative.

A case of pachymeningitis - don’t forget IgG4.

M Werndle¹, R Smith²
¹North Bristol NHS Trust, Bristol, United Kingdom, ²North Bristol NHS Trust, Bristol, Bristol

Purpose
We present the MRI findings of our institution's cases of pathologically proven intracranial IgG4 related disease to add to the body of literature for this rare entity.

Materials and Methods
We present three cases of intracranial IgG4 related disease (RD). Case 1 is a 40 year old man who presented facial swelling and difficulty opening and closing his jaw. He was diagnosed 2 years from presentation, following a dural biopsy. Case 2 is a 33 year old
woman presenting with headache, visual disturbance and papilloedema. She was treated with anti-TB medication and followed up clinically and radiologically. A dural biopsy 5 years from presentation proved IgG4-RD. Case 3 is a 46 year old man who presented with headaches and right facial numbness with a clinically relapsing course whilst weaning off steroids. His case was diagnosed following a biopsy of temporalis muscle.

Results
Two cases presented with enhancing infiltrative lesions centred in the infratemporal fossa, with perineural and perivascular extension through skull base foramina into the intracranial compartment (Images A1 and A2). In all 3 cases, the intracranial disease included pachymeningitis, with dural thickening, enhancement (Image B) and T2 shortening (Image C). No intra-orbital mass or pituitary lesion was seen in our patients. CT scans of the chest, abdomen and pelvis revealed no evidence of IgG disease elsewhere in the body.

Conclusions
We present our three cases of biopsy proved IgG4 related intracranial disease, and their imaging findings. Pachymeningitis with low T2 signal was a feature in all three. Two of the cases had cranial nerve and intracranial arterial involvement, extending through the skull base foramina. None of the patients had radiological evidence of IgG4 RD elsewhere.

(Filename: TCT_1361_IgG4image.jpg)
A Rare Case of Eastern Equine Encephalitis

I Nguyen¹, S Li², A Sureshkumar³
¹University of Massachusetts, Baystate, Springfield, MA, ²Baystate Health, Springfield, MA, ³Baystate Health, Enfield, CT

Purpose
To present image findings of a rare case of Eastern Equine Encephalitis.

Materials and Methods
A 74-year-old male with past medical history significant for hypertension and post-concussion syndrome initially presented with altered mental status, left-sided weakness and left upper extremity contraction. Neurological work up including lumbar puncture, urine and serology testing revealed high serum IgG and positive Easter Equine Encephalitis IgM, which was confirmed by the Department of Public Health. Patient subsequently deteriorated to GCS 3 and was intubated. He remained comatose for a four weeks with no sign of neurological improvement, at which point family decided to proceed with comfort measure only. He deceased soon after. CT head was obtained on admission, and MRI brain was obtained for prognosis. Both reveal interesting findings of this rarely encountered brain infection.

Results
CT head/brain without contrast shows extensive edema of the right cerebral hemisphere with sulcal effacement and flattening of the right lateral ventricle. There is no evidence of intra-axial or extra-axial hemorrhage, fluid collection, or mass. MRI brain with contrast demonstrates diffuse effacement of the right frontal, parietal, temporal, and occipital sulci with associated cortical edema and T2 hyperintensity in the subcortical and deeper white matter extending to the pericallosal white matter. There is extensive swelling and signal abnormality in the bilateral basal ganglia, thalami, and extending inferiorly to the midbrain and posterior pons. No acute intraparenchymal hemorrhage on susceptibility-weighted images nor restricted diffusion on apparent diffusion coefficient maps is demonstrated. No midline shift nor hydrocephalus is noted.

Conclusions
Eastern Equine Encephalitis (EEE) is a rare but often fatal viral neuroinvasive infection. About 8 cases of EEE were reported a year in the United State, with the highest incidence found in the New England region. Currently, there are no effective vaccines or antiviral treatments against the disease, although some researches show promises. Early diagnoses of EEE can lead to aggressive supportive treatments that can subsequently reduce mortality. EEE cannot be diagnosed with neuroimaging alone, however, MRI can demonstrate the extent of the disease and thus clinical prognosis. As more cases of EEE were reported with images reviewed, pattern of brain involvement in this mosquito-born illness can be further characterized and future cases will be recognized earlier.
Chronic, Smoldering HSV-1 Encephalitis with Associated Vasculitis

M McLaughlin¹, J McNally², E QUIGLEY³
¹University of Utah, Salt Lake City, UT, ²University Of Utah, Salt Lake City, UT, ³UNIVERSITY OF UTAH, SALT LAKE CITY, UT

Purpose
To describe the imaging findings on vessel wall MRI in a case of chronic, smoldering herpes simplex virus encephalitis with associated vasculitis in a patient presenting to our institution in November 2019.

Materials and Methods
41 year old female presenting to the ED in January 2019 with new onset headache and generalized tonic-clonic seizures. The patient was admitted to the hospital and lumbar puncture demonstrated positive CSF PCR for herpes simplex virus. The patient was started on acyclovir therapy and after showing clinical improvement was discharged home. The patient experienced continued headaches which prompted multiple outpatient visits. Work-up including repeat lumbar puncture demonstrated persistent CSF pleocytosis with negative HSV PCR. The patient presented to our institution for neurology evaluation in November 2019, and was admitted for further work up. Neurological examination on admission was normal other than mild cognitive impairment. Lumbar puncture was performed demonstrating 15 WBC and positive HSV-1 PCR.
Results
Figure 1 - Contrast enhanced MRI of the brain showed interval increased FLAIR hyperintensity and enhancement in the left anterior medial temporal lobe (1A - January 2019, 1B - November 2019), with areas of blooming on gradient susceptibility reflecting parenchymal hemorrhage. Vessel wall MR imaging showed focal vessel wall enhancement of the adjacent left M1 middle cerebral artery segment (1D), with minimal associated luminal narrowing (1C).

Conclusions
HSV encephalitis reflects a reactivation of latent virus within the trigeminal ganglion with subsequent spread of infection to the meninges and brain parenchyma. The most common causal agent is HSV-1. The classic pattern of findings on MRI includes abnormal T2 and FLAIR signal hyperintensity, often with associated enhancement and diffusion restriction indicating cytotoxic edema. Imaging findings may progress to cortical necrosis and hemorrhage. The virus shows a predilection for the temporal lobes, inferior frontal lobes, insular cortex, and cingulate cortex. Prognosis is improved by early recognition and treatment with antiviral therapy. Untreated cases have a high mortality rate. We present here a case of chronic, smoldering herpes simplex virus encephalitis caused by HSV-1, incompletely treated with antiviral therapy over the course of 10 months. Vessel wall imaging demonstrates an associated vasculitis affecting the left middle cerebral artery adjacent to the temporal lobe.
Predicting Outcomes in Patients with Acute Ischemic Stroke: Informative Value of CT Perfusion Compared to Multi-Phase CT Angiography

J OSPEL, O Volny, M Najm, W Qiu, M Goyal, B Menon

UNIVERSITY HOSPITAL BASEL, BASEL, Switzerland, University of Calgary, Calgary, Alberta, University of Calgary, Calgary, AK

Purpose
The purpose of this study was to evaluate whether adding multiphase CT angiography (mCTA) information vs. CT perfusion (CTP)-derived information to clinical baseline information and non-contrast head CT (NCCT) improves statistical models that predict outcomes in patients with acute ischemic stroke.

Materials and Methods
The Prove IT study was a prospective observational multi-center study (n = 570) that enrolled patients admitted with suspected acute ischemic stroke. Baseline demographics and other clinical information, NCCT, mCTA and CTP were obtained in all patients. ASPECTS was read on NCCT; collateral status was read on mCTA using a 3 point ordinal scale. Three different commonly used CTP core thresholds were applied to obtain ischemic core volumes (relative cerebral blood flow (rCBF)<30%, absolute cerebral blood flow < 7 ml/100g/min, absolute cerebral blood volume< 2ml/100g). The CTP penumbra/core mismatch ratio [penumbra defined as Tmax>9 sec (GE CTP 4D), core defined as rCBF<30%] was also calculated. Ordinal logistic regression was performed to determine associations between clinical baseline characteristics (patient age, baseline mRS), workflow metrics (onset to imaging time, treatment decision), baseline ASPECTS and a) multiphase CTA collateral score versus b) different CTP-derived parameters with patient outcome, defined as 90 days modified Rankin Score (mRS). Akaike information criterion (AIC) and Bayesian information criterion (BIC) values for these models were calculated and compared.

Results
Overall, 494 vessel occlusions were detected (86.6%), among them 304 proximal occlusions (53.3%). Patients were treated with alteplase (n = 164, 27.5%), mechanical thrombectomy (n = 106, 17.8%), alteplase + mechanical thrombectomy (n = 175, 29.4%), tenecteplase (n = 13, 2.2%) and conservative management (n = 138, 23.1%). Multiphase CTA collateral, baseline ASPECTS, baseline NIHSS, patient age and treatment decision were significant predictors of patient outcome. Information loss was less in models that included mCTA based information when compared to models that included CTP based information. (see AIC and BIC values for statistical models.

Conclusions
Information provided by a quick and easy to implement imaging tool such as mCTA is comparable if not better than tools such as CT Perfusion, for prognostication in the acute stroke state.
Prevention of recurrent stroke: AI-based classification of etiology using high-end imaging features, histopathological reports and clinical data

H KNIEP, P Sporns, M Wildgruber, A Jeibmann, J Minnerup, J Fiehler, U HANNING

UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, Germany, Muenster University Hospital, Muenster, North Rhine-Westphalia, University Medical Center Hamburg-Eppendorf, Hamburg, AK

Purpose

Recurrent events account for 20% of all ischemic strokes. Targeted prevention requires a clear understanding of the underlying pathology. However, etiology remains unknown in 40% of all cases (1). We hypothesized that quantitative information from images, histopathological reports and clinical data can be used for machine learning-based prediction of etiology to efficiently support differential diagnostics and prophylaxis of second ischemic strokes.

Materials and Methods

The analysis includes 112 patients with occlusion of the carotid-T or middle cerebral artery who underwent thrombectomy. Thrombi were semi-automatically delineated in CT angiography scans and 2436 high-end image features were extracted. Thrombi samples were histologically analyzed and immunohistochemistry for CD3, CD20, and CD68/KiM1P was performed. Additional clinical parameters were extracted through chart review. The final diagnosis of stroke etiology as defined by the TOAST classification (2) was available for all included patients. A total of 2460 quantitative markers including imaging features, histological information and clinical data were evaluated for their ability to predict the underlying etiology in a 3-class random forest algorithm with 5-fold cross-validation.

Results

17 of the 112 included patients had arterioembolic strokes, 54 had cardioembolic strokes, and 41 had other determined or cryptogenic strokes (Table 1). Receiver Operating Characteristics areas under the curve of the validation sets were 0.66 for predicting arterioembolic etiology, 0.74 for cardioembolic etiology and 0.72 for other courses (Figure 1). The most important predictors of etiology were high-pass filtered texture metrics, thrombus mean density and age (Figure 2).
Conclusions
High-end image features, histopathological analysis and clinical data employed in an artificial intelligence-based classifier allowed for differentiation of stroke etiology according to TOAST criteria. In clinical routine, such algorithm may support differential diagnosis of stroke etiology and hence enable targeted prophylaxis of second events.

Table 1: Demographic characteristics of study cohort; #: Number of; SD: standard deviation

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<th>Age SD</th>
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<tr>
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<td>24</td>
<td>72.4</td>
<td>12.0</td>
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<tr>
<td>Other (TOAST 4 &amp; 5)</td>
<td>41</td>
<td>21</td>
<td>65.5</td>
<td>19.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>112</strong></td>
<td><strong>55</strong></td>
<td><strong>68.9</strong></td>
<td><strong>15.4</strong></td>
</tr>
</tbody>
</table>

Figure 1: Receiver Operating Characteristics for validation set predictions of proposed machine learning classifier; AUC: Area under the curve; CI: Confidence interval

Figure 2: Importance of top-5 predictors (Gini impurity)

Location-specific Alberta Stroke Program Early CT Score (ASPECTS) Paradigm In Acute Ischemic Stroke: A Systematic Review and Meta-analysis

S Seyedsaadat¹, J Pederson², A Neuhaus³, A Rabinstein⁴, W Brinjikji⁴, D Kallmes⁵
¹Westchester Medical Center, Valhalla, NY, ²Superior Medical Experts., St Paul, MN, ³University of Oxford, Oxford, oxford, ⁴Mayo Clinic - Rochester, Rochester, MN, ⁵Mayo Clinic, Rochester, MN

Purpose
To study the contribution of region-specific ASPECTS infarction and stroke laterality to neurological outcome.

Materials and Methods
We searched MEDLINE and EMBASE for reports on ASPECTS in AIS patients from 2000 to March 2019. Two investigators independently reviewed articles and extracted data. Three-month functional outcome defined as mRS>2 was the primary endpoint. The Quality in Prognosis Studies tool was used to assess the risk of bias of the included studies. Random-effects meta-analysis was performed. Cochrane's Q-test and I² statistics were used to assess data heterogeneity. Egger's regression was performed to assess publication bias.

Results
Regarding the weights of individual ASPECTS regions in predicting outcome when ischemic, the strongest contribution to long-term outcome was from infarction of M6 (OR 3.26; 95% CI, 2.21–4.80). This was followed by M3 (OR 2.42; 95% CI, 1.45-4.04) and M2 (OR 2.40; 95% CI, 1.56-3.66). Regarding stroke laterality, right M6 (OR 5.13; 95% CI, 0.40–33.10) and left M5 (OR 3.38; 95% CI, 2.04–5.59) infarcts were the strongest predictors of poor outcome. Pairwise comparisons between individual ASPECTS regions
regarding association between infarct and poor neurologic outcome were not significant with the exception of M6 vs. lentiform (p-value <0.05).

Conclusions
The results of this study indicate an uneven distribution of infarction in different ASPECTS regions and suggest that ASPECTS regions may be unequally weighted in predicting outcome of AIS patients. With regards to stroke location, right M6 infarction was the strongest predictor of poor outcome. Creating and validating eloquence-weighted ASPECTS, could improve the prediction of prognosis and patient selection for embolectomy.

(Gadolinium Enhancement is not Specific for ICAD Plaque Symptomaticity)

R Khabbaz1, P Vakil2, A Shaibani3, M Potts4, R Abdalla5, M Hurley6, T Carroll7, B Jahromi4, S Ansari6
1University of Illinois - Chicago, Chicago, IL, 2University of California - San Francisco, Chicago, IL, 3Northwestern University Feinberg School of Medicine, Chicago, IL, 4Northwestern University - Feinberg School of medicine, Chicago, IL, 5Northwestern University, Chicago, IL, 6Northwestern University Feinberg School of Medicine, Chicago, IL, 7University of Chicago, Chicago, IL

Purpose
High resolution vessel wall MRI (VWI) is sensitive for detecting post-contrast enhancement in patients presenting with stroke/TIA symptoms attributable to intracranial atherosclerotic plaques. However, it has not effectively been demonstrated to be specific for this characteristic. In this study, we compare post-contrast enhancement in symptomatic and asymptomatic high-grade plaques.

Materials and Methods
We retrospectively identified patients who presented with TIA/stroke and received high-resolution VWI with the 3D T1-SPACE protocol. All high-grade, large intracranial artery plaques, as identified on CT/MR angiography, were classified as symptomatic or asymptomatic if the presenting TIA/stroke symptoms, neurological exam, or MR DWI abnormalities corresponded to the distal vascular territory. Plaques were analyzed in orthogonal 1mm slices using OsiriX, and values for pre-contrast intracranial plaque hemorrhage (IPH) and post-contrast intracranial plaque enhancement (IPE) were calculated in accordance with methods established in current literature. Qualitative analysis of plaque enhancement was performed independently by 2 neuroradiologists and compared using the chi-square method. Generalized estimating equations (GEE) methodology for univariate and multivariate logistic regression were used to identify plaque characteristics that predicted symptomaticity.

Results
We analyzed 75 patients with 111 plaques (64 asymptomatic and 47 symptomatic). Average IPE in symptomatic plaques was 55% versus 43% in asymptomatic plaques, however this difference was not statistically significant when compared using student's t-test (p=0.08). Univariate analysis demonstrated only location in the anterior (versus posterior) circulation (p<0.01) and time from symptom onset to imaging (p=0.02) as significant predictors of symptomaticity. In multivariate analyses, IPH was a significant predictor of symptomaticity (p=0.04) when controlling for location, IPE, and time from symptom onset, but IPE was not (p=0.1). IPE was a significant predictor of symptomaticity when controlling for location (p=0.03) or time from onset (p=0.04).

Conclusions
Our study demonstrates that quantitative and qualitative assessment of PE using HR-VWI cannot be used to predict plaque symptomaticity without appropriate consideration of location in the anterior/posterior circulation and time from symptom onset.
Cost-Effectiveness of Bridging Thrombolysis versus Direct Endovascular Thrombectomy in acute ischemic stroke patients with Large Vessel Occlusion (LVO)

A Malhotra¹, X Wu², M Khunte³, Y Wang⁴, C Zhu⁵, D Gandhi⁶, P Sanelli⁷
¹Yale University School of Medicine, New Canaan, CT, ²Yale University School of Medicine, New Haven, CT, ³Yale School of Medicine, New Haven, CT, ⁴Sichuan Provincial People's Hospital, Chengdu, Sichuan, ⁵University of Washington, Seattle, WA, ⁶University of Maryland School of Medicine, Baltimore, MD, ⁷Northwell Health NSUH, Manhasset, NY

Purpose
There is continuing debate regarding utility of routine pretreatment with intravenous thrombolysis (IVT) prior to mechanical thrombectomy (MT) in patients with large vessel occlusion (LVO). The purpose of this study is to assess the cost-effectiveness of bridging IVT prior to MT relative to direct MT.

Materials and Methods
A decision-analytic model was constructed using TreeAge Pro Suite 2019 (Cambridge, MA) over the lifetime span of patients from a societal perspective. The two treatment strategies considered were immediate thrombectomy and bridging therapy with IVT, with possibility of achieving recanalization after IVT before thrombectomy. Input parameters for outcomes after each treatment strategy was derived from a systematic review of studies comparing IVT-eligible patients in both arms. Both short- (90 days) and long-term (lifetime) models were constructed. One-way, two-way and probabilistic sensitivity analyses and multiple subgroup analyses were performed.

Results
In the short-term model (90-day), bridging therapy achieved 0.13 QALY at a cost of $63,370, whereas the thrombectomy group achieved 0.012 QALY at a cost of $65,393. In the long-term model (life-time), bridging therapy achieved 8.39 QALY at a cost of $398,836, whereas the thrombectomy group achieved 7.83 QALY at a cost of $429,914, making bridging therapy the dominant strategy. The difference in health benefit is 0.56 QALY which translates into 204.4 days in perfect health. One-way sensitivity analysis varying the good outcome after bridging therapy shows that it is the optimal strategy when the proportion of good outcome after it is above 38.9%. When varying the good outcome in the thrombectomy group, it replaces bridging therapy to be the cost-effective strategy when the proportion of good outcome is above 46.8%. Two-way sensitivity analysis varying the proportions of good
outcomes after both strategies shows that IMT is the cost-effective strategy as long as the good outcome associated with it is at least 1% higher than that in the control group.

Conclusions
Our study results show bridging thrombolysis with IVT to be cost-effective in LVO patients prior to mechanical thrombectomy, and support the current AHA/ASA guidelines. This has implications for organization of stroke care as well in regards to "Drip n' Ship" versus "Mothership" strategy for initial triage of acute stroke patients.

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Sub-analysis from the SELECT Trial: Sub-cortical Infarction is Present in a Significant Number of Distal Large Vessel Occlusions.

C Sitton1, D Pujara2, R Riascos3, A Sarraj4
1UTHSC Houston / UT Health, Houston, TX, TX, 2McGovern Medical School, Houston, TX, 3Univ. Of Texas - Houston, Houston, TX, 4UT Houston, Houston, TX

Purpose
Involvement of the subcortical regions is a significant cause of disability in patients with LVO. We assessed the relationship between clot location and subcortical infarct in patients with successful recanalization, subdividing the M1 segment. We test the hypothesis that distal M1 occlusions and M2 occlusions should have less impact on the caudate, lentiform nucleus, and internal capsule than more proximal occlusions.

Materials and Methods
SELECT was prospective cohort study enrolling acute LVO up to 24 hours. Core lab evaluation included pre-procedure CT ASPECTS, CTA (clot location), CTP(CBV ASPECTS, RAPID parameters), pre/post mTICI, and infarct volume and ASPECTS on f/u CT or MRI by 72 hours. Clot location was subdivided into ICA/T, proximal M1, distal M1, distal M1 trunks(superior and inferior), and M2 trunks. The distal MCA was defined distal to the ATA origin. The M1-M2 junction was defined as vertical to horizontal transition of the MCA. The presence of infarction on 72 hour ASPECTs was assessed for each clot location. After noting a significant number of subcortical infarcts in distal occlusions, the effect of IV TPA was assessed.

Results
The caudate nucleus was involved in 38% of distal M1 occlusions, and 28% of M2 occlusions. The internal capsule was involved in 23% of distal M1, and 6% of M2. The lentiform nucleus was involved in 50% of distal M1, and 33% of M2. There were not a sufficient number of M1 trunks for analysis. Aggregating distal M1 and M2 occlusions, subcortical involvement was present 53.85% of the time, significantly different from the null hypothesis of zero involvement with a chi-square 47.9 and P value of < 0.0001. There was a lower incidence of subcortical involvement in a subgroup of patients not treated with TPA: In treated patients, 63% of M1 occlusions and 60% of M2 had subcortical involvement vs. 37.5% and 12% in the untreated group M1 Pearson chi2(1) = 4.0908 P-value = 0.04 M2 Pearson chi2(1) = 4.2195 P-value 0.066
Conclusions
Compromise of lenticulostriate vessels with subsequent infarction of subcortical structures is present in a significant percentage of patients even when the clot location is distal to the origin of these vessels. Some of this may be secondary to normal variant anatomy, but clot migration prior to initial imaging may be significant contributor to this phenomenon. This is supported by significantly greater involvement in the M2 occlusions and a trend toward greater involvement in distal M1 occlusions in patients receiving TPA.

Sub-analysis from the SELECT Trial: Performance of NCCT and CBV ASPECT Scores by Individual Region in Prediction of Final Infarct Regions by MRI in Patients with Successful Reprofusion

C Sitton¹, D Pujara², R Riascos³, A Sarraj⁴
¹UT/UTHSC Houston / UT Health, Houston, TX, TX, ²McGovern Medical School, Houston, TX, ³Univ. Of Texas - Houston, Houston, TX, ⁴UT Houston, Houston, TX

Purpose
The superiority of CBV ASPECTS over non-contrast CT has been established. We examine if some NCCT and CBV ASPECT areas are more consistently accurate at predicting the location of final infarct than others, and explore causes of discrepancy.

Materials and Methods
SELECT was a prospective cohort study of LVO presenting up to 24 hrs. Imaging evaluation included pre-procedure CT ASPECTS, CTA clot location, CTP(CBV ASPECTS, RAPID), pre/post mTICI, and infarct volume and ASPECTS on 72 hour CT or MRI. For ASPECT scores, each individual region was scored and recorded separately. Spearman rho coefficients comparing concordant positivity of CT, CTV, and MR aspect scores with each other were calculated for patients achieving TICI3 recanalization. Global aspect scores and scores for individual regions were compared.

Results
Among non-contrast CT regions, M1 had the highest correlation with final MRI infarct location with a coefficient of 0.3658 and p of < 0.0001. The lentiform nucleus and M4 region were also reasonably correlated. M6 had the worst correlation. Most of the error was due regions that eventually infarcted not being recognized or apparent on pre-procedure CT study. One exception was the insular ribbon, which was over and under called nearly equally. The CT perfusion regions performed universally better, due to more true positive predictions. Coefficients were between 0.31 and 0.50 with P values < 0.0001 for all regions except M3. Most errors were related to under calling abnormalities, except for the insular ribbon and M1, where there was some overcall. Aggregate ASPECT scores outperformed most individual regions in both groups. NCCT aspects predicted final aspects with Spearman's rho of 0.3617, P < 0.0001; CTV aspects 0.48, p <0.0001.

Conclusions
There is poor correlation between individual NCCT ASPECTs regions and the location of final infarcts, even in patients with successful reperfusion. This appears to be primarily due to the relative lack of sensitivity of NCCT in detecting areas already infarcted or likely to infarct prior to reperfusion. Some areas, however, were more consistently under called than others. This could be physiologic, due to reader bias, or a bias of the ASPECTs methodology itself. CBV ASPECTs performed better at identifying areas of core prior to reperfusion, but still underestimated the development of ischemic changes in many of the ASPECTs locations.
Use of virtual noncontrast dual energy CT for improved delineation of infarct immediately following mechanical thrombectomy

S Moghimi1, D Byrne2, B Niu3, A Rohr4, F SETTECASE5
1University of British Columbia, Vancouver, British Columbia, 2Vancouver General Hospital, Vancouver, BC, 3University of British Columbia, Vancouver, BC (British Columbia), 4Vancouver General Hospital, Vancouver, British Columbia, 5UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC

Purpose
Early delineation of infarct after mechanical thrombectomy (MT) may help prognostication and potentially improve management decisions. Iodine staining post-MT often limits evaluation of extent of infarction [1]. Dual energy CT (DECT) can be used to reconstruct virtual non-contrast (VNC) images [2] and may help improve the conspicuity of infarcted areas [3, 4]. We compared areas of infarct detected on immediate post-MT DECT and VNC with follow-up conventional CT.

Materials and Methods
Institutional review board approval was obtained. Patients who underwent MT for treatment of anterior circulation stroke between January and September 2019 were consecutively reviewed. 28 patients (age 68 ± 17 years, 16 female) with a modified treatment in cerebral ischemia (mTICI) score of 3, without hemorrhagic transformation, were included. VNC reconstructions were generated using vendor software (Syngo.via, Siemens, Erlangen, Germany). Alberta stroke program early CT score (ASPECTS) scores were obtained on non-contrast DECT studies immediately after MT and were compared to follow up CT studies conducted within 24 to 48 hours post-thrombectomy. ASPECTS on post MT VNC DECT were compared to final ASPECTS on follow up (24-48 hour) non-contrast CT studies. A Wilcoxon rank sum test was applied to compare the ASPECTS scores across DECT, VNC, and follow-up CT studies.

Results
The ASPECTS assigned to the DECT (median = 9) were significantly different from the 24-48 hour follow up CT (median = 7.5) (p=0.002). The difference between 24-48 hour follow up CT ASPECTS and VNC reconstructions (median = 6.5) did not reach statistical significance (p=0.770). Caudate lobe infarcts were detected with a higher sensitivity using VNC (78%) compared to non-contrast DECT (17%). Similarly, VNC reconstructions were more sensitive in detecting infarcts within the lentiform nucleus (78%) compared to non-contrast DECT (28%).

Conclusions
VNC images, generated using DECT immediately post MT, may provide a means for early delineation of infarct extent and thus aid in prognostication and post-procedural care. Further study on larger sample sizes is warranted.
Cost-Effectiveness of Endovascular Thrombectomy for extended time-window (6 – 24 Hours) Stroke

A Malhotra1, X Wu2, M Khunte3, C Zhu4, C Matouk2, D Gandhi5, P Sanelli6
1Yale University School of Medicine, New Canaan, CT, 2Yale University School of Medicine, New Haven, CT, 3Yale University, Higganum, CT, 4University of Washington, Seattle, WA, 5University of Maryland School of Medicine, Baltimore, MD, 6Northwell Health NSUH, Manhasset, NY

Purpose
The benefit of thrombectomy for LVO patients presenting from 6 – 24 hours with a mismatch between clinical deficit and infarct shown on imaging has been established by multiple trials. The purpose of this study is to assess the cost-effectiveness of thrombectomy for extended time window LVO patients.

Materials and Methods
A Markov decision-analytic model was constructed accounting from a societal perspective. Two treating strategies were considered for patients with acute ischemic stroke 6 – 24 hours from last seen well: thrombectomy and conservative treatment. Both short- (90 days) and long-term (lifetime) models were constructed. One-way, two-way and probabilistic sensitivity analyses and multiple subgroup analyses were performed.

Results
Base-case calculation showed thrombectomy to have a higher cost and higher utility in the 90-day model, but the incremental cost-effectiveness ratio is higher than the willingness-to-pay threshold of $100,000/QALY. Long-term model showed thrombectomy to be the dominant strategy, with lower cost ($349,306 compared to $413,646 in controls)) and higher heath benefit (7.11 QALY compared to 4.27 in controls). Subgroup analyses, based on patient age, time last seen well, presenting National Institute of Health Stroke Scale (NIHSS), and type of stroke (wake-up Vs unwitnessed) showed thrombectomy to remain the dominant strategy. One-way sensitivity analysis shows that thrombectomy is the optimal strategy when the proportion of good outcome after thrombectomy is above 15.7%. When varying the good outcome in the control group, conservative management replaces thrombectomy to be the cost-effective strategy when the proportion of good outcome is above 46.9%. Two-way sensitivity analysis varying the proportions of good outcomes after both strategies shows that thrombectomy is the cost-effective strategy as long as the good outcome associated with it is at least 2% greater than in the control group. Two-way sensitivity varying the mortality risks associated with both treatment strategies from 0 to 30% showed that the superiority of thrombectomy is robust throughout both ranges.

Conclusions
Treating LVO patients who present between 6 and 24 hours with endovascular thrombectomy results in significant cost-savings and health benefits. The conclusion is robust across age groups, presenting NIHSS, and types of strokes.
Cost-Effectiveness of Perfusion Imaging in Selecting Extended Time Window Stroke Patients for Endovascular Thrombectomy

A Malhotra1, M Khunte2, X Wu3, Y Wang4, D Gandhi5, P Sanelli6
1Yale University School of Medicine, New Canaan, CT, 2Yale University, Higganum, CT, 3Yale University School of Medicine, New Haven, CT, 4Sichuan Provincial People's Hospital, Chengdu, Sichuan, 5University of Maryland School of Medicine, Baltimore, MD, 6Northwell Health NSUH, Manhasset, NY

Purpose
Perfusion imaging is recommended for patient selection for endovascular thrombectomy in the extended time window (beyond 6 hours), although Medicare currently does not reimburse for perfusion imaging. The purpose of this study is to assess the cost-effectiveness of perfusion imaging in selecting candidates for thrombectomy for extended time window stroke patients.

Materials and Methods
A Markov decision-analytic model was constructed accounting from a societal perspective. Two selection criteria for thrombectomy were considered for patients with extended time window ischemic stroke: 1) ischemic core and penumbra mismatch based on perfusion imaging and 2) clinical deficit and core infarct volume. Both short- (90 days) and long-term (lifetime) models were constructed. One-way, two-way and probabilistic sensitivity analyses and multiple subgroup analyses were performed.

Results
Base-case calculation showed perfusion imaging to have a higher cost and higher utility in the 90-day model, assuming a cost of $65 for perfusion study. Long-term model showed perfusion to be the dominant strategy, with lower cost ($374,240) and higher health benefit (5.12 QALY). One-way sensitivity analysis varying the difference in proportions of patients undergoing thrombectomy under both criteria from 0% to 20% showed using perfusion imaging is the more cost-effective strategy throughout the range. One-way sensitivity analysis varying the cost of perfusion in the short-term model showed when it cost less than $42, perfusion would be cost-effective. In the long-term model, as more patients undergo thrombectomy and achieve better outcomes, perfusion is cost-effective even if its cost exceeds $10,000. Two-way sensitivity analysis varying the proportions of good outcomes after thrombectomy in both strategies showed that perfusion remained cost-effective until the proportion of good outcome after thrombectomy in patients selected based on deficit-core mismatch is at least 12% higher than that of patients selected based on penumbra-core mismatch in absolute values.

Conclusions
Better patient selection for thrombectomy results in perfusion imaging being cost-effective, given the significantly better outcomes in thrombectomy compared to control patients. Given the increasing numbers of extended window stroke patients and centers capable of performing thrombectomy, reimbursement for perfusion imaging should be revisited.
Distinguishing Extravascular From Intravascular Ferumoxytol Pools Within the Brain: Proof of Concept in Patients with Treated Glioblastoma

R Barajas¹, D Schwartz¹, H McConnell¹, B Hamilton¹, L Starkey¹, D Pettersson¹, J Nickerson¹, J Pollock¹, L Szidonya¹, C Varallyay¹, J Jaboin¹, A Raslan¹, A Dogan¹, J Cetas¹, J Ciporen¹, S Han¹, P Ambady¹, L Muldoon¹, R Woljter¹, W Rooney¹, E Neuwelt¹
¹Oregon Health & Science University, Portland, OR

Purpose
Glioblastoma-associated macrophages are a major constituent of the immune response to therapy and are known to engulf iron-based MRI contrast agent, ferumoxytol. Current ferumoxytol-MRI techniques for localizing macrophages are confounded by contaminating intravascular signal. The aim of this study was to assess the utility of a newly developed MRI technique, Segregation and Extravascular Localization of Ferumoxytol Imaging (SELF1), for differentiating extravascular from intravascular ferumoxytol contrast signal at a delayed 24-hr imaging timepoint.

Materials and Methods
Twenty-three patients with suspected glioblastoma progression following chemoradiotherapy underwent ferumoxytol-enhanced SWI MRI. SELF1 maps were generated as the voxelwise difference between the delayed (24 h) and the early (immediately after ferumoxytol administration) SWI maps. Continuous SELF1 map values were separated into positive and negative components. Pearson's r correlation coefficients were calculated for early and delayed imaging values. Overall survival was classified from the date of diagnosis until death or last follow-up. A multivariate Cox regression analysis, covarying for age and KPS, was used to assess mean delayed time points and SELF1 positive scores. P-values less than .05 were considered statistically significant.

Results
Negative SELF1 values correlated with early (r= -0.79, p< 0.01) and delayed (r= -0.48, p< .02) time point SWI values, demonstrating that intravascular signal detected in the early time point persists into the delayed time point (Figure 1). Positive SELF1 values correlated with the delayed (r= 0.87, p< 0.01), but not the early (r= 0.17, p= 0.44) time point SWI values, suggesting successful detection of newly developed extravascular signal. Cox regression analysis approached but did not reach significance for the tumor-wide positive SELF1 metric (B=2.98, Wald=2.57, p=1). Higher KPS and age were associated with longer and shorter survival (p=.02 and .05, respectively) in the positive SELF1 metric multivariate model (p=.02 and .05, respectively), but not the delayed time point model (p=.06 and .06), further demonstrating the clinical value of isolating inflammation-specific signal with the positive SELF1 metric.
Conclusions
SELFI MRI improves upon current techniques by eliminating intrinsic tissue and intravascular ferumoxytol signal and may inform glioblastoma outcomes by serving as a more specific metric of macrophage content compared to the currently used uncorrected T1 or SWI techniques.

Plaques and Tangles: PET-MRI Study of World Trade Center Cognitively Impaired Responders

A Franceschi\textsuperscript{1}, M Clifton\textsuperscript{2}, M Kritikos\textsuperscript{3}, K Naser-Tavakolian\textsuperscript{4}, O Ahmed\textsuperscript{5}, M Salerno\textsuperscript{4}, D Franceschi\textsuperscript{5}, L Bangiyev\textsuperscript{6}, G Cruciata\textsuperscript{2}, P Vaska\textsuperscript{7}, S Clouston\textsuperscript{8}

\textsuperscript{1}Northwell, New York, NY, \textsuperscript{2}Stony Brook University Hospital, Brooklyn, NY, \textsuperscript{3}Stonybrook University hospital, Stony Brook, NY, \textsuperscript{4}STONY BROOK UNIVERSITY HOSPITAL, Stony Brook, NY, \textsuperscript{5}Stony Brook University Hospital, Stony Brook, NY, \textsuperscript{6}Stony Brook University Hospital, Stony Brook, NY, \textsuperscript{7}Renaissance School of Medicine at Stony Brook University, Stony Brook, NY, \textsuperscript{8}Stonybrook, Stonybrook Univ, NY

Purpose
Recent studies have noted a high risk of cognitive impairment (CI) among responders to the 9/11/2001 attacks at the World Trade Center (WTC). This study examined preliminary results collected from a pilot study of WTC responders with CI (WTC-CI) whose
burden of β-amyloid (Aβ), tau deposition in cortical regions of interest (ROI's), and neurodegeneration was assessed utilizing an integrated 3T PET/MRI scanner.

Materials and Methods

Twelve WTC-CI responders with a Montreal Cognitive Assessment (MoCA) score <23, were recruited and split into two groups. Responders received intravenous injection of either <5 mCi of [18F]-Florbetaben neurotracer to measure Aβ deposition, or <5 mCi [18F]-Flortaucipir neurotracer to measure tau deposition. Imaging was conducted on a Siemens® Biograph mMR integrated 3T PET/MRI. Neurodegeneration was assessed utilizing semi-quantitative automatic brain parcellation routine in Neuroquant™, and age/sex-corrected volumetric percentiles were reported. Quantitative analysis employed standardized uptake value ratios (SUVR) to measure global cortical deposition of either neurotracer in bilateral regions of interest. Aβ (A+) and tau (T+) positivity were determined qualitatively by the neuroradiologist and quantitatively using standard SUVR cutoffs.

Results

Twelve WTC-CI responders were aged 54.92 ± 5.38 years old; 5 were female. Qualitative and quantitative PET imaging analysis identified four amyloid and three tau-positive readings. MRI bi-hemispheric analysis identified frontal, occipital and temporal lobes and inferior temporal gyri and the entorhinal cortex below the 10th percentile of age/sex matched norms in these subjects. Interestingly, the hippocampus showed the least degeneration across cortical regions; the entorhinal cortex showed the most. Multiple t-tests of [18F]-Florbetaben versus [18F]-Flortaucipir SUVR retention in several cortical ROI's revealed non-significant differences between Aβ and tau deposition. However, in the occipital lobe, more tau was evident when compared to Aβ deposition.

Conclusions

These analyses identified reductions in whole brain volumes in all twelve responders with WTC-CI, with neurodegeneration evident particularly in the entorhinal cortices, with corresponding Aβ and tau deposition across these ROIs. Taken together, our preliminary results suggest that the etiology of WTC-CI is a neurodegenerative process, which may manifest as a hippocampal-sparing type of cognitively-imparing disease.

1323

5:19PM - 5:25PM

Albumin-Stabilized Manganese-Based Nanocomposites with Sensitive Tumor Microenvironment Responsivity and Their Application for Efficient SiRNA Delivery

k xu

1Daping Hospital, Chongqing, Chonging

Purpose

With the high reactivity and specificity toward endogenous hydrogen peroxide in the acidic tumor microenvironment (TME), manganese-based nanoparticles (NPs) have been widely explored as potent TME-responsive theranostic agents, possessing the functionality of TME modulation and tumor-specific T1-weighted magnetic resonance imaging (MRI). However, as is well-known, the optimized reduction condition of conventional Mn (IV)-based NPs is at pH ≤ 6.5, mismatching the pH range of TME (pH 6.5-7.0). The dissatisfactory imaging performance in the weakly acidic environment may limit their further applications in tumor diagnosis. Hence, developing nano-agents that can sensitively respond to TME in the weakly acidic environment is of high benefit for advanced biomedical applications.

Materials and Methods

Synthesis of RGD-BMnNPs was carried out by two-steps. Sulfo-SMCC first used to link the RGD and BSA through the typical synthesis. The Sulfo-SMCC (6.58 mg) and RGD (9.35 mg) were to proceed under constant agitation in 5 mL of PBS at pH 7.4 for 1 h, then the obtained reagents were added to BSA in 15 mL of PBS (pH=7.4) for a final BSA concentration of 10 mg/mL. It proceeded under constant agitation for 2 h under the nitrogen atmosphere. The mixture was dialyzed in PBS buffer at room temperature for 12 h, and then the product RGD-BSA kept at 37 °C. Secondly, RGD-BMnNPs were obtained through a biomineralization approach in aqueous solution at 37 °C with BSA serving as the reaction stabilizer. MnCl2 aqueous solution (1 mL, 100 mM) was rapidly added into RGD-BSA solution (20 mL, 10 mg/mL) at 37 °C under vigorous stirring. Five minutes later, the pH value was adjusted by NaOH (500 μL, 1 M). After reaction for 5 h at 37 °C, the products were dialyzed in PBS buffer at room temperature for 12 h to remove excess reactants.

Results

With Arg-Gly-Asp (RGD) peptide decorated bovine serum albumin employing as the stabilizer and scaffold, Mn (III) and Mn (IV) incorporated nanocomposites (RGD-BMnNPs) with suitable size, good stability, and excellent biocompatibility were successfully fabricated. The as-prepared NPs showed obvious contrast enhancement at pH 6.5-6.9 in vitro, and sensitive and rapid (30 min) T1-weighted imaging performance within the tumor region in vivo, which resulted from the intrinsic disproportionation reaction of Mn (III) at the weakly acidic environment. More interestingly, owing to the sheet-like morphology, good stability, and excellent biocompatibility of RGD-BMnNPs, the obtained nano-system RGD-BMnNPs/VEGFA-siRNA-Cy5 showed superior advantages in efficient siRNA delivery, including increased tumor uptake, improved tumor accumulation, prolonged circulation time, MR/fluorescence dual-modal imaging, and enhanced anti-angiogenesis therapy with the modulation of TME.

Conclusions

To be concluded, a novel nanoscale multifunctional material (RGD-BMnNPs) was successfully developed for sensitive TME-responsive performance and the modulation of TME. With the advantages of dual-valence states of manganese in the nanostructures,
RGD-BMnNPs set off the limitation of previous single Mn (IV)-based NPs in the weakly acidic environment. In the meanwhile, owing to the sheet-like morphology, good stability, and excellent biocompatibility of RGD-BMnNPs, the obtained nano-system RGD-BMnNPs/VEGFA-siRNA-Cy5 showed superior advantages in efficient siRNA delivery, including increased tumor uptake, improved tumor accumulation, prolonged circulation time, MR/fluorescence dual-modal imaging, and enhanced anti-angiogenesis therapy. And the combination of TME modulation by RGD-BMnNPs and effective anti-angiogenesis by VEGFA-siRNA may open the new way for overcoming TME associated clinical treatment resistance.

(Filename: TCT_1323_figure5a.jpg)

2716

5:26PM - 5:32PM

Correlation of Wall Shear Stress and Vessel Wall Enhancement for Intracranial Aneurysm Rupture Risk Stratification

M Pan¹, S Schnell², M Aristova³, D Robinson Cantrell³, R Abdalla¹, A Vali¹, M Potts², M Hurley¹, B Jahromi², A Shaibani³, S Ansari¹
¹Northwestern University Feinberg School of Medicine, Chicago, IL, ²Northwestern University - Feinberg School of medicine, Chicago, IL, ³N/A, N/A, ⁴Northwestern University, Chicago, IL, ⁵Northwestern University Feinberg School of Medicine, Chicago, IL

Purpose

Intracranial aneurysm rupture risk stratification is an active area of research, particularly in non-invasive imaging. 4D flow MRI measures intra-aneurysmal hemodynamics using a 3D time-resolved, ECG-synchronized phase-contrast MRI acquisition with 3-directional velocity encoding. Wall shear stress (WSS), the drag force of blood on vessel walls, is a hemodynamic parameter calculated from 4D flow MRI-derived velocity gradients. High-resolution vessel wall imaging (HR VWI) allows assessment of vessel wall inflammation using a T1-weighted spin echo MRI sequence before and after gadolinium contrast administration. Previous studies have suggested low WSS and high vessel wall enhancement are associated with increased risk of aneurysm rupture. In this study, we examined the correlation between WSS and vessel wall enhancement.

Materials and Methods

We studied 4D flow MRI and HR VWI data in 23 consecutive patients with a total of 27 intracranial aneurysms at least 4 mm in diameter. All aneurysms were segmented, and WSS was calculated from 4D flow MRI using a previously reported method (1) using in-house software written in Matlab (Mathworks, Massachusetts, USA). We calculated the wall enhancement index (WEI), a quantitative parameter describing vessel wall enhancement previously reported in (2). 4D flow MRI and HR VWI data were coregistered using 3D Slicer (3DSlicer, Massachusetts, USA) and cross sectional correlation between peak systolic WSS and WEI was analyzed. P-values were calculated using the Wilcoxon rank-sum test with a significance level of 0.05.

Results

Twenty of the 23 patients in this study harbored a single aneurysm, two patients had two aneurysms, and one patient had three aneurysms. Four of the 27 aneurysms were fusiform, and the remaining 23 were saccular. Overall, the mean WSS was 0.96 +/- 0.61 Pa and the mean WEI was 2.21 +/- 0.56. Mean WSS and mean WEI between anterior and posterior circulation aneurysms, and mean WSS between fusiform and saccular aneurysms showed a statistically significant difference (see table). Cross sectional correlation showed a weak negative linear association between peak systolic WSS and WEI.

Conclusions

We noted a statistically significant difference between mean WSS and WEI for anterior versus posterior circulation aneurysms as well as a significant difference in mean WSS between fusiform and saccular aneurysms. Peak systolic WSS correlated negatively with WEI suggesting low WSS may be associated with increased aneurysm wall inflammation.
Differentiation between Pilocytic Astrocytomas and Diffuse Astrocytomas using DWI, ASL, and CEST: A Histogram Analysis

K Kikuchi¹, O Togao², D Momosaka¹, Y Kikuchi¹, A Hiwatashi²
¹Kyushu University, Fukuoka, Japan, ²Kyushu University, Fukuoka, Fukuoka

**Purpose**
Pilocytic astrocytomas (PA) and diffuse astrocytomas (DA) are classified by WHO 2016 as the grades I and II, respectively, and they are considered as low-grade gliomas. The purpose of this study was to differentiate PAs from DAs using non-contrast MRI sequences by a histogram analysis.

**Materials and Methods**
Between January 2014 and October 2019, 21 patients (10 males, 11 females; 0–74 years; median 23 years) including 9 PAs and 12 DAs were retrospectively evaluated. MRI was performed with a 3.0-T unit. Apparent diffusion coefficient (ADC) was calculated by b-values with 0 and 1000 s/mm². Amide proton transfer (APT) was acquired with presaturation of 2 µT and 2 s. Cerebral blood flow (CBF) was calculated with labeling duration of 1650 ms and post-labeling delay of 1525 or 2000 ms using pseudo-continuous arterial spin labeling. ADC, APT, and CBF were measured with T2-prolonged lesion and analyzed using a histogram. These values were compared by Mann-Whitney U-test between the gliomas. Receiver operating characteristic (ROC) analysis was used to evaluate diagnostic performance.

**Results**
APT was significantly higher in PAs than that in DAs with the all percentiles (10th, 20th, 25th, 50th, 75th, 80th, and 90th; P < 0.05 for all). CBF was significantly lower in PAs than that in DAs with 75th, 80th, and 90th (P = 0.0278, respectively). There was no statistically significant difference in ADC (P > 0.05). ROC analysis found the 75th, 80th, and 90th percentiles of APT had the best diagnostic performance for differentiating between PA and DA (sensitivity 88.9%, specificity 100%, accuracy 95.2%, positive predictive value 100%, negative predictive value 92.3%, AUC 0.963, for all).

**Conclusions**
APT is the useful method to differentiate PA from DA without contrast media. Our result suggests that high value of APT is the pathognomonic finding of PA.

<table>
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<th>WEI (unitless)</th>
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<td></td>
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<tr>
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Utility of MRI Texture Analysis Assessment to Predict Meningioma Grade

O Ahmed1, K Naser-Tavakolian2, M Clifton3, E van Staalduinen1, O Hussaini1, A Khan1, H Li1, A Franceschi4, T Duong1, L Bangiyev5
1Stony Brook University Hospital, Stony Brook, NY, 2STONY BROOK UNIVERSITY HOSPITAL, Stony Brook, NY, 3Stony Brook University Hospital, Brooklyn, NY, 4Northwell, New York, NY

Purpose
The distinction between benign (WHO 1), atypical (WHO 2), or malignant (WHO 3) meningiomas is difficult using gross characteristics on imaging and is dependent mainly on pathology results. MRI texture analysis (MRTA) is a technique that utilizes image analysis, detection of surface intensity, and patterns that are indiscernible to the human eye. The purpose of this study is to assess whether MRTA can differentiate between histologic subtypes based on the WHO classification of meningiomas.

Materials and Methods
A retrospective review of 20 patients (mean age 61.6) with pathologically proven WHO grade 1, 2, or 3 meningiomas was performed. The pre-operative MRI ADC maps, FLAIR, and T1 post-contrast sequences were analyzed using LifeX software, which is designed to characterize image heterogeneity based on histogram, textural, and shape indices. Regions of interest (ROI) were drawn over the tumor by a radiologist blinded to the histological results. Thirty-two texture indices were generated and comparisons were made using analysis of variance (ANOVA) between the different WHO groups with a significance level of 0.05. Examples of texture indices that were generated include the grey-level run length matrix (GLRLM) which evaluated the size of homogeneous runs for each grey level, grey-level zone length matrix (GLZLM) which provided information on the size of homogeneous zones and neighborhood grey-level difference matrix (NGLDM) which assesses the difference of grey-levels between one voxel and its 26 neighbors in 3 dimensions.

Results
10 of 20 patients had a WHO grade 1 lesion, 9 were WHO grade 2, and 1 was WHO grade 3. T1-post contrast sequences demonstrated a significant difference between WHO grades using the following texture indices: GLRLM_GLNU (p = .005), GLRLM_RLNU (p = .001), GLZLM_LZE (p = 8.7 E-6), GLZLM_LZHGE (p = 4.7 E-08), and GLZLM_ZLNU (p = .04). ADC maps demonstrated a significant texture differences for the following texture indices: GLRLM_LRLGE (p = .01), GLRLM_LRHE (p = 1.5E-7), GLRLM_GLNU (p = 5.9 E-5), GLRLM_RLNU (p = 3.1 E-8), NGLDM_Busyness (p = 4.4 E-5), and GLZLM_SZE (p = 1.5 E-6). FLAIR demonstrated a significant difference between the three grades on texture index in GLZLM_ZLNU (p < 0.05).

Conclusions
MRTA of meningiomas using T1 post-contrast and FLAIR sequences as well as ADC maps demonstrated statistically significant differences between WHO grade 1, 2, and 3 lesions and therefore provide a noninvasive method to predict meningioma grade preoperatively.

2216

Robust Bayesian Covariance Estimation Beamformers for Magnetoencephalographic Brain Imaging

M Diwakar1, C Cai1, S Nagarajan1
1University of California, San Francisco, San Francisco, CA

Purpose
Robust estimation of correlated electromagnetic brain sources has been a challenge in magnetoencephalography (MEG). Adaptive beamformers, which are fast and efficient, use spatial filters that pass source signals at specific locations while suppressing noise. However, their performance deteriorates when sources are correlated. Several algorithms have been proposed to improve robustness to correlation and have been met with limited success due to the need for a prior information, limitation to scalar sources, or excessive computational time. Sparse Bayesian methods, which are excellent in learning sparse models from over-complete feature sets, can be employed to address this issue. We demonstrate that a novel Bayesian covariance estimation (BCE) beamformer, which explicitly estimates a probabilistic graphical model-based covariance for MEG data using Bayesian inference, can accurately reconstruct highly correlated and noisy brain activity in real subjects, in contrast to other benchmark algorithms including traditional adaptive beamformers.

Materials and Methods
BCE beamformers estimate the model covariance at low resolution (improving efficiency) using sparse Bayesian inference in the Champagne algorithm framework and subsequently perform adaptive beamforming at high resolution for source reconstruction. The BCE beamformer was tested against several benchmarks, including Champagne, MxNE, sLORETA, and the traditional minimum variance beamformer, using auditory evoked field data from 4 human subjects. MEG data were acquired at UCSF with a CTF Omega 2000 MEG system. Details of these datasets can be found in our prior publications (1). Implementation was via the NUTMEG library in MATLAB.

Results
Performance of BCE beamformers are similar to Champagne, with accurate localization of the primary auditory cortex bilaterally in all subjects. MxNE often biases activities to the wrong locations. sLORETA and the minimum variance beamformer create spurious activity in the presence of correlated sources.
Conclusions
BCE beamformers elegantly address the intrinsic limitations of traditional beamforming by estimating the model covariance with Bayesian inference prior to reconstruction. Analysis of real auditory MEG datasets in four human subjects demonstrates the BCE beamformer's ability to reconstruct correlated brain activity in a noisy environment. As correlation is the hallmark of communication, BCE beamformers are hoped to improve our understanding of dynamic brain networks through MEG.

Combination of MR dynamic susceptibility contrast perfusion weighted imaging and fluorine-18-deoxyglucose positron emission tomography in the evaluation of treatment response of patients with malignant brain tumors after chemoradiation treatment

X LIU¹, W Tian², A Hussain², H Wang³
¹UNIV OF ROCHESTER MEDICAL CENTER, PITTSFORD, NY, ²university of rochester medical center, Rochester, NY, ³UNIVERSITY OF ROCHESTER, PITTSFORD, NY

Purpose
MR dynamic susceptibility contrast perfusion weighted imaging (DSC-PWI), and fluorine-18-deoxyglucose (FDG) positron emission tomography (PET) can detect the tumor hemodynamic abnormality and tumor metabolite in malignant brain tumors. The purpose of this study is to evaluate the treatment response using MR DSC-PWI and PET in patients with malignant brain tumors after chemoradiation treatment.

Materials and Methods
58 patients with malignant brain tumors, including high grade gliomas, brain metastases and cerebral lymphomas, after chemoradiation treatment were enrolled in this study. 66 lesions with paired MR DSC-PWI and FDG-PET examinations, with interval ranging within 2 weeks, were evaluated. The rCBV maps without and with contrast leakage correction were generated using FDA-approved NordicICE programs. Two neuroradiologists measured the maximal rCBV ratio and the tumor versus normal tissue count ratio (TNR) in the "hot" ROIs. The paired t-test and Spearman Rank correlation analysis were used for the association between the rCBV of DSC-PWI and TNR derived from FDG-PET.

Results
The mean maximal rCBV ratio of rCBV with contrast leakage correction (1.71±1.33) were higher than rCBV without contrast leakage correction (1.12 ± 0.65, p<0.05). FDG-PET-TNR has better correlation with rCBV with contrast leakage correction than rCBV without contrast leakage correction, p<0.001.
Conclusions
The FDG-PET-TNR shows better correlation with maximal ratio of rCBV with contrast leakage correction. The rCBV without contrast leakage correction alone is limited in the evaluation of treatment response. Combination of FDG-PET and MR-DSC-PWI parameters could provide comprehensive information of tumor hemodynamic and metabolic abnormality in the patients with malignant brain tumors after chemoradiation treatment.

2283


M Cooper¹, B Risk², J Allen³
¹Emory University School of Medicine, Atlanta, GA, ²Emory University Rollins School of Public Health, Atlanta, GA, ³Emory University, Atlanta, GA

Purpose
To identify and weight potential clinical and imaging risk factors for blunt cerebrovascular injury (BCVI) using elastic net statistical learning with sparsity in patients with blunt trauma undergoing screening CTA.

Materials and Methods
Consecutive patients > 15 years old with blunt trauma that underwent screening neck CTA at a Level 1 Trauma Center over a 2-year period were reviewed. Demographic and clinical data were recorded for each subject (Table 1). CTAs were independently reviewed by 2 neuroradiologists with a 3rd providing adjudication as necessary. Each internal carotid artery (ICA) and vertebral artery (VA) was graded using the Denver Grading Scale. Results from head, face, cervical/thoracic spine, and chest imaging were also recorded (Table 1). Univariate Fisher-exact test with FDR-correction was performed with odds ratios generated for each variable. Elastic net statistical learning with logistic regression was subsequently performed, which in contrast to univariate analyses, utilizes all variables simultaneously so that coefficients are adjusted for other variables. Magnitude of coefficients selected using this method indicate the importance.

Results
467 patients met our inclusion criteria, with 73 patients having BCVI on CTA. Univariate analysis demonstrated maxillofacial fracture, basilar skull fracture, and GCS had significant odds ratios for ICA injury (Table 1). C-spine fracture, spinal ligament injury on MRI, and age had significant odds ratios for VA injury on univariate analysis. Using elastic net statistical learning, the most important variables for ICA injury include maxillofacial fracture, basilar skull fracture, GCS, and carotid canal fracture. For VA injury, these included cervical spine transverse foramen fracture, ligamentous injury, C1-C3 fracture, posterior element fracture, and vertebral body fracture.

Conclusions
Overlapping findings are seen with both univariate and elastic net statistical learning methods for clinical and imaging BCVI risk factors. However, there are several potential risk factors identified with elastic net method, such as carotid canal fracture for ICA injury, that are not seen using the traditional univariate method. Elastic net allows the study of a large number of variables, is useful when covariates are correlated, and reduces spurious results due to confounders. Further study is warranted to determine if the same variables identified by elastic net in this single-center study remain using data from multiple centers.
Dynamic Gallium-68-DOTATATE PET/MRI: Implications for Meningioma Management and Pituitary Pathophysiology

M Roytman¹, M Skafida¹, E Lin¹, S Kim¹, S Pannullo¹, N Karakatsanis¹, J Ivanidze¹
¹New York-Presbyterian Hospital/Weill Cornell Medicine, New York, NY

Purpose
Ga-68-DOTATATE, a PET tracer targeting somatostatin receptor 2 (SSTR2), has clinical utility in the evaluation of meningioma. Dynamic PET/MRI captures kinetic information beyond conventional static acquisition protocols. Patlak analysis of dynamic PET data allows voxel-wise measurement of the parameter Ki, denoting the net influx rate constant. Dynamic data can further be post-processed into static PET images, through which volumetric standardized uptake values (SUV) can be derived. Our purpose was to correlate Ki with SUV in meningioma and normal pituitary tissue.

Materials and Methods
38 volumes of interest were identified in 18 patients, including 18 pituitary glands, 15 meningiomas, and 5 regions of suspected post-treatment change. Dynamic PET/MRI was acquired over 50 minutes and lesion-specific SUV were obtained. Lesions were stratified based on prior work with a threshold for meningioma of >3× superior sagittal sinus (SSS). Patlak analyses were used to generate voxel-wise measurement of Ki. Pearson analyses were performed to assess correlation between Ki and SUV in the pituitary gland, meningioma and regions of post-treatment change. Mann-Whitney tests were performed to compare median SUV and Ki, respectively, in meningioma and post-treatment change. Absolute values were additionally normalized to SSS and pituitary avidity.

Results
18 patients (WHO-I, N=3; WHO-II, N=9; WHO-III, N=2; Presumed, N=4) with a total of 15 meningiomas, 5 regions of suspected post-treatment change and 18 pituitary glands were included. In meningioma and post-treatment change cohorts, DOTATATE SUV demonstrated a strong, significant, positive correlation with Ki (r = 0.84; p < 0.0001). Findings remained robust after correction for SSS (r = 0.89; p < 0.0001) and pituitary avidity (r = 0.82; p < 0.0001). In the pituitary gland, SUV did not demonstrate significant correlation with Ki (r = 0.40; p = 0.10).
Conclusions
We validated previous work demonstrating significant differences in SUV and Ki between meningioma and post-treatment change, supporting a role for DOTATATE PET/MRI in meningioma evaluation. We further found a strong significant positive correlation between Ki and SUV in our meningioma and post-treatment change cohorts, suggesting early and sustained binding of SSTR2 on meningiomas. The lack of correlation between Ki and SUV in normal-appearing pituitary glands suggests a unique kinetic DOTATATE-SSTR2 binding pattern may be important in future studies evaluating benign and malignant pituitary processes.

(Filename: TCT_2648_ASNRFigure.jpg)

Scientific Abstract Session: Pediatric Infection/Inflammation/Metabolic
1659
5:05PM - 5:11PM
Accuracy of magnetic resonance imaging findings of inner ear structures to predict sensorineural hearing loss in infants with bacterial meningitis
G Orman1, M Kukreja1, J Vallejo2, N Desai1, T Huisman1, S Kralik1
1Texas Children's Hospital, Houston, TX, 2Texas Children's Hospital and Baylor College of Medicine, Houston, TX

Purpose
Meningitis most commonly affects young children and can result in significant adverse outcomes including death, neurologic disability, sensorineural hearing loss (SNHL) and seizures. Traditionally, imaging has been performed to assess for lumbar puncture safety and to assess for infection complications. The purpose of this study is to determine the diagnostic accuracy of MRI findings of inner ear structures for prediction of SNHL among infants with bacterial meningitis.

Materials and Methods
A retrospective review was performed among infants (age< 365 days) with bacterial meningitis (n=115). Independent and consensus blinded review of brain MRIs (n=239) performed within 16.3 (0-79) days of presentation were evaluated by two board certified pediatric neuroradiologists who were blinded to SNHL status. Abnormal appearance of the inner ear structures on MRI was defined as FLAIR hyperintensity or enhancement on postcontrast T1-weighted (T1-W) sequence. The consensus MRI of the inner ear structures on FLAIR and postcontrast T1-W was compared to gold standard audiometric testings to determine the sensitivity and specificity of MRI for detecting SNHL.

Results
The mean age at meningitis presentation was 50.6 (0-338) days and 24.3% had SNHL. Postcontrast T1-W demonstrated 61.4% sensitivity, 95.5% specificity, FLAIR hyperintensity demonstrated 50.0% sensitivity, 93.6% specificity and combined postcontrast T1 and FLAIR evaluation demonstrated 61.4% sensitivity and 94.2% specificity for prediction of SNHL. There was excellent interobserver agreement for postcontrast T1-W, FLAIR sequences and combined postcontrast T1 and FLAIR evaluation for presence...
of abnormal enhancement and hyperintense signal respectively (Kappa=0.95, 0.93 and 0.96 respectively). Factors associated with abnormal MRI finding in patients with SNHL included low CSF glucose (p=0.04, 0.02, 0.04) and high CSF protein (p=0.04, 0.03, 0.04).

Conclusions
Abnormal inner ear structure enhancement and/or FLAIR hyperintensity demonstrate high specificity for prediction of SNHL among children with meningitis.

2504

Differentiating Pediatric Multiple Sclerosis from ADEM at Initial Presentation on MR Imaging

D Fetzer1, G Aaen1, U Oyoyo1, A Achiriloaie1
1Loma Linda University Medical Center, Loma Linda, CA

Purpose
Pediatric multiple sclerosis (MS) is difficult to diagnose at presentation, and the clinical features often overlap those of acute disseminated encephalomyelitis (ADEM), neuromyelitis optica or clinically isolated syndrome. Established criteria for diagnosing MS are less reliable in pre-pubescent children. We seek to qualitatively and quantitatively define the MRI features of pediatric MS compared to ADEM at initial presentation.

Materials and Methods
A retrospective analysis of MRI scans obtained at first attack from 23 children diagnosed with MS and 15 children with ADEM was performed. T2/FLAIR hyperintense lesions were quantified and categorized according to location and size: distribution (periventricular, juxtacortical, scattered cerebral, scattered, brainstem) and size (S <1 x 1.5 cm; M < 2 x 2.5 cm and L > 2.5 cm.) The largest lesion was diametrically and volumetrically evaluated (Olea Sphere, Olea Medical, La Ciotat, France.) T1W post-contrast images were evaluated for different enhancement patterns: hetero/homogeneous, complete ring, incomplete ring. The presence/absence of "central vein sign" on GRE/SWI images was evaluated.

Results
The median age of the MS patients was 15 years (F: 16, M: 7) and the median age for ADEM patients was 4.5 years (F8, M:7), with a p value of 0.0. The MS patients had a larger total number of lesions (p = .006), smaller lesion size (p = .002) and more often a periventricular distribution of lesions (p = 0.04) compared to ADEM. The MS lesions showed enhancement more often than ADEM lesions (p = 0.012), however the central veins sign did not show statistical significance, likely related to technical variability, although observed more often in MS patients (30% vs 13%). No statistical significance was demonstrated between the axial diameter measurements or volumetric quantification of the largest lesion in each group. Evaluation of total lesion burden volume are pending.

Conclusions
Our study suggests that a pediatric patient presenting with neurological symptoms and cerebral white matter lesions is more likely to be diagnosed with MS if it is an older child, there are a large number of lesions, majority of the lesions are less than 1cm, are mainly periventricular in location, and many display contrast enhancement. Conversely, a patient is more likely to be diagnosed with ADEM if it is a younger child, there are overall a smaller number of lesions, many of the lesions are larger than 1cm, are not primarily periventricular and don't exhibit contrast enhancement.
16 y/o female with MS (A, B)  4 y/o female with ADEM (C, D)
A retrospective analysis of baseline brain MRI features in infants with confirmed congenital CMV infection - can imaging contribute to the decision of treatment initiation?

C KACHRAMANOGLOU1, L ZOMBORI2, P GAUR3, H LYALL2, W Jan2
1IMPERIAL COLLEGE HEALTHCARE NHS TRUST, LONDON, United Kingdom, 2Imperial college healthcare NHS trust, London, London

Purpose
We aim to describe the pertinent MR features and establish the role of MRI in the immediate postnatal period in cases of cCMV.

Materials and Methods
MRI examinations of 61 infants with congenital CMV infection referred to our pediatric unit at Imperial Healthcare NHS Trust, London were reviewed. Cases of postnatal infection, non-diagnostic/unavailable MRI, study performed later than 4 months of age were excluded. Imaging findings were categorized as: Normal – 0, Structural abnormality alone – 1, White matter signal abnormality alone – 2, White matter abnormality plus any other structural lesion – 3. White matter abnormalities were scrutinized taking into consideration the corrected gestational age. Additional findings were recorded. Baseline clinical evaluation was documented, including new-born hearing test. Infants were categorized to asymptomatic and symptomatic as per European Consensus. All statistics were performed on IBM SPSS STATISTICS Version 23. Statistical significance was taken at 5% level.

Results
There were 32 (52%) males and 29 (48%) females. The mean gestational age was 37.5 weeks. The mean age at the day of scanning was 25 days. 32 (52.5%) were asymptomatic, 13 of which had sensorineural hearing loss (40 %) and 29 (47.5%) were symptomatic. MRI was normal in 20 out of the total 61 patients (33%) and abnormal in 41 (67%). Of the 32 asymptomatic patients, 17 (53%) had abnormal MR features, whereas 15 (47%) had normal MRI. Of the 29 symptomatic babies, 24 (83%) had abnormal and 5 patients (17%) had normal intracranial appearances. When the MR scores were broken down to individual categories, 20 (33%), 5 (85), 10 (16%), 26 (43%) patients scored 0, 1, 2, and 3 respectively. White matter signal abnormality was the commonest finding, seen in 34 (83% of abnormal studies and 56% of total number of studies), followed by cyst formation in 28/41 (68% of abnormal studies and 46% of total number of studies). Polymicrogyria was identified in 13 cases (32% of 41 abnormal, 21% of total 61 patients). Parenchymal calcifications and cerebellar abnormalities were demonstrated in 16% and 15% respectively.

Conclusions
Baseline brain MRI provides additional information which may guide treatment in cCMV cases. White matter signal abnormality is a pertinent MR feature that warrants serious consideration in the decision for initiation of treatment.
Intrauterine transmission of HSV with devastating CNS sequelae - a rare but potentially mitigable entity

S ffrench-Constant, H LYALL, S Ramji, W Jan
1Imperial College NHS Trust, London, United Kingdom, 2Imperial college healthcare NHS trust, London, London, 3Charing Cross Hospital, Imperial College NHS trust, London, United Kingdom

Purpose
The vast majority of neonatal Herpes Simplex Virus (HSV) infection cases are transmitted in the intrapartum period, with a small number of cases acquired postnatally [1]. Intrauterine transmission of HSV is very rare, equating to around 1 in 100,000 deliveries [2], but its consequences are devastating. The 'classical' manifestation is a triad of cutaneous lesions, central nervous system (CNS) and ophthalmic involvement, although over half of patients do not present as such [3,4]. We present 2 cases of intrauterine HSV transmission causing severe, global neurological disability and highlight how a high degree of suspicion and early diagnosis with fetal MR imaging could facilitate timely treatment and possible reduction in morbidity.

Materials and Methods
In our first case, mother had two episodes of symptomatic HSV recurrence during pregnancy. Unfortunately baby was born without any prophylaxis on board. He had extensive skin abnormality and an MRI at 11 weeks demonstrated perisylvian polymicrogyria and gross gliosis of the basal ganglia and mesial temporal lobes, with a generalised loss of supratentorial white matter bulk. In our second case, mother developed symptomatic HSV in her first trimester and was given a short course of acyclovir. Baby was born at 37 weeks and developed respiratory distress and seizures, but had no skin lesions. Cranial US and subsequent MRI showed extensive parenchymal hemorrhage and cystic lesions and a follow up MR at 3 months showed diffuse end stage leukomalacia.

Results
Case 1: (a) Medical photograph depicting extensive skin lesions. (b) T2W MRI at 2 months demonstrates global cortical developmental malformation, with polymicrogyria predominantly affecting the perisylvian regions. Case 2: (c) CT demonstrates Axial T2W scans showing white matter abnormalities.

a) Normal white matter signal in 40/40 neonate aged 4 days (Score 0).
b) Global white matter abnormal signal in asymptomatic 40/40 neonate aged 6 days (Score 1).
c) Right temporal polymicrogyria with patchy white matter changes in the right temporal and occipital region in a 40/40 scanned aged 45 days (Score 3).
d) Bi-frontal white matter signal abnormality, in a 31/40 neonate scanned aged 65 days. Bilateral polymicrogyria is also noted (Score 3).
extensive acute haemorrhage, with diffuse cerebral oedema and patchy loss of grey-white matter differentiation. (d) T2W MRI at 2 months demonstrates diffuse end stage leukomalacia with little residual brain parenchyma.

Conclusions
Intrauterine transmission of HSV is very rare and can have devastating effects on the developing CNS. Early detection of CNS abnormalities on prenatal US or fetal MR imaging can allow timely administration of antiviral treatment and reduce neurodevelopmental abnormalities. Based on the imaging appearance, we postulate that the bulk of the damage likely occurred in early second trimester. The current UK guideline of commencing prophylactic acyclovir at 36 weeks would therefore be too late to prevent severe damage to the developing brain.

Quantitative Proton Magnetic Resonance Spectroscopy in Primary Mitochondrial Disorders

F Goncalves¹, A Goldman-Yassen¹, C Alves¹, J Martin-Saavedra¹, S Teixeira², A Vossough³
¹Children's Hospital of Philadelphia, Philadelphia, PA, ²The Children's Hospital of Philadelphia, Philadelphia, PA, ³University of Pennsylvania - CHOP, Philadelphia, PA

Purpose
Proton MRS (1H-MRS) is a technique to non-invasively study brain metabolites in vivo. 1H-MRS has been shown to detect abnormal
brain accumulation of lactate in primary mitochondrial disorders (PMDs). However, differences in lactate concentration among the different PMDs have not been explored. We aimed to explore differences in quantitative 1H-MRS derived metabolite concentrations, particularly of lactate, and their ratios, in PMDs. We analyzed quantitative 1H-MRS data of the brain in pediatric patients with different types of genetically confirmed PMDs to evaluate differences in metabolite concentration and ratios.

Materials and Methods
Forty-six PMDs patients were evaluated with quantitative 1H-MRS using LCModel. Thirty-two patients were scanned in a 3T (TR/TE, 1700/20ms with 192 averages) and fourteen in a 1.5T scanner (TR/TE, 1500/20ms with 256 averages). Single voxel 1H-MRS spectra were obtained from the right basal ganglia of all the patients. According to the type of DNA mutation, there were twenty-six patients with nuclear (nDNA) and twenty with mitochondrial DNA (mtDNA) mutations. According to phenotypes, there were fifteen patients with Leigh syndrome (LS), seven patients with POLG related disorders (POLGRD), and five patients with mitochondrial encephalopathy, lactic acidosis, and stroke-like episodes (MELAS). The rest of the patients had Cockayne, Pearson, Kearns-Sayre syndrome, complex IV deficiency, COQ4, CPEO-plus, pyruvate deficiency, MT-ATP6, SCA28, MPV17 or LHON. The remaining eight patients had no defined specific phenotype. For group comparison, t-tests and Wilcoxon rank-sum tests were applied.

Results
There was no statistically significant difference between lactate concentrations, lactate ratios, or other metabolite concentrations in PMDs with mtDNA compared to those with nDNA mutations (1.67±0.24 vs 1.155±0.205, p=0.132). There was a statistically significant difference between lactate concentrations in LS vs POLGRDs (1.776±0.25 vs 0.97±0.353, p<0.039). The lactate/Creatine ratio was higher in LS than the others combined (p=0.045), which may be explained by a significant lower creatine concentration in LS (3.542±0.259 vs 4.267±0.186, p<0.029). Myo-Inositol/Creatine ratio was also higher in LS (0.52±0.074 vs 0.325±0.053, p<0.03).

Conclusions
Lactate/Creatine and Myo-Inositol/Creatine ratios were significantly higher in LS patients than other PMDs combined, along with lower creatine. LS patients also had significantly higher lactate concentration compared to POLGRDs patients.

2110
5:40PM - 5:46PM
Autoimmune Cortical Encephalitis in Two Children with Anti-myelin Oligodendrocyte Glycoprotein (MOG) Antibody in Serum and CSF

D Doig1, C McNamara1, L Mewasingh1, S Beri1, B Jones1, C KACHRAMANOGLOU1, W Jan1
1Imperial College Healthcare NHS Trust, London, United Kingdom

Purpose
Anti-myelin oligodendrocyte glycoprotein (anti-MOG) antibodies, directed against a component of the myelin sheath, are often detectable in the blood or CSF of pediatric patients with acute inflammatory demyelinating disease. Encephalitic presentations in anti-MOG-antibody-positive patients are recognized, but rare, and very few pediatric cases have been described. We review key clinical and MRI findings in two recent cases and explore the potential underlying immunological process for the varying clinical and imaging presentation.

Materials and Methods
Case 1: an 11-year old with recent coryzal illness and headache was admitted following a generalized seizure. CSF analysis revealed a raised mononuclear cell count and raised protein level. Detailed infective screen was negative. Aquaporin-4 and NMDA receptor antibody antibodies were negative. Serum and CSF MOG IgG assay was positive. Following methylprednisolone, intravenous immunoglobulin (IVIG), and plasma exchange, there was sustained clinical improvement. Case 2: a 4-year old child, recovering from chickenpox infection, presented with headache, fever, abnormal behaviour, hemiparesis and loss of speech followed by seizures. Infectious screen was negative except for evidence of recent varicella zoster infection. Serum autoimmune antibody screen revealed positive titres of anti-MOG antibody in serum and CSF. Partial recovery of limb power and speech was documented following IVIG.

Results
Case 1: MRI demonstrated diffuse cerebral oedema, with bihemispheric cortical swelling and T2/FLAIR hyperintensity in the deep grey matter (fig 1A). There was reduced diffusivity in these regions on DWI (fig 1B) with corresponding low signal on ADC. There was no parenchymal enhancement post contrast. The spinal cord was normal. Case 2: An extensive region of cortical T2/FLAIR signal hyperintensity with a posterior and left-sided predominance was demonstrated, with reduced diffusivity in these regions on DWI (fig 2A and 2B) and corresponding low signal on ADC.

Conclusions
Cortical encephalitis is a rare manifestation of anti-MOG antibody positivity in children. These two patients presented with seizures following recent viral infection, with widespread cortical abnormality on MRI, but both improved following treatment. Early testing for anti-MOG antibody in serum or CSF in this setting may allow differentiation from infective causes of encephalitis and early institution of appropriate therapy.
Progression of White Matter Lesions in Pediatric Sickle Cell Disease: Midterm follow up

S Benitez, K Hsu, B Chulpayev, D Manwani, W Mitchell, K Morrone, S Lee
Montefiore Medical Center, Bronx, NY, Albert Einstein College of Medicine, Bronx, NY, Children's Hospital at Montefiore, Bronx, NY, Albert Einstein College of Medicine, Montefiore Medical Center, Bronx, NY

Purpose
A significant proportion of pediatric sickle cell disease (SCD) are known to have white matter lesions on brain MRI. Those findings have been shown to be correlated with decreased cognitive and school performance, however, follow up imaging findings on those white matter (WM) lesions have not been clearly understood. We aim to review follow up brain MR findings in pediatric SCD patients to investigate potential risk factors which may be associated with progression.

Materials and Methods
A retrospective review of pediatric SCD patients from 2010 to 2019 at a tertiary referral academic center was performed. Patients who had their first MRI brain before 18 years of age and had at least one follow up brain MRI were included. Brain MRI's were reviewed
by 2 neuroradiologists and WM changes were categorized per hemisphere and by size as per the SWiTCH Trial [1]. Potential risk factors including presenting symptoms, number of crisis events, and transfusion history were analyzed.

**Results**
Among 238 pediatric SCD patients, 88 patients had at least one follow up brain MRI. Mean age for the first brain MRI was 10.5 years. Mean first follow up interval MRI brain was 1.7 years and median follow up period was 3 years (range 1 month to 8 years). Poor school performance and assessing stroke prevalence were among the most common indications for brain MRI. Fifteen patients (15/88, 17%) of all patients had undergone a bone marrow transplant (BMT) while two patients (2/7, 29%) who progressed underwent a BMT. Forty three patients (43/88, 49%) demonstrated white matter disease, and seven patients (7/88, 8%) demonstrated brain MRI evidence of progression of WM lesions (M:F=4:3). Among them, 4 patients progressed from prior WM lesions and 3 developed new WM lesions from normal prior brain MRI. Regarding history of transfusion in patients who showed progression of WM lesions, chronic transfusion, episodic transfusion and no history of transfusion were seen in 4 patients (57%), 2 patients (29%) and 1 patient (14%), respectively. All patients in the progression group were HgbSS. There was no difference in the incidence of WM lesion progression (p>0.05) between patients who had WM lesion on the first MRI and patients who did not. The history of transfusion also did not show any statistical difference in the incidence of WM lesion progression (p>0.05).

**Conclusions**
The progression of WM lesions appears to be unrelated to the existence of prior WM lesions nor related to transfusion history.

### 2430

5:54PM - 6:00PM

**Apparent Diffusion Coefficient Histogram Radiomic Metrics for Classification of Intraventricular Brain Tumors in Children**

F Goncalves\(^1\), D Khrichenko\(^1\), J Martin-Saavedra\(^1\), C Alves\(^1\), S Teixeira\(^1\), S Andronikou\(^1\), A Vossough\(^2\)

\(^{1}\)Children's Hospital of Philadelphia, Philadelphia, PA, \(^{2}\)University of Pennsylvania - Children's Hospital of Philadelphia, Philadelphia, PA

**Purpose**
Accurate preoperative imaging diagnosis of supratentorial pediatric intraventricular tumors is not always straightforward. Conventional MRI features such as T1- and T2-weighted signal and contrast enhancement may overlap among various choroid plexus tumors and embryonal tumors. This study aimed to perform apparent diffusion coefficient (ADC) histogram analysis, assessing various metrics in different intraventricular tumors for histological classification.

**Materials and Methods**
Twenty-three intraventricular pediatric tumors were retrospectively evaluated. There were 12 choroid plexus papillomas (CPP), six choroid plexus carcinomas (CPC), three ATRTs, one PNET, and one medulloepithelioma. The ATRT, PNET, and medulloepithelioma cases were bundled in a single group of embryonal tumors according to the 2016 WHO classification of brain tumors. All tumors were investigated by MRI by using diffusion-weighted imaging. All tumors were manually segmented using an in-house developed parametric (pMRI) software and diffusivity metrics were automatically calculated on a pixel-by-pixel basis. Only the solid components of the lesions were included in the analysis. The following first-order histogram radiomic metrics were calculated: mean ADCmean, ADCKurtosis, ADCskewness, ADCvariance, and Shannon index of entropy. Differences in the whole tumor metrics were assessed using the Kruskal-Wallis test with post hoc comparison.

**Results**
There were significant differences in ADCmean (1744±101 vs 1215±136 vs 971±150 10-3mm/s², p<0.002) ADCKurtosis (1.01±0.54 vs 2.191±0.739 vs 4.635±0.809, p<0.022) among choroid plexus papilloma, choroid plexus carcinoma, and intraventricular embryonal tumors, respectively. In post hoc analysis, the ADCmean of CPP was significantly higher than CPC and embryonal tumors, and on the other hand, the ADCKurtosis of embryonal tumors was significantly higher (leptokuric) from both types of choroid plexus tumors.

**Conclusions**
Simple first-order histogram radiomic analysis of pediatric supratentorial intraventricular tumors using mean ADC and ADC kurtosis can differentiate between choroid plexus papilloma, choroid plexus carcinoma, and intraventricular embryonal tumors.
Unusual Case of Biotin-Thiamine Responsive Encephalopathy Without Basal Ganglia Involvement

R Kelsch¹, A Krishnan², D Nolan²
¹Beaumont Health, Royal Oak, Oxford, MI, ²Beaumont Health, Royal Oak, Royal Oak, MI

Purpose
The purpose of this presentation is to review the imaging of an unusual case of biotin-thiamine responsive encephalopathy. The purpose is also to contrast with the more typical features of biotin responsive basal ganglia disease that, though rare, neuroradiologists should be on the lookout to be able to contribute to the diagnosis of this potentially treatable disease.

Materials and Methods
The patient is a 7 month old male who presented to our institution at 1 month of age with irritability, poor feeding, and prolonged seizures. The patient was found to have focal status epilepticus arising from the left occipital region, refractory to several typical anti-seizure medications. A brain MRI revealed several large areas of restricted diffusion as described in the imaging findings section. CSF studies demonstrated increased lactate. The infant was started on IV steroids, due to concern for mitochondrial disorder, with subsequent seizure improvement. A concern for underlying mitochondrial condition led to genetic testing, which revealed a pathogenic SLC19A3 mutation. This was diagnostic of SLC19A3-related autosomal recessive biotin-responsive disease. Therefore, the infant was started on high dose thiamine and biotin with improvement in the patient's alertness and development. Typical imaging features described in the literature of involvement of the caudate (described in some literature as 100% of cases) and putamina was not seen in this infant. Further, the dominant feature in our patient was diffusion restriction, which is reportedly not commonly seen in this condition (1).

Results
MRI of the brain demonstrates large areas of restricted diffusion involving the bilateral centrum semiovale (Image A, red arrows) extending to the bilateral corona radiata, the left occipital lobe (Image B and C, blue arrows), and symmetric areas of the bilateral thalami (Image B, yellow arrows). No definite involvement of the caudate/putamina was seen.

Conclusions
The 'atypical' findings in our case with significant diffusion restriction and lack of caudate involvement should not dissuade the radiologist and clinician from suggesting this condition. The early administration of biotin and thiamine results in partial or complete improvement while delay or lack of treatment may result in death or severe neurologic sequelae.
Interventional Spine Programming: Amazing Spine Advances That Need to Be Part of Your Practice - Right Now!

1553

8:20AM - 8:25AM

Intraosseous Basivertbral Nerve Radio-Frequency Ablation For The Treatment Of Vertebrogenic Chronic Low Back Pain

L Manfrè¹, H Alqatami², G D'Agostino³, F Ventura¹, A De Vivo¹
¹IOM, catania, italy, ²Institute of Hamad Medical Corporation, Doha, qatar, ³azienda ospedaliera provinciale di catania, caltagirone, italy

Purpose
The aim of this study is to evaluate the efficacy of Basivertebral Nerve Radiofrequency ablation (BVA) in treating patients affected by vertebrogenic chronic low back pain (CLBP).

Materials and Methods
From January 2018 patients with CLBP were evaluated. 61 patients were eligible for percutaneous CT-guided BVA. Inclusion criteria: CLBP (>6 months), MRI findings of disc degeneration and Modic changes, evidence of vertebral body uptake on SPECT/TC, failure of conventional therapies. Pre-operative pain intensity and disability were rated respectively by the VAS and ODI score. A 10-point improvement threshold for the ODI score and a 2cm improvement threshold for the VAS score were set as clinical success. BVA was performed in a fully percutaneous CT-guided procedure (STAR ®) in local anesthesia or mild conscious sedation. MRI was performed 1 month after procedure in order to assess the target success of the procedure. Clinical follow-up was performed after 6 months.

Results
Mean operative time was 40 minutes. No major or minor complications were detected at immediate post-operative CT control scan. Targeting was successful in 100% of patients. 6 months VAS and ODI scores decreased significantly compared to baseline: VAS mean change was -5.7 cm and clinical success was reached in 96.7% of patients. 59/61 exhibited a greater improvement compared to MCID: more than 4 points. ODI score mean change was -32.8 points and 96.7% of patients reached clinical success. The improvement was higher than the MCID: more than 30 points in 59/61 patients.

Conclusions
CT-guided percutaneous intra-ossseous BVA seems to be a safe, fast and powerful technique for pain relief in patients with vertebrogenic CLBP. Therefore, the CT-guided procedure is fast and safe and can be performed in local anesthesia or conscious sedation. Moreover SPECT/TC seems to be a reliable diagnostic tool to select patients that should undergo BVA procedure.

Interventional Spine Programming: Neuromodulation

2289

9:20AM - 9:25AM

Radiofrequency ablation under US guidance: a feasibility study

M Bellini¹, G Sadotti², C Zini³, D Notaro⁴, S Marcia⁵, L Manfrè⁶, L Monti⁷

¹IOM, catania, italy, ²Institute of Hamad Medical Corporation, Doha, qatar, ³azienda ospedaliera provinciale di catania, caltagirone, italy, ⁴University of Catania, Sicily, Italy, ⁵University of Bari, Italy, ⁶IOM, Catania, Italy, ⁷University of Bari, Italy
Purpose
Imaging guided radiofrequency ablation (RFA) of medial branches is generally followed by a long-lasting therapeutic efficacy, in patients with lumbar facet joints syndrome (LFJ). CT or fluoroscopic guidance are commonly used for RFA. The aim of the present study was to evaluate the feasibility of RFA under ultrasonography (US) guidance and the clinical outcome.

Materials and Methods
28 patients (7 male, 21 female, age range 32-78) with double positive block test and medical or physical therapy failure were enrolled in the present study; exclusion criteria were in patients responsive to medical and physical therapy over a period <6 months. A written informed consent was obtained from all the patients. The ablation was performed for 3 minutes at 90° Celsius with an average time of 20 minutes between entering and leaving the US room. Visual analog scale (VAS) score and clinical evaluation was performed before, 1 and 3 months after the procedure. Technical success was defined as correct placement of RFA needle at the level of the affected zygapophyseal joint and optimal response to sensory/motor stimulation.

Results
The technical success was reached in all patients. No major or minor complications related to the procedure were registered; all patients were discharged after a mean time of 3 hours. In 12 patients the RFA was performed at both sides and in 3 levels in the same session. All patients showed relevant improvement in symptoms with preoperatively mean VAS score of (8) dropped to (5) after 1 month and to (2) within 3 months.

Conclusions
RFA under US guidance can be effective and safe in patients with LFJ syndrome with positive block test without radiation exposure. The US procedure is able to reduce machine time and the costs. Further studies on the same topic would be highly desirable to investigate the possible role of US guidance in RFA in comparison with CT or fluoroscopic guidance.

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1Unit of Neuroimaging, Dept. of Neurosciences, Azienda Ospedaliera Universitaria Senese, siena, Italy, 2Uniti of Radiology, Siena, SI, 3Uniti of Radiology, Hospital Santa maria annunziata, USL Centro, Firenze, FI, 4Studio RX Gentile, Palermo, PA, 5N/A, N/A, 6IOM, viagrande, Italy, 7University Hospital of Siena, Siena, Italia
Battery-Powered Bone Biopsy System Demonstrates Similar Diagnostic Yield But Decreased Radiation Dose and Procedure Time Compared to Manual Bone Biopsy Systems

S KIHIRA1, C Koo1, A Lee1, A Aggarwal1, A DOSHI1
1Icahn School of Medicine at Mount Sinai, New York, NY

Purpose
To investigate differences in diagnostic yield, procedure time, and radiation dose between manual and battery-powered bone biopsy systems in CT-guided biopsy of lytic, sclerotic, and suspected discitis/osteomyelitis.

Materials and Methods
This was a retrospective single center IRB approved study. A total of 585 CT-guided core needle biopsies were performed at one institution from May of 2010 to February of 2019. Classification of bone lesions, location, bone biopsy system, suspected origin of primary disease, final pathology diagnosis, diagnostic yield, presence of crush artifact, radiation dose, and procedure times were collected. For the battery-powered system, OnControl (VidaCare) was used. For the manual drill system, Bonopty (AprioMed), Murphy (Cook), and Laurane drill systems were used. Comparison within lytic, sclerotic, and suspected discitis/osteomyelitis were made by Fisher exact test. Subgroup analysis of the drill systems for procedure time and radiation dose were made by one-way ANOVA.

Results
Our patient cohorts consisted of a total of 585 patients with 402 lytic, 110 sclerotic, and 53 suspected infectious lesions. The mean ± standard deviation of age (years) was 62 ± 13 with M/F of 305/280 for all lesions. The diagnostic yield was 85.5% (362/422) for lytic, 82.7% (91/110) for sclerotic, 50.9% (27/53) for infectious lesions, and 82.1% (480/585) for all lesions. No statistical difference was found when comparing diagnostic yields of powered drills to the manual systems for lytic, sclerotic, and infectious lesions. However, in a subgroup analysis, radiation dose and procedure time was significantly lower for powered drill compared to manual drill system in lytic (p=0.001 for both) and sclerotic lesions (p=0.028 and p=0.012, respectively). No significant differences were seen between the drill systems for suspected infectious lesions.

Conclusions
Our findings demonstrate that there was no significant difference in diagnostic yield when comparing battery-powered and manual bone biopsy systems for CT-guided bone biopsies, however, the use of the power-drill system resulted in significantly reduced procedure time and radiation dose in lytic and sclerotic lesions without significant differences in suspected infectious lesions.

Table 3: Comparative performance of the drill systems in various lesion classifications.

<table>
<thead>
<tr>
<th>Lesions</th>
<th>Diagnostic Yield</th>
<th>Crush Artifact (%)</th>
<th>Radiation dose (mGy/cm²)</th>
<th>Procedure time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lytic Lesions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual System</td>
<td>83.4 (201/241)</td>
<td>5 (12/241)</td>
<td>845</td>
<td>42</td>
</tr>
<tr>
<td>Powered System</td>
<td>89.0 (161/181)</td>
<td>7.7 (14/241)</td>
<td>6.57</td>
<td>35</td>
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<tr>
<td>p value</td>
<td>0.069</td>
<td>0.168</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>Sclerotic Lesions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual System</td>
<td>76.4 (42/55)</td>
<td>7.3 (4/55)</td>
<td>1061</td>
<td>44</td>
</tr>
<tr>
<td>Powered System</td>
<td>89.1 (49/55)</td>
<td>7.3 (4/55)</td>
<td>0.028</td>
<td>0.012</td>
</tr>
<tr>
<td>p value</td>
<td>0.064</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infectious Lesions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual System</td>
<td>50.0 (9/18)</td>
<td>11.1 (2/18)</td>
<td>1113</td>
<td>46</td>
</tr>
<tr>
<td>Powered System</td>
<td>51.4 (18/35)</td>
<td>0.0 (0/35)</td>
<td>811</td>
<td>39</td>
</tr>
<tr>
<td>p value</td>
<td>0.576</td>
<td>0.111</td>
<td>0.155</td>
<td>0.128</td>
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<tr>
<td>All Lesions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual System</td>
<td>80.3 (252/314)</td>
<td>5.7 (18/314)</td>
<td>900</td>
<td>43</td>
</tr>
<tr>
<td>Powered System</td>
<td>84.1 (228/271)</td>
<td>6.6 (18/271)</td>
<td>704</td>
<td>36</td>
</tr>
<tr>
<td>p value</td>
<td>0.538</td>
<td>0.387</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Note: Percentage followed by (number of cases/total number of cases) for diagnostic yield and crush artifacts. Mean values are listed for radiation dose and procedure time.

(Filename: TCT_1139_TableASNRfinal.jpg)
Quantifying Brain Iron in Hereditary Hemochromatosis Using Quantitative Susceptibility Mapping and R2*  

Our objective was to map brain iron in HH subjects.

Materials and Methods

Genetically-proven HH (C282Y homozygotes) subjects and healthy controls (HC) were recruited for this study. Gradient echo data were collected with the following parameters: TE1=5 ms, TE6=30 ms, ATE=5 ms, resolution 0.43 mm×0.43 mm, slice thickness=2 mm. Using TE2-TE6 data, susceptibility [1, 2] and R2* maps were constructed. Regions in the DGM and dentate nucleus were traced, then reviewed by a neurologist. Susceptibility and R2* values were calculated and compared between the groups as well as reference values [3, 4].

Results

Forty-three subjects with HH (mean age: 58.7+13 years) and 11 HC (mean age: 64.9+7 years) were included in this study. Table 1 shows average mean susceptibility and R2* values for each cohort. Differences between HCs and HH subjects were observed in GP and DN in QSM data (Figure 1) but only in the DN for R2* (Figure 2). The correlation between R2* and susceptibility was 0.77 when pooling all subjects and structures. The regression equation gave the following relationship: R2* = 0.13*χ+23.55, which agrees with previously reported values [3]. We also noted elevated iron in the DN, SN, RN but lower iron in the GP, in both cohorts.

Conclusions

Both R2* and susceptibility mapping showed elevated brain iron in HH subjects. This was evident when comparing controls from the same scanner as well as with data from other studies [3,4]. Using ME-SWIM data provides a robust means to measure high brain iron which may lead to phase aliasing at longer echo times, causing reconstruction issues in susceptibility mapping. The following limitations should be considered: 1) we compared data to studies which have used different data collection parameters; and 2) the number of controls was low. However, we plan on recruiting more age-matched controls in the future. Since iron induced organ damage in HH can be prevented by phlebotomies, quantification of brain iron will have potential implications for therapeutic interventions.
Table 1: Mean susceptibility and R2* values for the gray matter structures and the dentate nucleus. P-values between the groups are also presented.

Figure 1: Susceptibility (ppb) vs. age plot of the dentate nucleus for hemochromatosis (HH) and healthy control (HC) subjects.

Figure 2: R2* vs. age plot of the dentate nucleus for hemochromatosis (HH) and healthy control (HC) subjects.

Figure 3: R2* vs. susceptibility of all structures pooled for all subjects.
Excitotoxic injury in minimal Hepatic encephalopathy - Predictive modelling with Proton Spectroscopy

J CHAGANTI
FRANZCR, MD, PhD, SYDNEY, NSW

Purpose
Minimal hepatic encephalopathy (mHE) is a precursor for development of irreversible neurological injury. CHE, unlike HE, is not associated with neurological deficits but still associated with cognitive impairment which is potentially reversible. A biomarker to predict the mHE, could make a difference in the way these patients are currently managed clinically. MR spectroscopy by virtue of its ability to measure the metabolic changes at the cellular level, is an attractive option for identifying the likely impact of mHE on neurological status. In this prospective cross sectional study we present the metabolite changes in cirrhotic patients with and without covert HE.

Materials and Methods
This was a single-centre prospective cohort study initiated in 2018. Minimal HE was defined using neuropsychological assessment: psychometric hepatic encephalopathy score (PHES) and continuous reaction time (CRT). The participants were stratified into three groups; cirrhosis with covert HE (CHE) (PHES<4 +/- CRT-index<1.9); cirrhosis without HE (NHE) (PHES≥4 +/- CRT-index>1.9); and healthy controls (HC). Participants underwent: single voxel MRS was performed in the parietal region and metabolite parameters were obtained using LC-model software; electroencephalography; assessment of liver function; serum ammonia, metabolomic and cytokine analysis; and chronic liver disease questionnaire (CLDQ). Statistical analysis was performed using IBM SPSS. Volumes of the brain were studied in different regions using FSL and were correlated with spectroscopically derived metabolites.

Results
Results: A total of 35 patients (mean age 63 years; male 71%) were recruited: CHE (n=15); NHE (n=11); and HC (n=9). The parietal glutamine/creatine (Gln/Cr) ratio was significantly higher in both MHE 1.12 vs HC 0.28 (p<0.001); and NHE 0.49 vs HC 0.28 (p=0.04). PHES scores were found to be correlated negatively with glutamine/creatine (Gln/Cr) (r=-0.6, p<0.001) and positively with myoinositol/creatine (Ins/Cr) (r= 0.6, p<0.001) and choline/creatine (Cho/Cr) (r= 0.47, p=0.004). NHE was also associated with a similar attenuated pattern of metabolite change. This MRS metabolite pattern was associated with higher MELD scores, higher ammonia levels and lower CLDQ scores. Volumetric data showed that there is positive correlation with glutaminergic excitotoxicity and reduced caudate and putaminal volumes.

Conclusions
Glutaminergic excitotoxicity, in CHE is potentially reversible and there by could be used as a strong biomarker.
An MRI-Based Quantification for Correlation of Imaging Biomarker and Clinical Performance in Carbon Monoxide Poisoning

A Lee¹
¹Soonchunhyang University Hospital, Bucheon, Bucheonsi, Korea, Republic of

Purpose
The purpose of this study was to determine the relation between quantitative magnetic resonance imaging biomarkers and clinical performances in the early chronic phase of carbon monoxide intoxication.

Materials and Methods
Eighteen magnetic resonance scans and cognitive evaluations were performed in patients with carbon monoxide intoxication at early chronic phase. ADC ratios of affected vs. unaffected centrum semiovale and corpus callosum were obtained. SI ratios between affected centrum semiovale and normal pons in T2-FLAIR images were obtained. The Mini-Mental State Exam and the clinical outcome scores were assessed. Correlation coefficients were calculated between MRI and clinical markers. The patients were further classified into poor-outcome and good-outcome groups on the basis of clinical performance, and imaging parameters were compared. T2-SI ratio of centrum semiovale was compared with that of 18 sex-matched and age-matched controls.

Results
T2-SI ratio of centrum semiovale was significantly higher in the poor-outcome group than that in the good-outcome group and was strongly inversely correlated with results from the Mini-Mental State Exam. ADC ratios of centrum semiovale were significantly lower in the poor outcome group than in the good outcome group and were moderately correlated with the Mini-Mental State Exam score.

Conclusions
A higher T2-SI and a lower ratio of the ADC values in the centrum semiovale may indicate the presence of more severe white matter injury and clinical impairment. T2-SI ratio and ADC values in the centrum semiovale are useful quantitative imaging biomarkers for the correlation with clinical performance in individuals with carbon monoxide intoxication.
Evolution of Uremic Encephalopathy

J LEE¹, R Hynceck²
¹HARTFORD HOSPITAL, VERNON, CT, ²Hartford Hospital, Hartford, CT

Purpose
The purpose of this presentation is to review the clinical and imaging findings of uremic encephalopathy (UE), which is a metabolic disorder that is characterized by an increase in blood urea nitrogen and acidosis.

Materials and Methods
AR is a 54 y/o female who presented to the ED with confusion and slurred speech. History included type 2 diabetes with ESRD on peritoneal dialysis. She had a prior history of CVA with residual left sided weakness. On physical examination, she demonstrated left sided gaze deviation with lethargic response, dysarthria, new right upper and lower extremity weakness. Her BP on presentation was 185/79. She had several documented seizures on EEG. BUN was 86 and ABG showed acidosis. The patient was switched from...
peritoneal dialysis to hemodialysis with ultrafiltration. BUN subsequently decreased to a range of 30-50 and her acidosis and seizures ultimately resolved.

Results
The admission CT demonstrated symmetric hypoattenuation within the lentiform nuclei and thalami. There was no vessel occlusion/stenosis on CT angiography. The initial brain MRI showed symmetric expansile T2 hyperintensity within the basal ganglia including a characteristic Y-shaped rim of T2 signal known as the lentiform fork sign representing the external and internal capsules merging infero-posteriorly into a common stem. There were several areas of gyriform cortical and subcortical T2 hyperintensities within both cerebral hemispheres with patchy T2 hyperintensities involving both thalami and the left cerebellum. Restricted diffusion is seen in the thalamic lesions and some of the subcortical lesions. 2 weeks later, MRI showed complete resolution of abnormal signal in the lentiform nuclei and considerable improvement in the remainder of the parenchymal lesions.

Conclusions
Uremic encephalopathy (UE) is a metabolic disorder that occurs in patients with renal failure and is treated with hemodialysis. The lentiform fork sign is the classic MR appearance of the basal ganglia in patients with UE. Basal ganglia lesions can be associated with restricted diffusion. Additional areas of involvement include cerebral cortex and subcortical white matter, mesial temporal lobes, and brainstem. Symptoms include emotional changes, cognitive changes and memory deficit. In severe cases, patients may experience seizure, psychosis, coma and occasionally death. Therefore it is important that suspected cases of UE are correctly identified and brought to the attention of the clinician so that definitive care is not delayed.
Gadolinium-Induced Cranial Marrow Signal Changes and Leukopenia: Is There a Common Genesis?

J DEBEVITS¹, D Bageac², C Hu², R Wu², D Karimeddini², L Wolansky²

¹UCONN HEALTH, Farmington, CT, ²UConn Health, Farmington, CT
Purpose
Our purpose was to determine whether cranial marrow signal changes attributed to gadolinium deposition was associated with leukopenia seen in subjects who received monthly triple-dose gadopentetate dimeglumine (0.3 mmol/kg) as part of the BECOME trial. In the BECOME Trial, patients received monthly contrast-enhanced scans with to track MS lesions for up to two years. Blood work obtained prior to each monthly scan revealed a trend of several hematologic abnormalities, including leukopenia, which occurred with a significantly higher incidence than could be explained solely by treatment side effects during the original BECOME trial. Since white blood cells are created from progenitor cells in the bone marrow, we hypothesized that there might exist an association between these two abnormalities.

Materials and Methods
Subjects (N=67) received monthly triple-dose gadopentetate dimeglumine (0.3 mmol/kg) as part of a head-to-head MS treatment comparison between Betaseron and Copaxone for up to two years (up to 78 dose-equivalents). Manual segmentation of the cranial diploic space was performed using ITK-SNAP on a T2W sequence. Using an automated technique, this ROI was overlaid on the monthly T1W fat-saturated images to determine monthly changes in pixel intensity. S/N ratios established average SI change over the 12 months of the study, defined as S/N = Bone/Air. Linear mixed regression modeling with random intercept was used to test for significance of the signal intensity. Incidence of leukopenia compared with monthly marrow signal changes was performed using the type 3 test of fixed effects.

Results
A statistically significant increased T1 Fat-Sat SI changes was seen in the cranial diploic space during the first 14 months of gadolinium administration: S/N=0.039 (S.E. 0.008; p<0.0001). Incidence of leukopenia increased significantly over the course of the trial with OR 1.103 (1.047, 1.162, p<0.001). Marrow signal increase was not different between leukopenic and normal subjects (p = 0.8160).

Conclusions
Even though our research has previously demonstrated results which suggest intracranial gadolinium deposition, it is perhaps reassuring that this analysis has found no association between signal changes in the intracranial marrow and incidence of leukopenia. This implies that gadolinium in the marrow does not necessarily interfere with the ability of progenitor cells to produce leukocytes as was hypothesized.

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Arterial Spin Labeling Findings in Osmotic Demyelination Syndrome

O Kohannim, M McDonald
UC San Diego, San Diego, CA

Purpose
To report arterial spin labeling findings of pontine and extrapontine osmotic demyelination syndrome

Materials and Methods
A 75 year old male with a past medical history of alcoholic cirrhosis, complicated by esophageal varices, ascites, and prior hospitalizations for hepatic encephalopathy, was brought to the hospital by family with five days of altered mental status. Per patient's family, he was behaving differently, eating less and more recently, walking out of the house spontaneously and talking incoherently. He was admitted to the hospital with an initial sodium count of 122. His hospital course was complicated by hypernatremia, with his sodium level rising to 136, three days after admission, and peaking at 164, five days after admission. A brain MRI performed a day prior to the peak sodium count did not reveal any acute intracranial abnormality. Given the rapid alterations in his sodium counts and refractory confusion, a second brain MRI was ordered ten days later with suspicion for osmotic demyelination syndrome.

Results
Brain MRI revealed new patchy and linear regions of FLAIR hyperintensity in the central pontine parenchyma, lateral thalami, caudate and lentiform nuclei as well as subinsular white matter, associated with various degrees of diffusion restriction, concerning for pontine and extrapontine manifestations of osmotic demyelination syndrome. Subtle FLAIR hyperintensity and high diffusion weighted imaging (DWI) signal were also seen contouring the paramedian aspect of the periradical cortex. Arterial spin labeling sequence revealed markedly elevated perfusion in the dorsal brainstem structures, thalami and the bilateral periradical cortex.

Conclusions
Osmotic demyelination syndrome is commonly seen in the setting of alcoholism and malnutrition with imaging findings lagging behind clinical symptoms. Involvement of the pons, bilateral thalami, basal ganglia and periradical cortex is classic. Increased perfusion within the pons was reported in 2006 in a single case of central pontine myelinolysis in its acute phase following liver transplantation. The authors speculated that increased perfusion was related to higher metabolic activity due to increased cell number and activity with accompanying vasodilation. Perfusion abnormalities have not been previously reported in extrapontine osmotic demyelination syndrome. In our case, the arterial spin labeling images specifically highlight the subtle FLAIR and DWI signal abnormalities in the periradical cortex.
Presumed Thallium CNS Toxicity Due To Pica During Pregnancy

S MONTOYA¹, M Potchen²
¹Massachusetts General Hospital, Boston, MA, ²University of Rochester Medical Center, Rochester, NY

Purpose
Thallium is a naturally occurring heavy metal which is extremely neurotoxic. Outbreaks of thallotoxicosis (CNS thallium toxicity) due to environmental exposures have been attributed to soil contamination by pesticides and fertilizers, and water contamination by manufacturing byproducts. Conversely, acute thallium toxicity is mainly attributable to intentional poisoning. Thallium toxicity is rare, and imaging of thallium toxicity is sparsely documented. Here we present a case of presumed thallium toxicity due to unintentional chronic ingestion.

Materials and Methods
A 28-year-old pregnant woman presented from a remote village in southern Africa with new onset seizures. Brain imaging at that time was reportedly normal. She continued to seize without identifiable etiology; work-up for eclampsia and infectious processes yielded no identifiable cause. Repeat MRI obtained after six weeks of status epilepticus revealed significant interval brain atrophy and new signal abnormality within the basal ganglia. It was later elicited that she developed pica behavior during her pregnancy, and often
ingested dirt in small but frequent quantities. Based on clinical history and imaging findings, it was determined that she suffered from thallium toxicity due to pica; thallium is a known contaminant found in the patient's home region. The woman eventually succumbed to her illness. Unfortunately, laboratory or pathology confirmation could not be obtained due to unavailability of the required diagnostic tools.

Results
T1-weighted (left) and T2/FLAIR-weighted images (right) show increased signal within the basal ganglia symmetrically and bilaterally. There is extensive confluent T2/FLAIR hyperintensity involving the periventricular white matter and extending throughout the white matter of the bifrontal lobes. Additionally, there is gyral fullness and accompanying T2/FLAIR hyperintensity (likely edema) of the left more than right superior frontal gyri, bilateral frontal opercula, and bilateral temporal opercula. There is also profound diffuse volume loss for age.

Conclusions
We present a case of presumed chronic thallium toxicity during pregnancy, unconfirmed but probable based on clinical history and imaging findings. Although an unusual entity for this audience, it is important for those involved in rural or global health to recognize thallotoxicosis as a possible cause for toxoencephalopathy given its potentially ubiquitous nature.

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Molly, water, and the brain

L van den Hauwe¹
¹Antwerp University Hospital - University of Antwerp, Antwerp (Edegem), Belgium

Purpose
To present the neuroimaging findings in a patient with fatal MDMA-related complications.
Materials and Methods
A 33-year-old woman was found unconscious after attending a dance festival the day before. The patient was sent to a regional hospital where a NCCT of the brain was performed and the diagnosis of SAH was made. Patient became hemodynamically unstable as a result of ventricular tachycardia. Patient was referred to our hospital for further treatment. Initial CT was reviewed and diagnosis of pseudo-SAH due to diffuse brain swelling/edema was made. Laboratory findings showed severe hyponatremia; urine toxicology screening was + for amphetamines. Patient was intubated, hypertonic salt solution and mannitol were administered; intraparenchymal pressure monitoring was placed. FU imaging demonstrated decreased cerebral swelling, acute ischemic lesions, and a cytotoxic lesion of the corpus callosum. Patient died a few days later due to cardiac failure and diffuse brain edema with secondary brain herniation.

Results
NCCT showed cortical sulci effacement and ventricular narrowing as seen in diffuse brain swelling. Hyperdense aspect of the tentorium and increased attenuation within the basal cisterns and subarachnoid spaces (SAS) was reported as SAH. Correct diagnosis of pseudo-SAH due to diffuse brain swelling was confirmed by FU MRI (normal SI of the SAS on FLAIR and GRE T2*) and negative CSF analysis. Acute ischemic lesions with gyriform swelling of the occipital cortical gray matter and high SI on FLAIR/T2 within the gray and white matter was seen. DWI displayed cortical cytotoxic edema and mild vasogenic edema in the adjacent subcortical white matter, a similar lesion in the left parietal lobe and a small cytotoxic ovoid lesion in the center of the splenium of the corpus callosum on DWI.

Conclusions
MDMA is the 2nd most popular used illicit drug; abuse is associated with important morbidity and mortality with various types of intracranial hemorrhage, including SAH being described, frequently associated with AVM or aneurysms. Imaging findings in MDMA-related brain complications include pseudo-SAH due to severe hyponatremia-related brain swelling/edema, a potential imaging pitfall that should not be mistaken for real SAH. MDMA-induced hyponatremia is hypothesized to result from enhanced serotonergic activity and arginine vasopressin release in the brain leading to hyperthermia-induced polydipsia and syndrome of SIADH secretion.

Scientific Abstract Session: Interventional
2352
11:00AM - 11:06AM
Bleomycin for the treatment of venolymphatic malformations of the head and neck – A systematic review.

S Finitsis¹, J Shankar², K Faiz³, J Linton³
¹Aristotle University of Thessaloniki, Thessaloniki, Thessaloniki, ²University of Manitoba, Winnipeg, MB, MB, ³University Of Manitoba, Winnipeg, Manitoba

Purpose
The purpose of our study was to assess our own experience and perform a systematic review of the published literature to synthesize the evidence on the safety and efficacy of bleomycin for the treatment of head and neck venolymphatic malformations.

Materials and Methods
Methods: A systematic review of the literature (1995 - present) was performed. Pubmed, Embase and Cochrane Library databases were searched from to identify studies on sclerotherapy of venolymphatic malformations of the head and neck. Two reviewers independently screened and extracted data and assessed the risk of bias. The primary outcome was subjective or objective reduction of lesion size as well as minor and major complications.

Results
A total of 32 studies with participants met the inclusion criteria among which 1121 patients were included in the systematic review. The quality of the evidence was low. Bleomycin/pingyangmycin sclerotherapy achieved subjective or objective lesion size reduction in 98.3% (need to give confidence interval) of cases. Minor complications were observed in 15.7% (need to give confidence interval) of cases. No minor complication occurred in the studies where the median bleomycin dose administered per session was less than 1mg/Kgr. Major complications including extensive necrosis, oral or respiratory obstruction were not observed. There was 1 mortality case (0,0008%) (need to give confidence interval) after bleomycin injection.

Conclusions
Conclusion: Bleomycin is a very effective and safe sclerotherapy agent for the treatment of venolymphatic malformations of the head and neck. Using the lowest possible dose appears reasonable to reduce the occurrence of minor complications.
Intravascular sound measurements to quantify venous pulsatile tinnitus in a patient-specific benchtop model

M Amans¹, K Valluru¹, S Kondapavulur¹, B Kilbride¹, H Haraldsson¹, W Smith¹, K Meisel¹, D Saloner¹

¹University of California San Francisco, San Francisco, CA

Purpose

Pulsatile tinnitus (PT) is a debilitating condition that can be caused by aberrant blood flow in blood vessels near the cochlea. Often times PT is very difficult to diagnose with best published diagnosis rates hovering around 50% and requiring multiple advanced imaging procedures and often times include diagnostic cerebral angiography. A tool that could "hear" pulsatile tinnitus, as the patient does, would allow physicians to reliably diagnose the cause of this difficult symptom.

Materials and Methods

We developed the "Phonocatheter", a catheter that can measure and record PT sounds as well as replay them in real time. The Phonocatheter is a 6Fr catheter able to record intravascular sounds through an embedded microphone. Glycerol-water mixture was pumped through two benchtop PT models that represent a PT patient's transverse sinus anatomy before and after lumbar puncture (LP) to mimic blood flow at a mean flow rate of 7.4 cc/s. The Phonocatheter was inserted through a 9Fr access port and was navigated into the stenosis region (Fig. 1A). An electronic stethoscope was placed externally over the same stenosis region to record PT transluminally and validate the sound measurements recorded by Phonocatheter (n=10). Variation in peak-to-rms sound amplitude values from the transverse sinus in pre-LP and post-LP models was calculated for the sound measurements obtained by both Phonocatheter and electronic stethoscope. Wilcoxon rank sum test was used to statistically determine the differences in measurements between the patient-specific models.

Results

Both the electronic stethoscope and Phonocatheter were able to record transluminal and intravascular sounds generated from stenosis respectively. The Phonocatheter was in good agreement with the electronic stethoscope demonstrating that the peak-to-rms (mean ± standard deviation) sound amplitude was significantly louder (p<0.0001) in the stenosis region in pre-lumbar puncture model (Stethoscope: 9.03 ± 1.61; Phonocatheter: 6.62 ± 1.55) compared to the same region in post-lumbar puncture model (Stethoscope: 4.20 ± 0.86; Phonocatheter: 3.62 ± 0.88) (Figs. 1B and 1C).

Conclusions

We have developed a prototype of microphone enabled catheter that can measure sound in patient-specific PT flow models, and potentially measure sounds quantitively in PT patients.
Distal Radial Access in the Anatomical Snuffbox for Neurointerventions

A Kuhn¹, K de Macedo Rodrigues², J Singh², F Massari³, A Puri⁴
¹UMass Medical Center, Worcester, MA, ²University of Massachusetts Medical Center, Worcester, MA, ³UMASS Medical School, Southborough, MA, ⁴University of Massachusetts, Worcester, MA

Purpose
To describe our initial experience with a variety of neurointerventions performed via distal radial access (dRA) and to demonstrate the safety and feasibility of this approach.

Materials and Methods
A retrospective review of our prospective neurointerventional database of endovascular interventions was conducted and between May and October 2019 all patients in whom the intervention was performed via dRA in the anatomical snuffbox were identified. Patient demographics, clinical information, procedural and radiographic data was collected.

Results
A total of 48 patients with a mean age of 64.4 years (range 35–84 years) were identified. 27 patients were female. dRA was achieved in all cases. Conversion to femoral access was required in 5 cases (10.4%) due to tortuous vessel anatomy and limited support of the catheters in the aortic arch. Interventions performed included aneurysm treatment (with flow diverters, Woven EndoBridge (WEB) device placement, coiling or stent-assisted coiling), arteriovenous malformation and dural arteriovenous fistula embolization, carotid artery stentings, stroke thrombectomy, thrombolysis for central retinal artery occlusion, intracranial stenting, middle meningeal artery embolization, vasospasm treatment and spinal angiography with embolization. Radial artery vasospasm was seen in 2 cases and successfully treated with antispasmodic medication. No symptomatic radial artery occlusion or ischemic event was observed.

Conclusions
dRA is safe and effective for a variety of neurointerventions. Our preliminary experience with this approach is very promising and shows high patient satisfaction.
Y-90 endovascular radiosurgery for the treatment of glioblastoma multiforme: A pilot study in a canine model

S Manupipatpong¹, A Pasciak², F Hui³, R Krimins⁴, L Gainsburg⁵, M Dreher⁶, D Kraitchman⁴, C Weiss³
¹Johns Hopkins University School of Medicine, Baltimore, MD, ²Johns Hopkins University School of Medicine, Laurel, MD, ³Johns Hopkins Hospital, Baltimore, MD, ⁴Johns Hopkins University, Baltimore, MD, ⁵Mid-Atlantic Veterinary Neurology and Neurosurgery, Catonsville, MD, ⁶Boston Scientific/ BTG, Oxford, CT

Purpose
To evaluate the safety and feasibility of Y-90 endovascular radiosurgery (ER) in the treatment of glioma in a canine model.

Materials and Methods
Three healthy research dogs (R1-3) and five client-owned dogs on anti-epileptics with spontaneous, intra-axial brain tumors (P1-5) received unilateral Y-90 glass microsphere infusions in either the PCA (R1), MCA (R2), or ICA (R3, P1-5), followed by quantitative Y-90 PET/CT. R1-3 had neurological exams, as clinically indicated, and a 4-week post-ER MRI. P1-4 had serial neurological exams and 1-, 3-, and 6-month MRIs. Due to a small sample size, only descriptive statistics are reported.

Results
R2-3 developed transient neurologic defects consistent with the treated side, which resolved in 13 days. R1 had no post-procedure neurologic deficits. The treated hemisphere in R1-3 received a maximum of 378±121Gy (x̄±σ) of radiation, with maximum dose twice as high in more distal deliveries (PCA, MCA). MRIs at 1 month were normal without atrophy or microinfarction. All dogs except P2 were on corticosteroids and seizure-free prior to treatment. P1-3 had transient post-procedure neurologic deficits which resolved in 20-33 days, while P4 had no neurologic deficits. P5 passed away 12-hours post-ER. The tumors received 46.2±11.7Gy of radiation with 19.3±12.2% of the tumor volume receiving >70Gy. MRIs at 1-month post-ER showed decreased tumor size in all four dogs: by 69% and 59% in P1 and P2 on post-contrast MRI and by 24% and 26% in P3 and P4 on FLAIR MRI. The average number of spheres per cm³ of tumor, calculated using the measured activity per cm³ on PET/CT and expected activity per bead, ranged from 1490 (P2) to 5280 (P1), with P1 having the greatest tumor to normal tissue ratio of spheres per cm³ at 1.9 to 1. At 53 days, P2's seizures returned with tumor enlargement, and he was euthanized 5 months post-ER. P1 and P3 remain asymptomatic with stable disease at their 6- and 3-month visits, respectively. P4 developed a unilateral menace deficit with no tumor growth on MRI at 3-months post-ER.

Conclusions
Y-90 ER in the canine brain is technically feasible and caused no permanent neurologic deficit despite >400Gy of radiation to critical brain structures. Four of five tumor dogs had favorable dosimetric, radiologic, and clinical outcomes, all outliving the 63-day mean survival time associated with their original diagnosis and symptomatic treatment. Long-term outcomes, histopathology, and a larger sample size are needed to better understand brain Y-90 ER viability.
Benchtop Model of Idiopathic Intracranial Hypertension with Transverse Sinus Stenosis

K Valluru¹, T Shen², K O’Reilly³, H Haraldsson¹, E Kao¹, J Leach¹, K Meisel¹, D Saloner⁴, M Amans⁵

¹University of California San Francisco, San Francisco, CA, ²University of California Davis, Davis, CA, ³Marquette University, Milwaukee, WI, ⁴UCSF, San Francisco, CA, ⁵University Of California, San Francisco, San Francisco, CA

Purpose
Idiopathic Intracranial Hypertension (IIH) is a pathologic elevation of the intracranial pressure (ICP) that can lead to distressing pulsatile tinnitus (PT)¹. Venous sinus stenting (VSS) is an effective procedure offering PT resolution in patients with IIH and transverse sinus (TS) stenosis, with an intravascular pressure (IVP) gradient measuring >8 mmHg across the stenosis²–⁴. However, VSS has significant relapse rates due to the development of proximal TS stenosis adjacent to the stent⁵. An in vitro model that can mimic IIH pathophysiology and induce TS stenosis reliably in a controlled environment would allow us to evaluate the flow parameters responsible for restenosis.

Materials and Methods
We built a benchtop phantom that constitutes an interchangeable TS flow model submerged in a rigid water-filled chamber to simulate the potential effects of ICP exerted by cerebrospinal fluid (CSF) on TS stenosis. The phantom is equipped with a pressure sensor inside the chamber to record ICP and two calibrated needle gauges on either side of the TS flow model to monitor IVP gradient across the stenosis (Fig. 1A). Water is pumped through the flow model at a mean steady flow rate of 5 cc/s to simulate characteristic cerebral venous blood flow. ICP is manipulated by infusing additional water through the inlet provided on top of the phantom. To better approximate the high compliance of the TS, we tested seven thin-walled flow models of same size made of four different materials with a range of shore hardness factors (27A - 60A). The ICP was increased in the chamber from 0 – 60 cmH2O in 5 cmH2O increments and IVP gradient was recorded across the stenosis (n = 3 trials per flow model).

Results
The IIH phantom was able to reliably induce and reproduce a stenosis in all the flow models tested (Fig. 1B). In our results, the flow model made out of Agilus 30A was found to be borderline surrogate for TS as it produced a stenosis with an IVP gradient of 8 mmHg at an ICP of ~32 cmH2O, agreeing with typical lumbar puncture opening pressure values (≥25 cmH2O) seen in most IIH patients (Fig. 1C, 1D).

Conclusions
We developed a benchtop model that can mimic the pathophysiology of IIH and can reliably induce TS stenosis by increasing the ICP. We anticipate that our IIH model will facilitate evaluating anatomical and physiological parameters that induce restenosis and will eventually allow testing of new devices that could minimize VSS relapse rate in IIH patients.
Intraaortic injection of contrast is feasible in the Hybrid IR/CT suite and provides higher temporal resolution when compared to 4D CTA with IV contrast injection.

A Tarabishy¹, G Deib¹
¹West Virginia University, Morgantown, WV

Purpose
This is the first documented use of a time resolved 4D CT angiogram with intraaortic injection. We report the technical details and feasibility of utilizing a 4D-CT and C arm fluoroscope in a hybrid interventional suite for brain and spinal angiography with potential applications in replacing the need for selective individual and segmental spinal arteriography. Anticipated intra-aortic injection of only 15ml of iodinated contrast and 4-6 seconds of image acquisition for each 16 cm of brain or spinal column coverage. Volumetric data provided 2-3 frames per second with ability for 3D vascular reconstruction – and subtraction imaging that can be viewed in any projection.

Materials and Methods
We had 3 patient (with subacute intracranial occlusion, Brain arteriovenous malformation and Spinal dural fistula) whom successfully underwent the hybrid angiography in the IR hybrid suite with comparison to standard imaging modalities. The procedure was performed in the 4D-CT Angiography hybrid suite containing the Alphenix TM interventional angiography system and the Genesis TM Aquilion One CT scanner (Canon Medical Systems, Tustin, CA). Under standard sterile conditions, a 5F sheath was placed and standard plane angiography was performed, while volumetric CTA angiography was performed with a 5F pigtail catheter in the aortic
The injector that been filled with a 50% contrast (Optiray-320, Guerbet Group, Villepinte, France) and 50% saline mixture was connected to the pigtail catheter. A 1.5-second injection was performed at 20ml/second for total of 30ml, i.e. about 15ml of actual iodinated contrast. Volumetric angiography reconstruction of the data set was performed at 0.3s interval (320 images, 0.5mm thickness with 16cm of coverage).

Results
Diagnostic high temporal and spatial resolution imaging was obtained with this minimally invasive technology. Select multiplanar CT images at different time frames with comparisons across standard planar catheter angiography showing the separate opacified arterial, parenchymal/nidal and venous phase imaging. Time density curves of both IV and IA CTA showing the separation of the enhancement curves of the artery and veins.

Conclusions
Time resolved Intraaortic-CTA is clinically feasible with high spatial and temporal neurovascular evaluation. It is noted for having higher temporal resolution as compared to standard IV-CTA and reduced contrast load, radiation dose and potential for procedural complications as compared to standard angiography.

Stroke After Protected versus Unprotected Carotid Artery Stenting: An analysis of the National Surgical Quality Improvement Program

P Nazari¹, P Golnari², S Baisiwala¹, S Ansari¹, A Shaibani¹, M Hurley¹, M Potts¹, B Jahromi¹
¹Northwestern University - Feinberg School of medicine, Chicago, IL, ²Northwestern University, Feinberg School of Medicine, Chicago, IL

Purpose
Cerebral protection devices (CPD) are widely used to reduce thromboembolic complications during carotid artery stenting. While case series and systemic reviews suggest CPD efficacy in reducing perioperative complications during CAS, CPD use is not always possible and the magnitude of its protective effect remains unclear. The aim of this study was to evaluate the effect of CPD on stroke and outcome after CAS in current practice.

Materials and Methods
Data was extracted from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) CAS-targeted database spanning 2011 to 2016. The primary outcome was 30-day stroke and discharge to home. Multivariable logistic regression analysis was used to identify independent factors associated with 30-day stroke. The adjusted model included terms for patient- and procedure-specific factors including CPD use, gender, age, race, anatomical high risk factor, emergency operation, symptomatic versus asymptomatic, diabetes, smoking and pre-operation antiplatelet use.
Results
A total of 690 patients undergoing CAS for carotid artery stenosis were identified. A single stent was used in 637 patients, 143 (22.4%) of whom underwent CAS without use of CPD. Stroke after CAS was higher without use of CPD than with CPD (7.0% vs 2.0%; p=0.003). In patients under 65 years of age, discharge to home occurred more frequently in patients undergoing CAS with CPD than without CPD (95.0% vs 85.7%; p=0.027). In multivariate analysis adjusting for patient- and procedure-specific factors, use of CPD (aOR=4.11; 95% CI: 1.47-11.48; p=0.007) and emergency operation (aOR=8.19; 95% CI: 1.01-66.18; p=0.049) were independent risk factors for stroke within 30 days after CAS. Factors associated with discharge to home were use of CPD (aOR=2.05; 95% CI: 1.03-4.08; p=0.042), asymptomatic stenosis (aOR=3.91; 95% CI: 1.88-8.10; p<0.001), non-emergent procedure (aOR=7.82; 95% CI: 2.40-25.47; p=0.001) and preprocedural use of antiplatelet medication (aOR=4.25; 95% CI: 1.38-13.06; p=0.012).

Conclusions
Using a multi-center national quality improvement database, we show that use of CPD is significantly associated with decreased stroke after CAS and increased likelihood of discharge home. This is independent of other risk factors such as symptom status, antiplatelet use and emergent versus elective treatment. Our data provides an estimate of additional risk incurred when CPD use is not feasible or undertaken.

2560
11:49AM - 11:55AM
Minimally Invasive Fluoroscopy-guided Percutaneous Transorbital Bleomycin Sclerotherapy for Treatment of a Slow Flow Intracanal Venous Malformation
A Kuhn¹, K de Macedo Rodrigues², A Puri³, J Singh²
¹UMass Medical Center, Worcester, MA, ²University of Massachusetts Medical Center, Worcester, MA, ³University of Massachusetts, Worcester, MA

Purpose
Orbital malformations represent rare slow flow vascular malformations, accounting for 1-4% of all orbital lesions. A minimally invasive treatment approach should be considered in selected patients as surgical excision may be challenging, incomplete and with a high risk of complication and postoperative recurrence.

Materials and Methods
A 21-year-old female presented to our clinic with left eye exophthalmos causing intermittent headaches, peripheral blurry vision and pressure behind her left eye. The cosmetic nature of the exophthalmos significantly bothered the patient. A preprocedure MRI of the orbit demonstrated a large macrocystic malformation behind the left globe, consistent with a venous malformation. Our patient successfully underwent a single-session fluoroscopy-guided Bleomycin sclerotherapy with percutaneous transorbital access for treatment of her orbital venous malformation. She tolerated the procedure very well and was seen for a follow-up clinic visit 3 months after the procedure. There was minimal residual exophthalmos was barely noticeable. A repeat MRI confirmed the successful treatment results with resolution of the previously seen large loculations of the mass and only some mildly dilated venous channels remaining. The pressure sensation behind the left eye, blurry vision and headaches had improved. The patient was very satisfied with her treatment results.

Results
Left eye exophthalmus (Figure 1A). Pre-procedure contrast enhanced MRI of the orbit shows a large, macrocystic left orbital malformation, consistent with a venous malformation (Figure 1B). Intraprocedural percutaneous transorbital access and injection of Bleomycin (Figure 1C). Simultaneous visualization of fluid-fluid level formation in a cystic compartment of the lesion under ultrasound (Figure 1D). Follow-up MRI 3-month post-procedure shows resolution of the previously seen large loculations of the mass and only some mildly dilated venous channels remaining (Figure 1E).

Conclusions
Sclerotherapy should be considered in selected patients with orbital venous malformations as it represents a safe and successful treatment option, especially when surgical debulking failed to provide symptom relief or the malformation reoccurred. Sclerotherapy provides permanent results with resolution or significant decrease in size of the orbital venous malformation. Patients are generally very satisfied with their treatment, specifically the cosmetic result.
Scientific Abstract Session: Interventional/Stroke 2
1532
11:00AM - 11:06AM

Effect of Endovascular Recanalization on Lesion Progression and Clinical Outcome in Patients with a Poor Collateral Profile

G BROOCKS¹, A Kemmling², J Fiehler³, H KNIEP⁴, T Faizy⁵, M BECHSTEIN⁶, L Meyer⁷, U Hanning³
¹UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, ²University Hospital Kaiserslautern, Kaiserslautern, AK, ³University Medical Center Hamburg-Eppendorf, Hamburg, AK, ⁴UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, GERMANY, ⁵Stanford University, STANFORD, CA, ⁶UNIVERSITY MEDICAL CENTER HAMBURG - EPPENDORF UKE, HAMBURG, 20246, HAMBURG, ⁷University Medical Center Hamburg, Hamburg, AK

Purpose
The impact of the cerebral collateral circulation on lesion progression and clinical outcome in ischemic stroke is well established. Moreover, collateral status modifies the effect of endovascular treatment and was therefore used to select patients for therapy in prior studies. The purpose of this study was to quantify the effect of vessel recanalization on lesion progression and clinical outcome in patients with a poor collateral profile. We hypothesized that in patients with poor collaterals, endovascular recanalization is associated with improved clinical outcome by directly reducing ischemic lesion progression.

Materials and Methods
171 acute ischemic stroke patients with acute middle cerebral artery occlusion were included. Collateral profile was defined using an established 5-point scoring system in CT-angiography. Lesion progression was determined using quantitative lesion water uptake measurements in the admission and follow-up CT (FCT) as imaging biomarker, and clinical outcome was assessed using modified Rankin Scales (mRS) scores after 90 days.

Results
130 patients exhibited a intermediate-poor collateral score (CS) of 0-2, and 41 had good collaterals (CS 3-4). In patients with poor collaterals and persistent vessel occlusion, the mean mRS after 90 days was 5.2 (95%CI: 4.6-5.7), which was significantly higher than in patients following successful vessel recanalization (mean mRS 4.0, 95%CI: 3.7-4.4). Edema formation in FCT was significantly lower in poor collateral patients with vessel recanalization versus persistent vessel occlusion (19.5%, 95%CI: 17-22% versus 27%, 95%CI: 25-29%).

Conclusions
Although poor collaterals are known to be associated with poor outcome, endovascular recanalization was still associated with significant edema reduction and comparably better outcome in this patient group. Patients with poor collaterals should not generally be excluded from thrombectomy.
Shifts in Patient Volumes Following the Addition of Endovascular Thrombectomy Capability in a 3 Center System

M Zhou¹, A Kansagra²

¹Washington University in St. Louis, St. Louis, MO, ²MALLINCKRODT INST. OF RADIOLOGY, SAINT LOUIS, MO

Purpose
With the introduction of Thrombectomy-Capable Stroke Centers (TSC), there is considerable interest among existing stroke hospitals to add endovascular thrombectomy (EVT) capability as a means to attract and retain stroke patient referrals. In this work, we quantify changes in patient volumes when adding EVT capability to an existing stroke center.

Materials and Methods
In MATLAB 2017a Simulink, we simulated an existing primary stroke center (PSC) upgrading to a TSC in a system comprising three hospitals: an EVT-capable comprehensive stroke center (CSC), an EVT-incapable PSC, and a PSC that gains EVT capability. We model these changes using two different routing paradigms that determine initial hospital destination. Patients are transferred when clinically appropriate after confirmation of large vessel occlusion. In Nearest Center, patients are sent to the nearest center regardless of EVT capability. In Bypass, patients with more severe strokes are sent to the nearest EVT-capable center, and all others are sent to the nearest center. Probability of good clinical outcome is determined by type and timing of treatment using clinical trial data.

Results
In Nearest Center, becoming a TSC maintains patient capture at 35.2% and retains 18.6% of patients that would otherwise transfer for EVT. Relative increase in EVT in the whole population was 0.7%. Absolute increase in population good clinical outcome was 0.8%.

In Bypass, becoming a TSC increases patient capture from 7.1% to 46.7%, representing an increase from 4.3% to 17.2% receiving IV tPA only, 0% to 18.2% receiving EVT that would otherwise transfer, and 2.6% to 11.5% receiving neither. Relative increase in EVT in the whole population was 0.5%. Absolute increase in population good clinical outcome was 0.6%.

Conclusions
Upgrading to a TSC dramatically shifts patient volume from CSCs, especially with routing models that permit bypass of nearby hospitals for EVT-capable centers. This shift in patient volume produces minimal improvement in population health. This data can inform planning efforts at stroke centers and hospital systems considering adding EVT capability.
D Bageac1, R De Leacy1
1Icahn School of Medicine at Mount Sinai, New York, NY

Purpose
Patients with a history of prior cerebral infarction have been observed to experience worse functional outcomes following mechanical thrombectomy (1). The location of prior infarction relative to the acute occlusion may significantly influence this finding. This study investigates the effect that the location of previous infarction has on 90-day outcomes of stroke intervention by mechanical thrombectomy.

Materials and Methods
A prospectively maintained single center database was queried for cases of stroke intervention by mechanical thrombectomy occurring between January 2015 and August 2019. The primary outcome measure was modified Rankin Scale (mRS) assessed at 90 days post-intervention. Good outcome was defined as mRS<3 (functional independence). Demographic and clinical data were assessed by chart review. Location of prior infarction was ascertained via radiology reports. A binomial regression was performed to ascertain the effect of these factors on 90-day outcomes.

Results
479 thrombectomy cases were identified and included in final analysis. 90 patients had a prior history of cerebral infarct, of which 46 were ipsilateral to the treated occlusion. Patients with a prior history of infarction were significantly more likely to present with a lower baseline mRS than those without (mean 1.58 vs 0.75 respectively; X2 (1, N = 479) = 48.3, p< .0001). These groups did not differ significantly with regard to age, gender, NIH Stroke Scale (NIHSS) at presentation, or time between stroke onset and final recanalization. Good outcomes at 90-days were seen in 35% of patients without a prior history of cerebral infarct, 27% with a prior history of contralateral infarct, and only 9% of patients with a history of ipsilateral infarct. After binomial regression controlling for all variables discussed above, prior ipsilateral infarct was revealed as an independent predictor or poor outcome (OR 5.7, 95% CI [1.8, 17.8]). Prior contralateral infarct was not an independent predictor of poor outcome (OR 1.12, 95%CI [0.49, 2.5]).

Conclusions
This single center retrospective analysis revealed a large (OR 5.7), statistically significant associate between poor 90-day outcomes after thrombectomy and a past history of cerebral infarction ipsilateral to the treated occlusion. This effect persists after controlling for known confounders. Interestingly, a history of contralateral infarct did not confer a significant risk increase. If validated, this finding may help inform clinical decision making regarding stroke intervention.

2743
11:21AM - 11:27AM

Poor Collaterals: to Go or not to Go

M Mohammaden1, L Pisani1, C Perry da Camara1, A Al-Bayati1, D Haussen1, R Nogueira1
1Emory University School of Medicine, Grady Memorial Hospital, Atlanta, GA

Purpose
The treatment effect of mechanical thrombectomy on large vessel occlusion strokes (LVOS) is based on the concept of salvageable tissue (penumbra), which is highly correlated with the degree of collateral blood flow. Our aim is to compare the outcome between patients with poor collaterals who underwent MT versus best medical treatment (BMT).

Materials and Methods
Stroke codes in a comprehensive stroke center from February 2018 to August 2019 were reviewed. Patients were included if they had; 1) intracranial internal carotid or middle cerebral artery occlusion without tandem lesion, 2) poor collateral in multiphase computed angiography (mCTA, ESCAPE Grade=0) and 3) good quality CT perfusion

Results
Among 1727 stroke codes, 32 patients were eligible for the analysis, 14 underwent MT and 18 were in the BMT arm, mean age 62.3±16.5 years, baseline NIHSS score 20±5, ASPECTS 5.9±2.6, median [IQR] last known well to image (LKW-image) 270 [89.3-449] minutes. Patients who underwent MT were significantly younger (52.9±13.6 vs. 69.6± 15.1 years, p=0.003) and were more frequently males (85.7% vs. 38.9%, p=0.01). There were no differences in baseline NIHSS score, ASPECTS, and LKW-Image. CTP parameters were comparable between both groups; rCBF <30% (p=0.10), Tmax >6 (p=0.31), absolute mismatch volume (p= 0.06). Patients who underwent MT had significantly lower final infarct volumes (134.8±10.6.5 vs. 248.7± 107.7 ml, p=0.01), lower discharge NIHSS scores (9.8± 9.4 vs. 17.1± 8.6, p=0.047) and higher rates of good outcome (42.9% vs. 5.6%, p=0.027). Symptomatic intracerebral hemorrhage and malignant edema were comparable between both groups.

Conclusions
Poor collaterals grade on mCTA should not be used as a treatment exclusion criterion for patients who may be otherwise thrombectomy candidates.
Favorable venous microvascular profile is associated with smaller ischemic lesion growth and smaller final core infarction volume in patients with acute ischemic stroke due to large vessel occlusion

T Faizy¹, R Kabiri¹, M Leipzig¹, S Christensen², G BROOCKS³, F Flottmann⁴, H Leischner⁵, M Lansberg⁶, G Albers⁷, J Fiehler⁸, M Wintermark⁹, J Heit¹⁰
Purpose
In the event of an acute ischemic stroke due to large vessel occlusion (AIS-LVO), patients with large core infarction and malignant edema have worse outcomes. Core infarction size growth is caused by poor cerebral blood flow and impaired microvascular perfusion. Cerebral microvascular perfusion is governed by the in-flow of arterial blood to the brain tissue, but also likely by the outflow of blood through the cerebral veins. Venous blood flow in the context of AIS-LVO may better indicate the the overall quality of tissue perfusion, as it reflects blood flow after passing the brain tissue. We determined if the venous microperfusion profile (VMP) predict ischemic lesion growth and final infarct core in AIS-LVO patients.

Materials and Methods
We performed a multicenter, retrospective cohort study of AIS-LVO patients undergoing thrombectomy triage with CT angiography (CTA) and CT perfusion (CTP). Patients with motion artifact and incomplete electronical medical data were excluded. Patient details were obtained from prospectively maintained stroke databases and the electronic medical record. VMP was determined by opacification of the vein of Labbé, sphenoparietal sinus, and superficial middle cerebral vein on pre-thrombectomy CTA as: 0, not visible; 1, moderate opacification; and 2, full. Brain edema progression and ischemic lesion growth was assessed by Net Water Uptake (NWU), which was calculated on pre-treatment and post-thrombectomy non contrast computed tomography images using manual regions of interest. Primary outcome measure was ischemic lesion growth after thrombectomy. Secondary outcome was final core infarction volume, which was manually segmented on follow-up CT and MRI studies 24-48 hours after thrombectomy.

Results
250 patients met inclusion criteria. Linear regression models found that increased patient age (p=0.011), higher blood glucose levels (p=0.007), lower TICI scores (<0.001) and reduced VMP (<0.001) predicted increased ischemic lesion growth (NWU). In a multivariate regression analysis, poor VMP predicted ischemic lesion growth while controlling for age, blood glucose, and TICI score (ß=-2.111840,[ 95% CI -2.80805256 -1.41562150]; p<0.001). After controlling for age, blood glucose, and TICI score, poor VMP predicted higher final core infarct size (ß= -22.57626,[ 95% CI -30.7799325 -14.3725813]; p<0.001).

Conclusions
Poor cerebral perfusion on the venous microvascular profile predicts ischemic lesion growth and final infarct core volume in AIS-LVO patients treated with thrombectomy.

1537
11:35AM - 11:41AM

Stent Occlusion after Emergent Stenting in Patients with Acute Ischemic Stroke and Tandem Lesions: Frequency, Predictors and Clinical Relevance
J Blasco Andaluz1, A Renu2, S Amaro2, J Moreno2, A Lopez-Rueda2, N Macias2, F Zarco3, A Vargas2, V Cuba Camasca2, A Marin Suarez2, A Narbona2, J Macho2, L San Roman2
1Hospital Clinic of Barcelona, Barcelona, Barcelona, 2Hospital Clinic of Barcelona, Barcelona, Catalonia, 3Hospital Clinic Barcelona, Barcelona, Catalonia

Purpose
Emergent carotid stenting is a widespread strategy for the treatment of tandem lesions in patients with large vessel acute ischemic stroke. Our aim was to investigate the frequency, predictors and clinical relevance of carotid stent occlusion after acute stenting during mechanical thrombectomy.

Materials and Methods
99 patients with tandem lesions and large vessel acute ischemic stroke, treated with emergent carotid stenting from a single-center prospective registry were analyzed. Carotid stent occlusion was defined as complete occlusion in post-procedural vascular imaging. Pretreatment, procedural and outcome variables (including final infarct volume and 90-day clinical outcome) were recorded and analyzed through logistic regression.

Results
A total of 22 out of the 99 included patients (22%) had stent occlusion in follow-up vascular imaging. In multivariate analysis the variables independently associated with stent occlusion were a lower use of post-stent angioplasty (adjusted-OR=13.2, 95%CI=2.59-67.05, p=0.002) as well as the degree of residual stenosis (adjusted-OR=2.2, 95%CI=1.37-3.56, p=0.001) and an mTICI score 0-2a (adjusted-OR=7.9, 95%CI=1.02-60.7, p=0.048) at the end of the endovascular procedure. Stent occlusion at follow-up was independently associated with poorer ordinal distribution of the 90-day modified-Rankin scores (adjusted-OR=3.9, 95%CI=1.32-11.28, p=0.014) and with an increased risk of symptomatic intracranial hemorrhage (OR=12.0, 95%CI=1.18-121.91, p=0.035). Final infarct volume was higher in those patients with stent occlusion and poorer intracranial vessel patency (TIMI<3) at follow-up MRI (p=0.024).

Conclusions
Carotid stent occlusion after emergent stenting in acute ischemic stroke patients with tandem lesions is not infrequent and may lead to...
poor outcomes. We provide relevant information in order to predict stent occlusion during early follow-up. Further investigation is warranted for the evaluation of strategies aimed to prevent carotid stent occlusion.

1340

Strategies to Mitigate Endovascular Thrombectomy Demand in Excess of Hospital Capacity

A Dalsania¹, A Kansagra²
¹Rutgers New Jersey Medical School, Newark, NJ, ²Mallinckrodt Institute of Radiology, Washington University School of Medicine, Saint Louis, MO

Purpose
The rise in demand for endovascular thrombectomy (EVT) has increased the possibility that multiple patients with acute ischemic stroke may present concurrently and exceed local capacity to provide timely treatment. The occurrence of excess demand has recently been studied, but to date there has been no quantitative assessment of strategies to reduce the occurrence of excess demand. In this work, we quantitatively compare the efficacy of various strategies to mitigate excess demand using computer simulation.

Materials and Methods
Strategies evaluated included a backup neurointerventional team for 3 h, 8 h, or 24 h; a separate pre-intervention imaging team; and 30% decrease in procedure duration. Hours of partial backup coincided with periods of greatest historical demand. For each strategy, empirical distributions for time of patient presentation and case duration were used to probabilistically generate arrival time and case duration for 16 000 independent trials, corresponding to 16 000 hospital-years. This process was repeated across a range of annual patient volumes, from 1 to 500 cases per year. Excess demand was calculated from time series representing the number of concurrent cases at each minute of the year for each trial at each patient volume.

Results
All strategies decreased annual excess demand compared to baseline (Figure). As expected, the greatest decrease was seen with a 24 h backup team. At a representative volume of 250 cases per year, availability of a backup team for 3, 8, and 24 h reduced the occurrence of excess demand by 27.0%, 60.3%, and 97.2%, respectively, compared to baseline. Similarly, availability of a pre-intervention imaging team and 30% decrease in procedure duration reduced the occurrence of excess demand by 26.6% and 17.7%, respectively, compared to baseline.

Conclusions
Several strategies can decrease the occurrence of excess demand for EVT, but a backup neurointerventional team produced the largest decreases. Substantial decreases in the occurrence of excess demand were realized even with partial backup coverage. Quantitatively understanding the benefit and cost of each of these strategies can facilitate development of rational and efficient models of care.
Real World Evidence for Acute Stroke Thrombectomy in the United States from the NVQI Registry

S Ansari1, R Abdalla2, D Robinson Cantrell3, A Mozafarykhamseh4, A Shaibani5, M Potts4, B Jahromi4, M Hurley1, N NVQI Investigators6
1Northwestern University Feinberg School of Medicine, Chicago, IL, 2Northwestern University, Chicago, IL, 3N/A,
N/A, 4Northwestern University - Feinberg School of Medicine, Chicago, IL, 5Northwestern University Feinberg School of Medicine,
Chicago, IL, 6Northwestern University, CHICAGO, IL

Purpose
Multiple randomized controlled trials demonstrated the significant clinical benefit of endovascular stroke thrombectomy in anterior circulation large vessel occlusions (LVO) within 6 hours. More recent trials have shown the benefit to extend up to 24 hours with advanced imaging selection. We aim to present real-world evidence for endovascular thrombectomy (EVT) practiced in the United States using the Neurovascular Quality Initiative (NVQI) registry.

Materials and Methods
Data from the NVQI registry was analyzed for anterior circulation acute ischemic strokes treated with EVT in 23 US centers (17 states) from Feb 2015 to Oct 2019.

Results
Anterior circulation EVT was performed in 90.5% (2808/3103 patients). LVO sites were most common in the MCA (74%) vs. the ICA (25% cervical and/or terminus) with few isolated ACA occlusions (1%). Mean age at intervention was 68.8 ± 15.4 (48.6% male) presenting with a mean NIHSS of 15.8 +/- 6.8. ASPECTS was reported in 69.2 % of cases with only 47.9% presenting with ASPECTS≥7. CT/CTA was performed in 94% of cases whereas MRI/MRA was limited to 14%. The median arrival to groin puncture time was 87 min, onset to groin time was 291 min, and procedure time was 33 min. 43.1% of patients received IV rtPA. 84% of cases were successfully treated (TICI 2b/3 reperfusion), 45% reported single pass successful recanalization, with 3.9% technical failures (2.3% access related). Intraprocedural complications were reported in 4.6% of cases (0.4% vessel perforations, 0.5% hemorrhagic transformations, 1.1% non-target embolization, and 1.2% iatrogenic dissections). Mean post-operative length of stay was 8.5±/11.4 days, with 11.2% in-hospital mortality. 90 day follow-up mRS was reported in 67.5% of cases with mRS≤2 achieved in 37.3% and 90-
day mortality reported in only 1.3% of cases. Missing data were most common in technical failure, intraprocedural complications, and 90-day mRS amounting to 13.5%, 15.3% and 32.5% of cases, respectively.

Conclusions
Stroke thrombectomy practices, procedural metrics, and outcomes from the NVQI registry mirrors the findings from the HERMES meta-analysis confirming the real-world practice and evidence for EVT in the US. Stricter quality reporting guidelines, improving clinical follow up, and the potential for automated imaging data adjudication will transition quality reporting infrastructures to be utilized for regulatory device monitoring, expanding indications, clinical trials, and value-based reimbursements.

Young Professionals Programming: Show Me the Money

2595

11:45AM - 11:50AM

Academic Performance-Based Compensation Models in Neuroradiology

N Coleman¹, W Mehan¹, P Schaefer², J Hirsch³
¹N/A, N/A, ²Massachusetts General Hospital, Wayland, MA, ³Massachusetts General Hospital, Boston, MA

Purpose
The purpose of this abstract is to highlight alternative compensation models for academic neuroradiology departments which could help account for the wide range of essential, but non-RVU-generating activities uniquely encountered by the academic neuroradiologist.

Materials and Methods
We will define the traditional RVU-based reimbursement model, review current attempts to develop compensation plans targeted at research, teaching, and administration, and describe potential models for incentivizing academic productivity as outlined in the recent JACR article "Academic Performance-Based Compensation Models" by Mehan, Schaefer, and Hirsch, but specifically tailored to the academic neuroradiology practice.

Results
The vast majority of compensation models in neuroradiology are at least partially based on the RVU, a nonmonetary standardized unit that includes a work component, practice expense, and professional liability. A certain number of RVUs are assigned to every Current Procedural Terminology code. Every reimbursable physician service must have a CPT code, which also has an associated RVU. Those RVUs then determine payment after the application of a standardized conversion factor. In similar fashion, research, teaching, and administrative activities can be tied to a certain "academic relative value unit" which may vary based on research publication author position, grants received, or educational leadership roles. Units could also be assigned for leading neuro-oncology tumor boards and neuroscience conferences, teaching neuroradiology residents and fellows, developing innovative clinical practice models and algorithms for neurological diseases such as stroke management, adopting or introducing new neuroradiological procedures, and for leadership positions in national professional societies. Various options when implementing an academic performance system include minimum productivity requirements, bonus schemes, and salary-at-risk models.

Conclusions
Academic neuroradiologists dedicate a great deal of time towards essential, but not directly reimbursable, activities including research, teaching, and leadership. Alternative compensation models which incentivize these efforts may well serve academic departments in their efforts to attract and retain radiologists.
### Normal Myelination of the Spinal Cord in Early Childhood: Imaging Characteristics on MRI

**E WEIDMAN¹, A Vossough²**

¹NEW YORK PRESBYTERIAN HOSP./WEILL CORNELL MED. COL, NEW YORK, NY, ²University of Pennsylvania - CHOP, Philadelphia, PA

**Purpose**

Unmyelinated normal white matter tracts in the pediatric spinal cord have T2-hyperintense signal on MRI and may mimic spinal cord disease. Autopsy studies have described incomplete myelination of spinal cord white matter tracts in early childhood, however the timeline of myelination of the spinal cord is not well known on imaging. The purpose of this study is to retrospectively evaluate the
degree of myelination of the spinal cord on conventional MRI sequences in early childhood to serve as a baseline for image interpretation.

Materials and Methods
Axial T2-weighted images of the cervical and thoracic spine acquired on 1.5 and 3.0 Tesla MRI between 1/1/2002 – 3/27/2019 in children age 0-2 years were retrospectively reviewed for presence of longitudinal T2-hyperintense signal in the spinal cord. Images were acquired as part of routine clinical care at a tertiary care children's hospital. Summary of medical records was reviewed for presence of known confounding pathology in the brain or spine. Cord signal was interpreted as normal in the clinical report by a subspecialty-trained pediatric neuroradiologist for all patients included in this study. Studies were categorized for degree of T2-hyperintense signal in the lateral cord seen on ≥2 contiguous slices (0 = no discernible signal; 1 = very faint, may require windowing; 2 = faint; 3 = obvious).

Results
435 MRI exams from 409 patients were retrospectively reviewed. 190 studies were included in analysis and 245 were excluded (due to motion-degraded axial T2, confounding pathology including white matter disease, tumor, infarct or parenchymal injury on spine or concurrent brain MRI). Longitudinal T2-hyperintense signal in the lateral cord was seen in all (15/15) subjects 0-1 month of age, and was not seen in subjects ≥ 21 months of age (0/15). By signal intensity category and age group (0-5, 6-11, 12-17, 18-24 months), Category 0 signal was seen in 47.5%, 80.0%, 76.2%, 97.0% of subjects, Category 1 in 13.8%, 11.4%, 21.4%, 0%; Category 2 in 23.8%, 8.6%, 2.4%, 3.0%; and Category 3 in 15.0%, 0%, 0%, 0% of subjects.

Conclusions
Characteristic longitudinal T2-hyperintensity in the spinal cord is commonly seen in infants and should not be mistaken for pathology, and is less obvious or absent after one year of age.

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2419

Head Circumference Calculation on MRI – A Simple Tool for use in Pediatric Neuroradiology

A Smyth1, J Potts2, M Sargent2

1BC Children's Hospital, Vancouver, DC, 2BC Children's Hospital, Vancouver, British Columbia

Purpose
While interpreting MRI brain examinations in a child, an attempt is made to assess head size by estimating the craniofacial ratio, which is subjective and inaccurate. It would be beneficial to know if the head circumference can be reliably calculated using a simple

(Filename: TCT_2112_ASNRFigure.jpg)
formula with two diameters measured from routinely performed sequences. The purpose of this study is to determine if the head circumference calculated by bi-planar MRI measurements are accurate when compared to the physical measurement obtained using a tape measure.

Materials and Methods
This is a prospective cohort study of 120 consecutive patients, aged 0-7 years, who had head circumference measurement performed, by nursing staff, using a tape measure (HC-TM) on the same day as a MRI brain. The greatest fronto-occipital diameter (FO) from the sagittal T1 sequence and the greatest biparietal diameter (BP) on the axial T2 sequence were measured on MRI. The head circumference (HC-MRI) was calculated using the formula: (FO + BP) x π/2).

Results
The mean HC-TM was 45.7 cm, with 95% confidence limits of 44.5, 46.9. The mean HC-MRI was 45.0 cm, with 95% confidence limits of 43.8, 46.2. The mean difference was 0.7 cm (HC-TM>HC-MRI), with 95% confidence limits of 2.7, -1.3. A Bland-Altman plot is attached which displays the results of the mean difference and the 95% confidence intervals between the two methods of head circumference measurement (see attached figure). The level of agreement between the two methods of measuring head circumference was calculated using an interclass correlation coefficient (ICC) and showed excellent agreement. The ICC was 0.98, with 95% confidence limits of 0.97, 0.99.

Conclusions
Head circumference can reliably be calculated using two measurements obtained on standard sequence MRI brain studies using a simple formula. This will be of benefit when interpreting MRI studies in the pediatric population and can be used as an additional metric when monitoring head growth over time.

![Bland-Altman plot](TCT_2419_headcircumferencescatterplot3v12019-11-07.JPG)

**Wernicke Encephalopathy in a 6 year old: A Case Report with Key Imaging Findings**

A Rizvi¹, E Gulko², H Mehta², G Dauer², S Bobra²

¹Westchester Medical Center, Norwalk, CT, ²Westchester Medical Center, Valhalla, NY
Purpose
We discuss a case of Wernicke Encephalopathy in a 6 year old female with emphasis on history and key radiological imaging features, and a discussion of key differential diagnoses.

Materials and Methods
We present a case of a unvaccinated 6 year old female with a history of recurrent urinary tract infections, who presented to the emergency room with 6 day history of UTI symptoms and 2-4 day history of ataxia, visual disturbances, and dizziness. The patient is also seen by a naturopathic doctor and readily takes 2-3 drops of vitamin A (only 1 drop was advised), silver colloid, olive leaf extract, grapefruit seed extract, and tea tree oil. Her physical exam demonstrated clumsy fine motor skills with ataxia and a wide-based gait.
CT of the head and MRI of the head and spine were performed. Findings demonstrated abnormal hypodensity and signal abnormality in the dorsal pons, midbrain, hypothalamus, thalamus, and basal ganglia. Findings were suggestive of a metabolic encephalopathy. The patient was prophylactically started on antibiotics and given multiple vaccinations. Her outpatient supplements were held and she was started on IV Thiamine, after which she showed dramatic clinical improvement. Repeat MRI brain demonstrated improving signal abnormality. Eleven days after admission, the patient was discharged.

Results
CT Head demonstrates hypodensity in the region of the third ventricle or along its margin. MRI brain demonstrates extensive abnormal T2/FLAIR hyperintensity involving large portions of the dorsal pons and dorsal midbrain. There is extension to the hypothalamic region, bilateral thalami, and right basal ganglionic region. No evidence of focal abnormal intracranial enhancement.

Conclusions
We present a case of Wernicke encephalopathy in a 6 year old female with dramatic improvement after IV Thiamine therapy and discontinuation of outpatient supplements. Given the findings and clinical course, it is suspected that the outpatient supplements the patient was taking may have been dissolved in ethanol, interfering with thiamine absorption and resulting in Wernicke encephalopathy. The imaging findings demonstrate the classic distribution, involving the thalami, hypothalamus, mammillary bodies, and periaqueductal gray matter. Additional differential considerations include infectious etiology such as viral encephalitis, acute disseminated encephalomyelitis, neoplasm, or other toxic/metabolic encephalopathy. We aim to discuss clinical and imaging features of key differential considerations.
CSNR Programming: Microskills of Neuroradiology Interpretation

2215
2:40PM - 2:45PM

Relative brain density is superior to absolute density in predicting hemorrhagic transformation of brain infarction post thrombectomy.

D Byrne1, J Walsh2, B Alomran2, B Niu3, F SETTECASE4, S Nicolaou2, T Field2, N Murray2, M Heran2, M van den Broek2, A Rohr2
1Vancouver General Hospital, Vancouver, BC, 2Vancouver General Hospital, Vancouver, British Columbia, 3University of British Columbia, Vancouver, BC (British Columbia), 4UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC

Purpose
Parenchymal hyperdensity is common on post thrombectomy CT and may relate to hemorrhagic transformation of infarction on follow-up imaging. The "metallic hyperdensity sign"(1) has been reported to be a reliable predictor of hemorrhagic transformation post thrombectomy. Although parenchymal contrast staining is a surrogate marker for endothelial damage, the concentration of contrast staining varies according to multiple factors such as volume of contrast administered, patient's renal function and cardiac output (2). We hypothesized that the ratio of the maximum HU value within areas of parenchymal contrast staining relative to the attenuation of the superior sagittal sinus may be a better marker than absolute maximum density.

Materials and Methods
39 patients with large anterior circulation artery occlusion, small infarcts on admission (pre-procedural ASPECTS> 7), successful mechanical recanalization (mTICI 2B/3) and parenchymal hyperdensity post thrombectomy were included. 0.3 cm² ROIs were drawn in the most hyperdense brain region on immediate post-thrombectomy CTs by two readers. Maximum HU value in the ROI and ratio of maximum HU to that in the superior sagittal sinus (SSS) were recorded. Values were then correlated with the development of hemorrhage on 24-h follow-up CTs.

Results
Although the maximum attenuation value of parenchymal hyperdensity identified on mixed 120kVp images was numerically greater in those patients who went on to develop intracranial hemorrhage (median 73.5 HU; range 52-370 HU;) than in those who did not (median 62.3 HU; range 47-96 HU), this difference was not statistically significant (p=0.231). The ratio of maximum attenuation of parenchymal hyperdensity on 120 kVp images to the density of the SSS was significantly higher (p=0.043) in those who went on to develop intracranial hemorrhage (median 0.97, range 0.74-4.0) than in those who did not (median 0.83, range 0.69-1.15).

Conclusions
We found that the ratio of the maximum attenuation value of parenchymal hyperdensity to the attenuation of the superior sagittal sinus may be a more reliable predictor of future hemorrhagic infarct transformation than the absolute density.

2290
2:45PM - 2:50PM

Vessel Wall MRI Predicts Acute and Future Stroke in Patients with Cerebral Amyloid Angiopathy

J McNally1, A Sakata2, M McLaughlin2, M Alexander2, S Kim3, A De Havenon3, G Stoddard2
1University Of Utah, Salt Lake City, UT, 2University of Utah, Salt Lake City, UT

Purpose
Cerebral amyloid angiopathy (CAA) is characterized by arteriolar wall β-amyloid deposition leading to stroke despite absent angiographic findings. In intracranial atherosclerosis, vessel wall MRI (vwMRI) depicts arterial wall enhancement, which is associated with concurrent and future ischemic stroke independent of stenosis. Our goal was to determine the association of vwMRI findings in CAA patients in relation to acute and future stroke.

Materials and Methods
IRB approval was obtained for this retrospective study on CAA patients with suspected stroke undergoing 3T-vwMRI from 2015-19. Modified Boston criteria were used by a vascular neurologist (AD) to diagnose CAA. Vessel wall enhancement was detected on pre/postcontrast flow-suppressed 3D-T1-weighted images and interrater agreement determined by prevalence/bias-adjusted Kappa analysis. Univariate followed by multivariate Cox regression was used to determine the association of vwMRI findings and cerebrovascular risk factors with future ischemic stroke in CAA patients, followed by backwards-elimination to a p<0.20 threshold. Kaplan-Meier survival curves were generated. All statistical analyses were performed with Stata 14.1 statistical software (StataCorp, College Station, Texas).

Results
50 CAA patients underwent vwMRI, 35/50 (70.0%) with ischemic stroke. 29/50 (58.0%) patients showed vessel wall enhancement (VWE), Kappa=0.80 (95%CI: 0.66-0.94). Subjects had total time at risk of 37.5 years and future ischemic stroke incidence event rate of 49.7% (95%CI: 34.5-67.2%) per year. Kaplan-Meier survival analysis showed shorter stroke-free survival for patients with VWE with event rate of 63.9% (95%CI: 43.2-84.0%) per year compared to 32.2% (95%CI: 14.4-62.3%) in those without VWE, Chi-square
of 4.9, p=0.027. Univariable Cox regression analysis for future stroke confirmed VWE increased future stroke risk (HR=3.1, 95%CI:1.1-8.6, p=0.027) as did initial stroke (HR=4.2, 95%CI: 1.2-14.3, p=0.023). Backward conditional modeling adjusted for risk factors and time from initial vwMRI to future stroke revealed that 2 factors remained in the final model: initial ischemic stroke (HR=3.4, 95%CI: 1.0-12.0, p=0.053) and VWE (HR=2.5, 95%CI: 0.9-7.0, p=0.080). C-statistic for the final model was 0.70, showing good concordance for future ischemic stroke.

Conclusions
In CAA, vessel wall enhancement has high interrater reliability. Along with initial stroke, vessel wall is an additional risk factor for future ischemic stroke risk.

(Filename: TCT_2290_Figure1.jpg)

2495

Perirolandic sign, a new diagnostic marker in the early onset of polymerase gamma related disorders.

F Goncalves1, C Alves1, S Teixeira1, J Martin-Saavedra1, A Vossough2, G Zuccoli3
1Children's Hospital of Philadelphia, Philadelphia, PA, 2University of Pennsylvania - Children's Hospital of Philadelphia, Philadelphia, PA, 3Philadelphia, Philadelphia, PA

Purpose
Pathogenic variants in the polymerase gamma gene (POLG) cause a group of clinical syndromes known as POLG-related disorders. Seizures are seen in up to 50% of the patients, including epilepsia partialis continua (EPC). Neuroimaging findings in POLG-related disorders have been described primarily in the later stages of the disease, with the occipital lobe being the most frequently involved. Brain MRI findings at the very early stage of pediatric POLG-related disorders have not been described. The aim of the study was to identify the very early brain MRI changes in children affected by POLG-related disorders and correlate these findings with EEG and clinical findings. The secondary goal of this study was to describe the evolution of brain MRI findings at follow-up.

Materials and Methods
Thirteen POLG-related disorders patients were included. Demographic information, age, clinical history at presentation, EEG findings, elapsed time between the first brain MRI and the most recent EEG. Pathogenic variants of each subject were recorded. The
presence of the signal changes such as the "perirolandic sign" involving the pre- or central gyri, MRI signal changes in the thalami, additional brain MRI findings, the specific sequences in which the signal changes were depicted, and the pooled follow-up findings on brain MRI were recorded.

Results
Nine patients were female (69%). The median age was 3 years. All patients had seizures. Other symptoms included regression, developmental delay, hypotonia, vomiting, and hepatopathy. EEG was abnormal in 86%. Clinical/EEG evidence of EPC was detected in 61%. The most frequent pathogenic variant found was c.1399G>A:p.A467T (54%). Brain MRI was abnormal in 92% of cases. The most common MRI changes were unilateral/bilateral perirolandic signal changes (54%) and unilateral/bilateral thalamic signal changes (77%). On follow-up imaging, the vast majority demonstrated volume loss (77%), which progressed very rapidly within a few weeks without lobar predominance. At follow-up, the most affected areas were the occipital lobe (61%) and thalamus (61%).

Conclusions
Unilateral/bilateral involvement of the perirolandic cortex and unilateral/bilateral thalamic changes, in the setting of EPC, may represent a new imaging phenotype during the early stages of POLG related disorders.
Using Convolutional Neural Networks to Determine the Impact of White Matter Hyperintensities on Cognitive Performance

J Puigu1, J Garre-Olmo2, A Jimenez-Pastor3, E Camacho-Ramos3, C Biarnes4, J Vilanova5, R Pamplona2, S Pedraza4, A Alberich-Bayarri3
1IDI-IDIBGI, Girona, Spain, 2IDIBGI-IAS, Girona, Girona, 3QUIBIM, Valencia, Valencia, 4IDI-IDIBGI, Girona, Girona, 5University of Lleida-IRBLleida, Lleida, Lleida

Purpose
Some degree of ischemic damage to white matter tracts is common in older adults; this damage is visible on magnetic resonance imaging (MRI) as focal or confluent white matter hyperintensities (WMH). Although growing evidence suggests links between WMH and Alzheimer's disease, the effects of WMH on cognition are unclear. Convolutional neural networks (CNN) have proven useful in image analysis in different domains. We compared the usefulness of CNN and Fazekas' visual rating scale for determining whether WMH burden is related to cognitive impairment.

Materials and Methods
We studied 418 healthy participants (mean, 66.67 +/- 7.96 years [range, 50-96 years]) consecutively recruited for a population-based study of aging. All imaging studies were obtained on a 1.5 T MRI system (Vantage Elan, Canon Medical Systems, Japan). CNNs were used to assess WMH volume, mean distance, number, and mean entropy. Two radiologists also rated WMHs on Fazekas' scale.

Cognitive performance was evaluated with Symbol Digit Modalities Test (SDMT), Verbal Fluency Test, Semantic Verbal Fluency Test (SVFT), Delayed Free Recall, Digit Span Test (forward), and Stroop Color and Word Test (SCWT). Multivariate linear regression models were adjusted to assess the association between WMH measured by the Fazekas' scale or the CNN approach on several neuropsychological tests. Standardized beta coefficients and coefficients of determination were estimated. All models were adjusted by age, gender, educational level, and cerebral volume.

Results
WMH burden was associated with SDMT, SCWT, and SVFT. In all models, compared to visual rating with Fazekas' scale (R2SDMT=0.464, β=-0.085, P=0.020), CNN-metrics found that WMH burden was a more significant contributor to information processing (R2SDMT=0.478, βmean entropy=-0.233, P<0.001), executive function (R2SCWT=0.306, βmean entropy=-0.416, P<0.001; βmean distance=0.154, P=0.005), and verbal functioning (R2SVFT=0.186, βmean entropy=-0.223, P-value=0.013; βlesion number=0.215, P-value=0.012; βlesion volume=0.241, P-value=0.040).

Conclusions
Our results suggest the impact of WMHs on cognitive performance can be better assessed by CCN than by conventional visual rating. CNN-based quantification could be useful to characterize the pathology of cerebral small vessel disease that affects the vasculature of white matter tracts, subcortical structures and cognitive performance.

Relationship between optic nerve angle, intracranial pressure, and visual outcomes in patients with idiopathic intracranial hypertension (IIH)

S Asnafi1, B Chen1, M Lin1, B Bruce1, J Lock1, R Sharma1, N Newman1, V Biousse1, A Saindane1
1Emory University School of Medicine, Atlanta, GA

Purpose
The tortuosity of the optic nerve can be quantified radiologically by measuring the angle of optic nerve deformation. In idiopathic intracranial hypertension (IIH) patients, lowering the intracranial pressure (ICP) to a normal range by lumbar puncture (LP) leads to straightening of the optic nerve and an increase in the measured optic nerve angle (ONA) on MRI. It is uncertain if ONA can be used as a marker of ICP or if a relationship between ONA and visual function exists. In this study, we aimed to determine the ONA in patients with and without IIH, and to explore the relationship between ONA, CSF-opening pressure (CSF-OP) on LP, and visual function.

Materials and Methods
Retrospective study of patients with/without IIH, who had neuro-ophthalmologic assessment (visual acuity, Humphrey visual field [HVF], fundus photography) and MRI brain immediately followed by LP with CSF-OP. Sagittal ONA was measured on multiplanar T2 SPACE images on a DICOM viewer by two masked reviewers. Papilledema was also graded on fundus photographs (Frisén scale) by two masked reviewers.

Results
Fifty-four IIH patients and 30 unmatched controls were included. The IIH group was six years younger (95%CI 2-10, p=0.002), had 8.7 kg/m2 heavier body-mass-index (4.9-12.5, p<0.001), and 26% more women (p=0.01) compared to controls. In both eyes, ONA
was significantly smaller in IIH patients by 12o compared to controls (7o-17o, p<0.001). In the IIH group, there was no significant correlation between ONA and CSF-OP in either eye (right [OD] r=0.19; left [OS] r=0.18; p>0.15). ONA had no significant correlation with logMAR visual acuity (OD r=0.26, p=0.06; OS r=0.15; p=0.27), HVF mean deviation (OD r=0.0059; OS r=-0.069; p=0.63), or Frisén grade (OD Spearman's rho=0.058; OS rho=0.14; p>0.30).

Conclusions
The ONA is a sign of raised ICP and is significantly smaller in IIH patients compared to controls, but does not correlate with CSF-OP, severity of papilledema, or visual function.

**2306**

**Juvenile-onset Alexander Disease: What the Adult Radiologist Needs to Know**

E Gordon¹, S Houshmand², Z Islam², M Hughes²
¹University of Pittsburgh, Pittsburgh, PA, ²University of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
To present a rare case of juvenile-onset Alexander's disease (AD)*, as well as to compare the clinical and imaging findings to the more well-documented and severe form in infancy.

Materials and Methods
A 25-year old female presented with a 17-year history of globus sensation and brief episodes of dyspnea with more recent episodes of dizziness. She had an uneventful childhood and met all developmental milestones. Physical exam, including a detailed neurological exam, was normal. Gastroenterology and otorhinolaryngology workups were normal, including labs, esophagram and laryngoscopy. A brain MRI was performed; based on the imaging findings and the late presentation of symptoms, a presumptive diagnosis of leukoencephalopathy was made with juvenile-onset AD in the differential. Genetic analysis revealed a heterozygous mutation (R239G) of the glial fibrillary acidic protein (GFAP) gene, confirming the diagnosis.

Results
MRI of the brain reveals multifocal areas of both supra- and infratentorial T2 signal abnormality. Atrophy of the medulla and proximal cervical cord was seen (Fig A). There was abnormal T2 hyperintensity in the peripheral midbrain (Fig B, arrowhead) as well as in the medulla and dentate nuclei (Fig C); relative sparing of the pons was noted. T2 hyperintensity of the periventricular white matter was also observed (not shown). Post-contrast T1-weighted imaging demonstrated focal enhancement in the left brachium pontis (Fig D).

Conclusions
This case illustrates the clinical and imaging findings characteristic of juvenile-onset AD. This disease exists among a spectrum categorized by age of onset, including the infantile-, juvenile- and adult-onset subtypes, each with its own characteristic clinical and MRI findings. As age of onset increases, imaging findings are less extensive just as disease severity is reduced. Compared to infantile-onset AD, juvenile- and adult-onset AD have imaging findings that are progressively more limited to the cerebellum, brainstem, and spinal cord. Specifically, there is less prominent frontal cerebral T2 hyperintense leukodystrophy but with continued demonstration of T2 hyperintensity and atrophy within the brainstem and cervicothoracic spinal cord and concomitant preservation of the pons. Although the slower course of disease obfuscates diagnosis of juvenile- and adult-onset AD, the characteristic imaging findings allow the radiologist to suggest this rare disease. *which accounts for 24% of approximately 500 reported cases of AD
Secondary Hemochromatosis of the pituitary gland as a rare cause of amenorrhea in a patient with Beta-thalassemia

H Kale¹
¹KDA Hospital, Mumbai, India

Purpose
Secondary hemochromatosis is not a well known cause for pituitary dysfunction. Deposition of iron in the pituitary gland may occur fairly early in the disease process although deposition is fairly sparse compared with other organs such as liver, heart and pancreas. Iron deposition in the pituitary may be overlooked on account of its low signal intensity on all sequences as well as decreased pituitary volume. Awareness of this entity can help tailor the protocol to include high resolution sequences for the correct diagnosis.
Materials and Methods
31 year old woman with history of Beta-Thalassemia (thalassemia major) presented with secondary amenorrhea. Had previously received multiple transfusions. Work up revealed iron overload with increased Serum ferritin level of 10069 ng/ml. Imaging was requested to evaluate Pituitary gland.

Results
Imaging of the sella revealed a diminutive pituitary gland with a diffusely low signal intensity on all sequences. The normal T1 signal of the posterior pituitary was preserved. With thin section T1 and T2 weighted sequences as well as dynamic contrast evaluation of the sella, intensely low signal intensity was seen in the pituitary gland. There was also presence of extensive blooming noted in the choroid plexus and along the falx/basal cisterns secondary to iron deposition. Hepatosplenomegaly was also seen with low signal intensity on all sequences. Given the clinical history, a diagnosis of secondary hemochromatosis involving the pituitary gland was established.

Conclusions
Hemochromatosis with iron deposition in the pituitary gland is a rare etiology for amenorrhea. Knowledge of this condition is essential for tailoring the protocol and reaching a correct diagnosis.

(Filename: TCT_1222_ASNR2020.gif)

1605

Rare case of Erdheim Chester Disease with Intracranial Involvement as Initial Presentation

M Bhatt¹, A Thaker¹
¹University of Colorado, Aurora, CO

Purpose
Erdheim-Chester disease (ECD) is a rare non-Langerhan's histocytosis with systemic manifestations characterized histologically by
infiltration of tissues by foamy histiocytes. This case depicts uncommon neurologic presentation of this rare disease (ECD), with additional findings of typical systemic disease.

Materials and Methods
A 41 year-old woman with reported history of asthma initially presented with a constellation of neurologic symptoms including blurry vision, positional dizziness, lip tingling, lower extremity weakness, and emotional lability. MRI was performed and demonstrated enhancing parenchymal masses involving the temporal lobes and upper brainstem. Stereotactic biopsy of a dominant right medial temporal mass revealed "inflammatory process with intense reactive gliosis, microgliosis" and no evidence of neoplasm. However, the patient was subsequently treated at an outside institution for presumptive glioma with fractionated radiotherapy to the brainstem. After 6 of 30 fractions, RT was stopped due to concern for misdiagnosis. Further pathologic evaluation revealed BRAF v600 positivity and +NTRK1 mutation. Steroids were then initiated and further imaging performed, including body PET/CT and thoracic CT. Constellation of systemic imaging findings were consistent with Erdheim-Chester disease. Patient was started on a BRAF inhibitor and had significant clinical and radiographic improvement.

Results
Initial contrast-enhanced MRI brain depicted multiple heterogenous T2 hyperintense enhancing masses within the pons and bilateral medial temporal lobes with significant vasogenic edema. PET/CT demonstrated FDG avidity of the femoral metaphysis with associated osteosclerosis, cortical thickening, and periosteal reaction, in addition to cystic changes with the lungs. Subsequent brain MRI following appropriate treatment for ECD showed progressive improvement in degree of enhancement and perilesional edema.

Conclusions
Erdheim-Chester Disease, a rare non-Langerhan's histiocytosis, has a constellation of systemic clinical, imaging, and histopathologic findings. Intracranial involvement, while uncommon, may take several forms and mimic neoplastic and other inflammatory processes.
Imaging Findings Similar to High-Altitude Cerebral Edema Seen in a Case of Severe Asthma Exacerbation

F Kebbel¹, R Riascos², A KAMALI³
¹McGovern Medical School, University of Texas Health Sciences Center at Houston, Houston, TX. ²Univ. Of Texas - Houston, Houston, TX. ³UT HEALTH, HOUSTON, TX

Purpose
To describe the MR findings of a case of severe asthma exacerbation which demonstrated significant similarities to the findings of High-Altitude Cerebral Edema (HACE).

Materials and Methods
31-year-old female with asthma presenting with shortness of breath, requiring intubation for hypercapnic respiratory failure. After several days, she acutely developed right gaze deviation, increased tone in bilateral lower extremities, and upper extremity posturing on hospital day 5. At that time, she underwent neuroimaging. She slowly improved and underwent a repeat MRI brain on hospital day 9. She was discharged with a diagnosis of status asthmaticus causing hypoxic ischemic brain injury secondary to hypercapnic respiratory failure.

Results
Initial CT and CTA showed patent but narrowed calibers of the anterior and posterior circulations compatible with vasospasm. Initial MRI brain showed diffuse diffusion restriction in the thalami and white matter of the cerebral hemispheres including the internal and external capsules and subcortical white matter of the centrum semiovale, corona radiata, and middle cerebellar peduncles. Numerous punctate microhemorrhages were seen in the corpus callosum, particularly within the splenium, and at the cerebral gray-white matter junctions. Follow up MRI brain four days later showed improvement of the restricted diffusion to the centrum semiovale and splenium with resolution of thalamic diffusion restriction. The microhemorrhages and cerebral edema were significantly improved. Given these findings, the suggestion that these findings could represent an atypical appearance of the physiologic causes/findings of high-altitude cerebral edema was proposed.

Conclusions
High-altitude cerebral edema is a severe complication of acute mountain sickness characterized by confusion, ataxia, mood changes, coma, and papilledema. Typical imaging findings include vasogenic edema along the white matter tracts of the brain with increased T2 signal in the corpus callosum and diffusion restriction in the splenium and subcortical white matter with resolution on follow up scans. More recent studies have shown the presence of microhemorrhages within the deep white matter, mostly in the corpus callosum and subcortical white matter. Our patient displayed all of these findings, despite meeting no other diagnostic criteria for HACE, suggesting that the physiologic causes of HACE can also be present in other causes of cerebral hypoxia, including in hypercapnic respiratory failure.
Glymphatic system activity in idiopathic normal pressure hydrocephalus and Parkinson’s disease using DTI-ALPS method

Y Bae¹, B Choi², J Kim²
¹Seoul National University Bundang Hospital, Department of Radiology, Seongnam, Gyeonggi. ²Seoul National University Bundang Hospital, Seongnam, Gyeonggi

Purpose
The impairment of glymphatic system has been suggested to be a cause of the neuro-degenerative disorders such as Alzheimer's disease (AD), Parkinson's disease (PD), and idiopathic normal pressure hydrocephalus (NPH). We aimed to assess the glymphatic activity using the non-invasive method called "Diffusion Tensor Image Analysis aLong the Perivascular Space (DTI-ALPS) in patients with PD and NPH.

Materials and Methods
From April 2017 to March 2019, study subjects with NPH, PD and age- and sex-matched control subjects were included. Clinical assessment was performed by a neurologist, and MMSE and UPDRS scores were collected. All MRI were obtained using 3T MRI including DTI with 32 directions of gradients and SWI. We adopted the methodology for the DTI-ALPS measurement, and calculated
the index called "ALPS-index" to quantify glymphatic activity along the perivascular space with the reference of SWI (reference: Taoka T, Jpn J Radiol 2017;35:172-178). The measurements were performed twice by two independent neuro-radiologists. The measured diffusivities and the calculated ALPS-index from the two readers were then averaged and used for further statistical analysis as follows: a. Interclass correlation coefficient (ICC) for inter-observer agreement on the measurements, b. Mann-Whitney test for the differences in the diffusivities and the ALPS-index between PD patients/control subjects and NPH patients/control subjects, and c. Correlation coefficient for the correlation between the diffusivities and ALPS-index in PD patients and NPH patients.

Results
Inter-observer agreement was excellent in all measurements (all, ICC>0.77). ALPS index was significantly lower in PD patients than in the control subjects (median 1.55 vs. 1.68, P=.027). Dextra and ALPS index were significantly lower in NPH patients than control (5.56 vs. 6.23, P=.011; 1.152 vs. 1.497, P<.001). In NPH and PD patients, ALPS index showed significant positive correlation with MMSE and MOCA, and significant negative correlation with UPDRS-III. -ALPS-MMSE: rho 0.722, P<.001 -ALPS-MOCA: rho 0.711, P<.001 -ALPS-UPDRS-III: rho -0.425, P=.02 In NPH patients, ALPS index was significantly higher in patients with shunt response (n = 5) than those without (n = 8) (median 1.25 and 1.01, P = .019).

Conclusions
The DTI-ALPS method can be useful in identifying glymphatic dysfunction in PD and NPH.

2131

2:19PM - 2:25PM

The Role of Susceptibility-Weighted Imaging as an Accessory Diagnostic Tool of Global Cerebral Anoxia in the Post Cardiac Arrest Setting

M Klumpp, M Coelho, A Goel, K Mirchia, R Mangla.

SUNY Upstate Medical University, Syracuse, NY.

Purpose
To examine the utility of Susceptibility-Weighted Imaging (SWI) in patients with concern for acute hypoxic-ischemic injury (HII) to the brain in the post cardiac arrest setting. We hypothesize that a disruption in global cerebral oxygen metabolism leads to variable paramagnetic properties within the cerebral vasculature, and therefore produces a spectrum of vascular prominence that can be graded and qualified. It is our goal to demonstrate SWI as an effective accessory tool to assist in qualifying the degree of ischemic injury. In addition, SWI may be a valuable alternative when DWI findings are inconclusive and clinical suspicion remains high.

Materials and Methods
Upon IRB approval, a retrospective chart review was conducted in our tertiary care center. A total of 50 adult patients were selected at random with acute cardiac arrest and MRI evaluation for anoxic brain injury. With review from a board-certified Neuroradiologist, SWI was evaluated with emphasis on the appearance of the superficial cortical veins. The great cerebral vein along with visualized arterial vasculature was also evaluated. This vasculature appearance was quantified using a scale of 0 – 3, 0 for absent or not seen, 1 for diminished appearance, 2 for present and normal, 3 for dilated. These findings were correlated with DWI results.

Results
Of the 50 patients chart reviewed 37 demonstrated MR findings consistent with anoxic brain injury on either T2-weighted or DWI imaging. Within those 37 cases 26 had DWI findings consistent with acute anoxic brain injury (70%). Within the SWI subset, 34 of the 44 available cases demonstrated absent (0) or diminished (1) superficial cortical veins (77%). Importantly, only 5 of the 37 patients (14%) with any MRI findings characteristic of anoxic brain injury did not show any form of diminished superficial venous vasculature on SWI. In comparison to DWI, only 5 of the 26 (19%) cases with DWI findings consistent with HII did not show any form of diminished superficial or great venous vasculature on SWI. Interestingly, 4 of 13 cases with no additional MR findings to suggest anoxic brain injury had diminished or absent superficial cortical veins.

Conclusions
The results of our study illustrate that SWI findings of diminished superficial and deep veins, along with attenuation of arteries are valuable findings in anoxic injury of the brain in the setting of cardiac arrest. We recommend the use of SWI as an accessory diagnostic tool especially in cases of indeterminate DWI findings.

2000

2:26PM - 2:32PM

Potential mechanisms of trigeminal neuralgia in patients presenting with imaging finding of idiopathic intracranial hypertension

S Asnafi, D Adamson, B Philbrick, A Saindane.

Emory University School of Medicine, Atlanta, GA

Purpose
Trigeminal neuralgia (TN) can occur in the absence of neurovascular compression1, 2. Some patients with TN present with a known diagnosis or imaging finding of idiopathic intracranial hypertension (IIH) and lack neurovascular compression on imaging. The co-

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existence of IIH and TN has been reported but the mechanism is unclear. We investigated whether intrinsic anatomic differences or acquired structural abnormalities may play a role in pathogenesis of TN in patients with findings of chronically elevated intracranial pressure (ICP).

Materials and Methods
We retrospectively reviewed patients with TN and imaging consistent with IIH (n=6; IIH+TN), IIH patients without TN (n=6; IIH-TN), and controls without TN who presented for hearing loss (n=9; control). The three groups were of similar gender and age. On FIESTA images we assessed (see figure) 1. trigeminal nerve angle (TNA), 2. osseous angle (OSA) at the Meckel cave (MC) entrance, 3. clearance of MC entrance (MCC), and 4. differences in course of the trigeminal nerve within MC. These measures were compared between groups, and within IIH+TN patients between the symptomatic and asymptomatic side.

Results
No patients had findings of neurovascular compression of the trigeminal nerves. Compared to controls (2.8 mm), there was a significantly smaller mean MCC for both patients in the IIH+TN (1.9 mm; p=0.04), and IIH-TN (2.3 mm; p=0.04) groups. Comparing symptomatic to asymptomatic sides in IIH+TN patients showed significantly smaller MCC (1.7 mm vs. 2.4 mm; p=0.006) and smaller OSA (81.6 degrees vs. 110.5 degrees; p=0.014) on the symptomatic side. Mean TNA was also smaller on the affected side though not significantly. Comparisons of nerve course within MC between groups and within IIH+TN patients by side demonstrated no significant differences.

Conclusions
Chronically elevated intracranial pressure may lead to decrease in clearance for entry of the trigeminal nerve into MC. An asymmetrically smaller MCC with a more acute ("pointier shaped") osseous lower opening of MC is associated with the symptomatic side in patients with IIH and TN.
White Matter Integrity on Diffusion Tensor Imaging and Depressive Symptoms in General Population

J Puig1, C Biarnes2, J Vilanova2, R Ramos-Blanes3, R Pampolona4, S Pedraza2, J Garre-Olmo5
Purpose
Depressive disorders are susceptible to genotype, chronic stress and adverse developmental environmental. These factors lead to changes in the biochemistry and brain structure. Diffusion tensor imaging (DTI) is a quantitative, noninvasive imaging method that provides insight into properties of brain microstructure assessing the integrity of white matter tracts. We aimed to explore the association between white matter integrity and depressive symptoms in general late-life general population.

Materials and Methods
We used data from 838 participants aged 50 years and over from a population-based study that underwent into a comprehensive clinical examination including a 1.5 T whole-body magnetic resonance imaging. Quantitative tract-specific measures based on DTI were extracted to examine their microstructural integrity according to fractional anisotropy (FA) values. The Patient Health Questionnaire-9 (PHQ-9) was used to assess depressive symptoms. PHQ-9 score was regressed on specific-tract FA values adjusted for age, gender, depression history, educational level and total WM volume.

Results
Mean age was 67.1 years (SD=7.3), 47.6% were women, and depression history was more frequent in women (42.9% vs. 17.1%). PHQ-9 score mean was 4.1 points (SD=4.0; range=0-24), and 10.7% scored 10 or more points. 21.0% of the PHQ-9 score variability was explained by the adjusted multivariate regression analysis. Decreased white matter microstructure in the left cerebral peduncle, right superior corona radiata, left posterior corona radiata, right external capsule, left superior longitudinal fasciculus, and right uncinate fasciculus demonstrated significant associations to the PHQ-9 score.

Conclusions
Our results suggest that depressive symptoms in late-life are related with reduced white matter integrity in some specific brain regions. Further research is needed to fully characterize potential imaging biomarkers in order to understand how structural damage explains the various clinical manifestations of depressive symptoms in late life.

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Comparison of compressed sensing Time-of-Flight(TOF) MR angiography and conventional TOF MR angiography with DSA

Y HEO1, H JEONG2, D Kim1, J Baek3
1INJE UNIVERSITY, BUSAN PAIK HOSPITAL, BUSAN, Korea, Republic of, 2INJE UNIVERSITY, BUSAN PAIK HOSPITAL, BUSAN, KOREA-REPUBLIC OF (KOR), 3INJE UNIVERSITY, BUSAN PAIK HOSPITAL, BUSAN, .

Purpose
Time-of-flight (TOF) MR angiography provides high spatial resolution, but it has a limitation associated with relatively long acquisition time. In this study, we hypothesized that compressed sensing (CS)-TOF MR angiography provide better spatial resolution and signal-to-noise ratio than conventional TOF MR angiography, while keeping the scan time clinically acceptable. We evaluated the CS and conventional TOF MR angiography and compared with DSA.

Materials and Methods
Twenty-six patients (12 men and 14 women; mean age, 61.3 ± 10.2 years) who underwent TOF MR angiography and DSA for evaluation of intracranial vascular lesions were included. The MR scan times were 6 minutes and 42 seconds for conventional TOF MR angiography and 5 minutes and 29 seconds for CS-TOF MR angiography. We performed CS- and conventional TOF MR angiography in the same imaging session. Two neuroradiologists independently reviewed both types of MRA and subjectively graded image quality and diagnostic confidence using 3-point scoring relative to the latest DSA findings. We also ranked the order of image quality preference (CS-TOF is better, or equivalent, or conventional TOF is better).

Results
Image quality and diagnostic confidence were not significantly different between two types of MR angiography in both readers with good interobserver agreement. According to the reader 1, 18 patients showed equivalent image quality of CS-TOF and conventional TOF MR angiography, however, CS-TOF MR angiography is better in 7 patients, conventional TOF MRA is better in 1 patient. According to the reader 2, 19 patients showed equivalent image quality of CS-TOF and conventional TOF MR angiography, however, CS-TOF MR angiography is better in 7 patients.

Conclusions
CS TOF MR angiography can provide better image quality than conventional TOF MR angiography without additional acquisition time. Thus, it could be helpful to diagnose intracranial artery disease.
Accelerated Controlled Aliasing in Parallel Imaging (CAIPI) T1-SPACE Using Delay Alternating with Nutation for Tailored Excitation (DANTE) Flow Suppression: Reduced Scan Time and Flow Artifacts without Reduced Image Quality

B Sannanaja¹, C Colip¹, D Hippe¹, M Ibrahim¹, T Khrisat¹, J Hartman¹, C Zhu¹, J Grinstead², M Mossa-Basha¹
¹University of Washington, Seattle, WA, ²Siemens healthineers, Issaquah, WA

Purpose
3D variable-flip-angle TSE sequences are commonly used techniques for intracranial vessel wall imaging, however, they are time consuming and may be prone to flow artifacts, especially with T1 shortening of blood after contrast administration.(1) The purpose of this study was to compare image quality of conventional 3D T1-SPACE with accelerated Controlled Aliasing in Parallel Imaging (CAIPI) T1-SPACE using Delay Alternating with Nutation for Tailored Excitation (DANTE) flow suppression to reduce the scan time and flow artifacts without reducing the image quality.

Materials and Methods
The study was approved by our institutional review board with informed consent. Patients with suspected intracranial vascular disease underwent standard post-contrast 3D T1 SPACE and post-contrast DANTE/CAIPI T1 SPACE sequences as part of their clinical brain MR imaging on a 3T Siemens Prisma MR system (Siemens Healthineers, Erlangen Germany). Scan time for conventional T1-SPACE was 8:08 and for DANTE CAIPI was 5:13, and both sequences had 0.56 mm isotropic true resolution. Two neuroradiologists blinded to patient data and sequence being reviewed independently evaluated post-contrast DANTE/CAIPI T1-SPACE and conventional T1-SPACE sequences. The sequences were evaluated using 4- or 5-point Likert scale evaluations for overall image quality, signal-to-noise ratio (SNR), extent/severity of artifacts, blood suppression, and sharpness and evaluable of wall lesions.

Results
A total of 99 patients were included in the study. The image quality was slightly superior with conventional T1-SPACE compared to DANTE/CAIPI T1-SPACE though it was not statistically significant (p=0.86). The conventional SPACE acquisition had better SNR (p<0.00001) whereas the accelerated imaging techniques had fewer artifacts and better blood suppression (p=0.035 and <0.00001 respectively). Overall lesion assessment for the arterial wall abnormalities was slightly better with conventional SPACE, though was not statistically different (0.34).

Conclusions
Accelerated post-contrast CAIPI T1-SPACE with DANTE flow suppression had lesser image artifacts and improved blood suppression but the SNR was superior with conventional T1-SPACE post-contrast. There were no statistically significant differences in the image quality and lesion assessment between these two techniques.
(VIM). While the significant acoustic impedance difference between the skull and soft tissue causes energy reflection, this can be overcome by increasing the transmit power. The drawback of increased power is heating of the scalp and skull, which can cause patient discomfort, and tissue damage. The amount of energy reflection depends on detailed bony structure of the calvarium, which can vary between patients. Predicting which patients can have successful HIFU is a clinical problem. The parameter most commonly used is the skull density ratio (SDR), which is roughly the ratio of the mean density of the diploic space to the mean density of the cortex. Experience has shown that patients with similar SDRs can have different responses to HIFU. There is a clinical need to better predict individual patient response to HIFU. We propose an alternative measure based on the heterogeneity of the calvarium, rather than a single ratio.

Materials and Methods
14 patients underwent HIFU for ET in this IRB approved retrospective study. An alternative skull processing method, Skull Heterogeneity Measure (SHM), was developed to measure heterogeneity of the calvarial density. SHM is derived as the total sum of the absolute values of all changes in Hounsfield density along a ray crossing the calvarium to focus on the ViM. SHM was computed for the pre-op head CT using a bone-sensitive kernel, for each patient for about 200,000 transcranial rays, and a mean value was obtained. These values were compared against clinical measures of procedural efficiency including the temperature rise per joule delivered, and the total energy delivered during the procedure to obtain clinical efficacy. A Pearson correlation coefficient was computed between the SHM value and clinical efficiency measures. The correlation was also computed for SDR.

Results
1. The SHM shows significant differences in patients with the same SDR, but different HIFU efficiency (Fig. 1).
2. Correlation coefficient of measure with clinical efficiency improves using SHM (e.g. Fig 2 showing r=0.79 (p<0.001), compared with r=0.47 (p=0.093) (Fig. 2).
3. Other measures also show similar improved correlation coefficient

Conclusions
A new measure is proposed for prediction of HIFU efficiency based on heterogeneity of calvarial density and shows a superior correlation with measures of clinical efficiency to the standard SDR.
Fig. 1

Easy HIFU

Difficult HIFU

SDR

SHM

Same SDR but different SHM

Fig. 2

Total Energy (J) vs. New Sdr

p: 0.000
r: 0.787

Total Energy (J) vs. Old Sdr

p: 0.093
r: 0.465

(Filename: TCT_1855_Figure-rev.jpg)
Prognostic Value of Longitudinal Measurements of MRI Radiomic Features in Glioblastoma

B Behrouzi\(^1\), S Daghighi\(^1\), A Chan\(^1\), A Sahgal\(^1\), S Myrehaug\(^1\), C Tseng\(^1\), H Soliman\(^1\), F SALEHI\(^1\), C Heyn\(^1\), S Symons\(^1\), S Rahimi\(^1\), P Jabehdar Maralani\(^1\)

\(^1\)University of Toronto, Toronto, Ontario

Purpose
To evaluate whether non-enhancing FLAIR hyperintense radiomic features generated from MRIs performed at several timepoints during radiation therapy (RT) can predict progression free survival (PFS) and/or risk stratification of patients with newly diagnosed glioblastoma (GBM).

Materials and Methods
35 patients underwent 4 MRIs at: RT planning (D0); on the 10th (D10) and 20th (D20) fractions of RT; and at one-month post-RT follow-up (D30). Endpoints were based on clinical and imaging RANO criteria at 6 months after RT. All neoplastic-related FLAIR hyperintense regions on all MRIs were contoured using a threshold-based method, with T1 contrast enhancing and necrotic regions excluded. 1743 features were extracted using pyradiomics [1], then scaled and centered. Patient datasets were randomly split into training (n=24) and validation (n=11) datasets. Statistically Equivalent Signatures (SES) algorithm equipped with generalized linear mixed modelling (GLMM) and mixed effects Cox regression were used for feature selection [2]. Radiomic signatures for each patient was constructed through linear combination of features weighted by their model coefficients. Radiomics score was calculated as median of signature values for each patient. The median radiomics score was used as a threshold for stratifying patients into high- vs low-risk groups. This threshold was tested in the validation group, and Kaplan-Meier and log-rank tests were used to test the difference between the resulting high- and low-risk groups. The concordance index was used to assess the performance of the signature in the validation dataset.

Results
All models using one (D0) or series of MRI images (D0-D10, D0-D20, and D0-D30) were significantly predictive of PFS in the training dataset (p<0.001). Each additional MRI improved model performance in the validation dataset (Fig 1), with the D0-D30 model achieving the best performance for patient risk stratification with a log-rank score of 4.28 (p=0.04) and hazard ratio of 7.42 (95% confidence interval (CI): 0.835, 66.02, p=0.07). This model also had the best concordance index at 0.729 (95% CI: 0.652, 0.806) for the validation dataset.

Conclusions
The radiomics signature constructed from non-enhancing FLAIR hyperintense regions of tumor from D0-D30 MRIs is an independent predictor of PFS in patients with GBM. Novel radiomics biomarkers acquired from non-invasive longitudinal MRI images can have a significant impact in care of GBM patients.
High diagnostic performance of contrast-enhanced 3D T1 black-blood fast spin echo in cranial nerve neuritis: compared with contrast-enhanced 3D T1 spoiled GRE and contrast-enhanced 3D FLAIR

Y Kang¹, H Lee²

¹Inje University Haeundae Paik Hospital, BUSAN, Busan, ²Inje University Haeundae Paik Hospital, Busan, Busan

Purpose
To evaluate the usefulness of the contrast-enhanced (CE) three-dimensional (3D) T1-fast spin-echo (FSE)-based magnetic resonance (MR) imaging sequence that uses a variable flip angle compared with CE 3D T1-spoiled gradient echo (GRE) and CE 3D-T2 fluid-attenuated inversion recovery (FLAIR) sequences.

Materials and Methods
We assessed 34 MRI positive symptomatic patients who underwent cranial nerve protocol MRI imaging at 3T for cranial nerve neuritis (V: 3, VII: 25, VIII: 5 and X/XI complex: 1) and 20 patients with negative results on cranial nerve protocol MRI, whose symptom were dizziness. Two radiologists (a board certificated neuroradiologist, and a 3-year-experienced radiology resident) independently reviewed randomly shuffled CE 3D-T1-FSE, CE 3D-T1-spoiled GRE and CE 3D-FLAIR of each patients with blind to the patient's diagnosis to determine the presence and the degree of neural enhancement. With 4-weeks interval, we performed 2 consensus reviews, by using CE 3D-FLAIR alone and with adjunctive CE 3D-T1-FSE. We compared AUCs using Z-test, diagnostic accuracy was compared using a McNemar's test, and interobserver reliability analysis was performed using the kappa statistics.

Results
The AUC of CE 3D-T1-FSE (reader 1, 0.952; reader 2, 0.912) was greater than that of CE-3D-T1-spoiled GRE (reader 1 0.870; reader
No significant difference in the diagnostic performance between CE 3D-T1-FSE and CE-3D FLAIR (reader 1, 0.714; p=0.002; reader 2, 0.890; p=0.052). The diagnostic sensitivity, specificities and accuracies were 90.3%, 100%, and 94.4%, respectively for CE 3D-T1-FSE, 74.1%, 100%, and 85.1%, respectively for CE-3D-T1-spoiled GRE, and 87.0%, 86.9%, and 87.0% for CE 3D-FLAIR. The diagnostic accuracy was higher after reviewing the adjunctive CE 3D-T1-FSE (100%) compared with CE 3D-FLAIR alone (87.0%) (p=0.018). [Figure] A 49-years old male clinically diagnosed left facial nerve palsy underwent cranial nerve protocol MRI. Distal meatal segment of left CN VII shows stronger enhancement on the (a) CE 3D-T1-FSE than (b) CE 3D-T1-spoiled GRE. In addition, (c) CE 3D-FLAIR alone may be insufficient to evaluate the nerve enhancement owing to high FLAIR signal intensity of nerve itself and overlapping appearance of CN VII/VIII complex.

Conclusions
CE 3D-T1-FSE significantly improves the accuracy compared with CE 3D-T1-spoiled GRE and provides added value over CE 3D-FLAIR for detecting cranial nerve neuritis.

![Image](TCT_1711_Figure.jpg)

2:05PM - 2:11PM

Measuring Lateral Ventricular Volumes Using Simulated Dual-inversion Recovery From STAGE Imaging

S Sethi1, M Fawaz2, K Ghassaban1, D Utriainen3, P Kokeny4, Y Chen5, C Zhang6, J Cheng6, E Haacke1
1Wayne State University, Detroit, MI, 2Magnetic Resonance Innovations, Inc., Bingham Farms, MI, 3SpinTech, Bingham Farms, MI, 4SpinTech Imaging, Bingham Farms, MI, 5Wayne State University School of Medicine, Detroit, MI, 6Department of MRI, The First Affiliated Hospital of Zhengzhou University, Zhengzhou, Henan, China

Purpose
Strategically acquired gradient echo (STAGE) imaging is a new rapid multi-contrast MRI protocol for evaluating neurological diseases [1-3]. Among numerous contrasts and quantitative maps, STAGE can generate synthetic contrasts of the gray matter, white matter, and cerebrospinal fluid (CSF) based on T1 and spin density values. We calculated lateral ventricular (LV) volumes using simulated dual-inversion recovery (simDIR) contrast and compared them to a well-established automated method using conventional MRI. This may serve as a proxy indicator for brain atrophy in neurodegenerative disease.

Materials and Methods
Fifteen subjects with Parkinson's disease and 15 healthy controls were imaged with both the STAGE protocol and 3D T1 MPRAGE (display resolution of 0.67×0.67×2mm³). SimDIR data for CSF were created using the quantitative T1maps and spin density maps from STAGE data (Figure 1) [3]. A full-width quarter maximum threshold was used on the simDIR data to segment the LVs, including the anterior, posterior, and temporal horns. LVs were automatically segmented using Neuroreader™ (Brainreader, Aalborg, Denmark) from MP-RAGE data. We performed correlations to compare the volumes between the two methods.

Results
SimDIR masks were constructed from the STAGE input data (Figure 1). Mean volumes ± standard error of the mean (SEM) using simDIR contrast for the right and left LV were 9.9 ± 1.1 mL and 11.6 ± 1.1 mL. Mean volumes ± SEM using T1-MPRAGE with Neuroreader were 9.8 ± 1.0 mL and 11.3 ± 1.0 mL. The correlation between the two methods was very strong (R = 0.99) for both hemispheres (Figure 2). Figure 1: Strategically acquired gradient echo (STAGE) input and output simulated dual-inversion recovery (simDIR) tissue masks. PSD: proton spin density; CSF: cerebrospinal fluid. Figure 2: Lateral ventricular volumes comparing automated results from T1-MPRAGE and Simulated Dual Inversion Recovery CSF masks.

Conclusions
Simulated DIR from STAGE is robust for segmenting the LVs which may be promising for following brain volumes longitudinally. While this study used a semi-automated thresholding approach, we plan to automate the volumes in STAGE post-processing for immediate usage by a physician without needing additional scan time.

![Image](TCT_1711_Figure.jpg)
Figure 1: Strategically acquired gradient echo (STAGE) input and output simulated dual-inversion recovery (simDIR) tissue masks. PSD: proton spin density; CSF: cerebrospinal fluid.

Figure 2: Lateral ventricular volumes comparing automated results from T1-MP-RAGE and Simulated Dual Inversion Recovery CSF masks.
Value of Tractography for Demonstrating Intertemporal Anatomic Connections. Not Just Another Pretty Face

C Besada¹, M Perez Akly², L Miquelinî², F Diaz², M Esteves da Cunha², L Di Napoli², F Olivera Plata², J Funes²
¹Hospital Italiano de Buenos Aires, CABA, Argentina, ²Hospital Italiano de Buenos Aires, CABA, CABA

Purpose
To demonstrate the value of tractography as a method of excellent anatomical resolution for the observation in vivo of the fascicles that reciprocally link the neocortex of both temporal lobes. To highlight the usefulness of this technique to evaluate the complex anatomical systematization of the human brain, focusing on the commissures.

Materials and Methods
We reviewed clinical cases of our daily practice mainly with acquired chronic lesions such as lobectomy and trauma and we performed tractography, focusing on the cerebral commissures. We reproduced with this technique the topography of the commissural fibers affected by degeneration secondary to the primary temporal lesion. These findings are concordant with those reported in classic anatomical descriptions.

Results
We were able to reproduce in high definition tractography the findings known by the classic anatomical descriptions particularly at the anterior white commissure. There are very few publications about classic anatomy that describe the connections between the temporal lobes through the cerebral commissures in the human brain. To find these reports we must refer to the great anatomical treaties of the nineteenth and early twentieth century: Dejerine, Popoff, among others. Anatomical descriptions have been made by direct examination of injured brains fixed in formaldehyde and then studied with myelin staining techniques: Weigert. The German-Argentine neurobiological school founded by the remembered Dr Christofedo Jakob and his disciples, has been a pioneer in this field. We could nicely reproduce the secondary degeneration of the commissural fibers that link both temporal neocortex, just as it was reported on the anatomical descriptions of past centuries.

Conclusions
Tractography is an excellent tool to recognize intertemporal connections, as former classic anatomists have described. Currently, it allows us to evaluate injured brains in vivo, demonstrating secondary degeneration of the associated commissural fibers with great anatomical precision, with the hope of helping to understand the complex systematization of the human brain.

Follow-up assessment after stent assisted coil embolization using PETRA qMRA compared with TOF MRA, CE-MRA and DSA
Purpose
Time-of-flight MR angiography have been widely used after coil embolization, but it is associated with limitations caused by magnetic susceptibility and radiofrequency shielding for follow-up after stent-assisted coil embolization. We evaluated the pointwise encoding time reduction with radial acquisition (PETRA) sequence in subtraction-based MRA (qMRA) using an ultrashort TE, TOF-MRA and contrast enhanced (CE) neck MRA during the follow-up after stent-assisted coil embolization for intracranial aneurysms.

Materials and Methods
Twenty-three patients (4 men and 19 women; mean age, 59.7 ± 2.50 years) underwent stent-assisted coil embolization for 24 intracranial aneurysms (18 distal ICA, 3 MCA bifurcation, 1 basilar top, 1 A-com, 1 distal VA) and were retrospectively evaluated using TOF-MRA, PETRA qMRA, CE-MRA from the same follow-up session. Two neuroradiologists independently reviewed three types of MRA and subjectively graded flow within the stents (relative to the latest DSA findings), occlusion status (complete occlusion, residual neck/sac) and presence of pseudo-stenosis. Interobserver and intermodality agreement for TOF-MRA and PETRA qMRA were evaluated.

Results
The mean score for flow visualization within the stents was significantly higher in PETRA qMRA, CE-MRA than in TOF-MRA, but there was no significant difference between PETRA qMRA and CE-MRA. Good interobserver agreement were observed for each modality (ICC, 0.620 for TOF-MRA, 0.613 for PETRA qMRA, 0.613 for CE-MRA). Aneurysm occlusion status of PETRA qMRA and CE-MRA was more consistent with DSA than TOF-MRA, and there was a better intermodality agreement between DSA and PETRA qMRA, DSA and CE-MRA than between DSA and TOF-MRA. Pseudo-stenosis was significantly more commonly observed in TOF MRA than PETRA qMRA and CE-MRA.

Conclusions
These findings indicate that PETRA qMRA is a useful follow-up modality for patients who have undergone stent-assisted coil embolization for intracranial aneurysms.
Clinically Feasible Visualization of the Ventral Intermediate Nucleus (VIM) of the Thalamus using MR Susceptibility-Imaging at 3T MRI

S Chung¹, T Shepherd¹, P Storey¹, A Mogilner², Y Lui¹
¹NYU School of Medicine, New York, NY, ²NYU Lagone Health, New York, NY

Purpose
Roughly 10 million Americans suffer from a tremor disorder that can severely impact on quality of life; yet only about 60% of patients benefit from medical treatment. For others, surgical treatment may be an option. Most surgical interventions target the ventral intermediate nucleus (VIM) of the thalamus [1]. However, visualization of the VIM is a major challenge due to low inter-nuclei contrast on conventional MRI, even with advances in diffusion that can fail if the white matter tracts are difficult to track. So, the current clinical practice relies on indirect localization of the VIM target based on standard geometric coordinates relative to the anterior and posterior commissures (AC-PC) line, reducing anatomic accuracy due to individual differences that carry potential
negative implications for clinical outcomes. Here, we introduce a MR Susceptibility Imaging with Short Echo Time (MR-SISET) that takes advantage of additional contrast achieved using short echo time (TE) to realize high inter-nuclei susceptibility contrast for direct and personalized targeting of the VIM for functional neurosurgery.

Materials and Methods

MR-SISET imaging was performed on 6 healthy individuals (age range, 23-41 years) using a 3T MR scanner (Skyra, Siemens) using a 3D multiple gradient echo sequence: FOV=220x170x75mm3, 1.25mm isotropic resolution, FA=22°, TR=92ms, 20 TEs=1.90:2.32:45.98ms. MR-SISET maps were generated by using the MEDI toolbox. Results were visually inspected by a neuroimaging researcher with 5 years' experience, and compared against indirect location of the VIM as determined by standard geometric coordinates (i.e., x=11mm, lateral distance from the AC-PC midline (MC); y=6.5mm, posterior distance from the MC; z=0mm, vertical distance from AC-PC line), recommended by a neurosurgeon.

Results

In Figure 1, MR-SISET maps show clear target regions of the VIM (dark region within green boundary). We found that the locations of the standard coordinates (red dot) differed slightly within the dark region across subjects, due to individual anatomical variability.

Conclusions

MR-SISET imaging provides intra-thalamic contrast to visualize the VIM target location. Contrast between nuclei is believed to arise from differences in myelin content and fiber orientation. Future work includes assessing its clinical feasibility by comparing our intended target with the actual surgical target, and determining safety margin of the VIM target based on clinical outcomes.

Advanced Imaging of Calvarial Pseudotumoral Venous Malformation

S Nelson1, O Oz1, T Patel1, M Pinho1

1University of Texas Southwestern, Dallas, TX

Purpose

Intraosseous hemangiomas are rare benign vascular lesions accounting for 7% of all skull tumors primarily in men of the 4th-5th decades [1, 2]. The most common locations in the skull are the frontal and parietal calvarium [3]. Atypical features make their diagnosis on CT/MRI difficult. The differential diagnosis for intradiploic expansile skull masses includes metastases, lymphoma, plasmacytoma, intraosseous meningioma, dermoid/epidermoid tumors, fibrous dysplasia and sarcomas [4]. Here, we present a case of calvarial intraosseous hemangioma/venous malformation simulating an aggressive mass, confirmed advanced MRI and tagged RBC SPECT CT.

Materials and Methods

50-year-old former professional football player presented to an outside Neurology clinic with complaints of daily brain fog, memory difficulty and headache for the past 7 years. A brain MRI was significant for a large calvarial lesion with cortical breakthrough to the scalp. The initial differential diagnosis favored aggressive etiologies such as osteosarcoma, metastases and intraosseous meningioma, prompting surgical referral. Neuroradiology was consulted for possible value of additional imaging.
Results
A) T1W Gd+ coronal image shows an avidly enhancing expansile mass of the right temporoparietal calvarium with extra osseous scalp extension (yellow arrow). T2 hyperintensity and lack of fat on T1WI was demonstrated (not shown). B) Axial ASL shows absent CBF (yellow outline) indicating a hypovascular mass. Red arrow indicates high CBF of Labbé vein C) DCE, with source delayed image above and graphed data below, shows lesion ROI (blue curve) with slow contrast uptake, plateau and no washout. Compare with orange curve of choroid plexus ROI showing high uptake (high flow/permeability) and fast washout. D) Tagged RBC SPECT CT shows avid uptake on delayed images confirming intraosseous hemangioma.

Conclusions
The imaging appearance of atypical intraosseous hemangioma may present a diagnostic dilemma on both CT/MRI particularly when there is cortical breakthrough and absence of fat signal in the lesion. In these cases, advanced imaging may play a complementary role. Low rCBF on ASL and slow progressive uptake on DCE without washout favors a non-malignant etiology. As in other body parts, the tagged RBC scan may help confirm the diagnosis of hemangioma of the skull by demonstration of intense uptake on delayed images, sparing patients from unnecessary craniectomy in many cases.
Impact on kidney function of consecutive, multidose use of iodinated contrast in patients with acute ischemic stroke

A Malhotra¹, M Khunte², X Wu³, D Gandhi⁴, P Sanelli⁵
¹Yale University School of Medicine, New Canaan, CT, ²Yale School of Medicine, New Haven, CT, ³Yale University School of Medicine, New Haven, CT, ⁴University of Maryland School of Medicine, Baltimore, MD, ⁵Northwell Health NSUH, Manhasset, NY

Purpose
Current guidelines endorse endovascular thrombectomy (EVT) as the standard of care for patients with LVO in the anterior circulation and vascular imaging with CT Angiography (CTA) is recommended for potential candidates for mechanical thrombectomy. This implies potential risk from exposure to multiple, consecutive doses of iodinated contrast. The purpose of this study is to study impact of multiple doses on iodinated contrast exposure on kidney function in patients with acute ischemic stroke undergoing thrombectomy.

Materials and Methods
After IRB approval and waiver of informed consent, retrospective review was performed of all consecutive patients with acute ischemic stroke and large vessel occlusion who underwent thrombectomy at our institution between January 2014 and September 2018. In addition to demographics such as age, sex, other variables recorded were baseline creatinine at presentation, amount of iodinated contrast received with CTA, conventional angiography or any additional studies, and subsequent daily serum creatinine levels up to a week after presentation. Patients were assessed for historical definition of contrast-induced nephropathy (CIN) – 25% relative increase, or a 0.5mg/dL absolute increase in serum creatinine. In addition, we looked for any 5% or 10% bump in serum creatinine, which has been proposed to be a more sensitive marker for acute kidney injury and persistent worsening of renal function.

Results
A total of 252 patients were included in the study, with 137 women and 115 men. The mean age of patients was 69.9 years (SD-15.1). 54/252 patients had a Baseline creatinine >1.2 mg/dL and 13 patients had baseline Cr >2.0 mg/dL. The mean contrast dose for CTA was 84.6 ml (SD-28.7) and for conventional angiography was 63.3 ml (SD-23.6). 43/252 patients had a jump in serum creatinine of >25% or more than 0.5 mg/dL in the first week. The number of patients had a 5 or 10% bump in creatinine on respective days after initial presentation are presented.

Conclusions
Our study establishes the effect of exposure to multiple doses of iodinated contrast on kidney function in acute ischemic stroke patients. A small (5 or 10%) bump in serum creatinine is more sensitive, and may manifest 72-96 hours after acute presentation, which would be missed at 48 hours (which has been used by previous studies).
Implications of Achieving TICI 2b vs TICI 3 Reperfusion in Patients with Ischemic Stroke: A Cost-Effectiveness Analysis

A Malhotra¹, X Wu², C Matouk³, P Sanelli³, D Gandhi⁴
¹Yale University School of Medicine, New Canaan, CT, ²Yale University School of Medicine, New Haven, CT, ³Northwell Health NSUH, Manhasset, NY, ⁴University of Maryland School of Medicine, Baltimore, MD

Purpose
The benefit of endovascular thrombectomy (EVT) in stroke patients with large vessel occlusion depends on the degree of recanalization achieved. The purpose of this study is to determine the health outcomes and cost implications of achieving TICI 2b versus TICI 3 reperfusion in acute stroke patients with large vessel occlusion.

Materials and Methods
A decision-analytic study was performed with Markov modeling to estimate the lifetime quality-adjusted life years (QALY) of EVT-treated patients, and costs based on the degree of reperfusion achieved. The study was performed over a lifetime horizon with a societal perspective in the United States setting. The base case calculations were performed in 3 age groups- 55, 65, and 75 years old patients. Economic outcome measures included short term (90-day) and long-term costs.

Results
Within 90 days, achieving recanalization status TICI 3 resulted in a cost-saving of $2,686 per patient and health benefit of 11 days in perfect health as compared to TICI 2b. In the long-term, for the 3 age groups, achieving TICI 3 resulted in cost-savings of $46,498, $25,832, and $15,719 respectively, and health benefits of 2.14 QALYs, 1.71 QALYs and 1.23 QALYs. Sensitivity analyses showed that clinical outcomes after TICI 2b and TICI 3, as well direct costs associated with them to be the most determining variables. Every 1% increase in TICI 3 in 55-year-old patients nation-wide resulted in a cost-saving of $3.4 million and a health benefit of 156 QALYs. Among 65-year-old patients, the corresponding cost savings and health benefit were $1.9 million and 125 QALYs. Among 75-year-old patients, the corresponding results are $1.1 million and 90 QALYS.

Conclusions
There are substantial cost and health implications in achieving complete versus incomplete reperfusion after EVT. Our study provides...
data to assess the cost-benefit analysis of emerging techniques including imaging selection that might increase the chances of achieving complete reperfusion. Improved imaging identification of patients likely to achieve complete reperfusion may warrant a more aggressive treatment approach in cases of already achieved TICI 2b. Our study reinforces the need for a more conservative definition of therapy success, and treatment approaches to achieve TICI 3 reperfusion.

CT Perfusion Derived Hypoperfusion Intensity Ratio Predicts CTA Collateral Status in Large Vessel Occlusion Acute Ischemic Stroke.

D Lyndon¹, A Rohr¹, B Niu², M Jutras³, F SETTECASE¹
¹Department of Neuroradiology, University of British Columbia, Vancouver General Hospital, Vancouver, British Columbia, ²University of British Columbia, Vancouver, British Columbia, ³Vancouver General Hospital, Vancouver, British Columbia
Purpose
Quality of pial and leptomeningeal collateral blood supply in the brain is a key determinant of outcome in large vessel occlusion (LVO) acute ischemic stroke (AIS). Single and multiphase CT angiogram (spCTA and mCTA) collateral scoring systems have been devised but they require training and experience to utilize accurately.1,2 We aimed to test whether hypoperfusion intensity ratio (HIR), an automatically calculated measure of the severity of hypoperfusion within the affected vascular territory,3 can be used as a surrogate for CTA collateral status and if there is a threshold HIR that predicts poor collateral status.

Materials and Methods
IRB approval was obtained. Imaging and hospital records of consecutive patients presenting to our centre with symptoms of AIS were retrospectively reviewed to identify patients with LVO imaged with both mCTA and CTP. Patients with pre-existing flow limiting stenosis were excluded. MCTA scores were calculated using a validated 6 point scale with scores of 0-3 indicating poor collaterals.1 CT perfusion images were assessed using RAPID software (Ischemaview) and HIR calculated as a ratio of Tmax>10 over Tmax>6 within the affected territory. Results were analysed using binary logistic regression, and an area under the curve value calculated to assess the value of HIR in predicting poor versus good collaterals. Optimal threshold of HIR for predicting poor collaterals along with corresponding specificity and sensitivity were calculated using the Youden index.

Results
37 patients with AIS due to LVO were included in the study with mean age = 68 (SD = 15.4), 18 female and 19 male patients. Initial ASPECTS scores ranged from 0 to 10 with a median score of 7. mCTA median score was 4, with 14/37 with poor collateral scores (0-3). Mean HIR were 0.61 (SD 0.17) in the poor mCTA collateral group, and 0.28 (SD = 0.20) in the good mCTA collateral group. HIR was a strong predictor of poor collaterals (area under the curve = 0.891). An HIR > 0.45 had a specificity of 78% and sensitivity of 79%, while an HIR > 0.55 had a specificity of 91% and sensitivity of 64% for poor collateral status.

Conclusions
HIR is a promising objective predictor of collateral status in patients with LVO AIS. As an automated and quantitative tool, it may be more reliable than more subjective CTA collateral scoring methods. Further studies are warranted to determine whether HIR predicts outcome or futile transfer of LVO patients.
A-C: Multiphase CTA in a patient with left M1 segment occlusion and poor collaterals. Images show early arterial, late arterial and late venous phases respectively, with only a few collateral vessels seen in any phase on the left.
D: Relative T_max in the left middle cerebral artery territory with hypoperfusion ratio shown.
Dual energy CT virtual non-contrast maps allow improved evaluation of infarct extent in patients transferred for mechanical thrombectomy who received IV contrast administration prior to transfer.

D Byrne¹, M van den Broek², J Walsh², B Niu³, F SETTECASE⁴, S Nicolaou², T Field², N Murray², M Heran², A Rohr²
¹Vancouver General Hospital, Vancouver, BC, ²Vancouver General Hospital, Vancouver, British Columbia, ³University of British Columbia, Vancouver, BC (British Columbia), ⁴UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC

Purpose
Increasingly, patients with acute ischemic stroke and large vessel occlusion are being transferred to tertiary centres for endovascular treatment, with transfer often taking several hours due to inter-facility delays (1). We noted that in cases where patients received intravenous contrast for CT angiography prior to transfer, that the infarct on the repeat non-contrast CT (NCCT) may be masked by contrast and therefore can be difficult to visualize. In these often late-window cases, infarct extent may also be underestimated on perfusion imaging (2). We aimed to determine if infarct extent could be better delineated by generating virtual non-contrast (VNC) images on the dual-energy CT (DECT) performed on arrival at our institution prior to EVT.

Materials and Methods
Cranial CTs of 27 patients who were transferred for endovascular treatment and who were then successfully recanalized (mTICI 2b/3) were included. Infarct extent as per Alberta Stroke Early CT Score (ASPECTS) on admission was recorded by 2 readers for a) the regular mixed kV images provided by the scanner and b) VNC images generated at the same time. Readers' degrees of confidence in their interpretation of each study was recorded with a 5-point Likert scale. Both sets of images were then compared to follow-up CT. Weighted κ values were calculated.

Results
Infarct extent on admission VNC maps provided better agreement with final infarct extent compared to mixed kV images. Both VNC (p=0.003, p=0.004) and mixed kV images (p<0.001, p=0.001) underestimated final infarct extent for readers 1 and 2, respectively. For reader 1, ASPECTS on VNC showed substantial agreement with discharge consensus ASPECTS (weighted κ 0.708), and moderate agreement with mixed kV images (weighted κ 0.560). For reader 2, ASPECTS on VNC also showed better agreement with discharge ASPECTS (weighted κ 0.388) than mixed kV images (weighted κ 0.282). Interrater agreement was similar for VNC (weighted κ 0.609) and mixed kV images (weighted κ 0.636). For reader 1, confidence improved significantly (p=0.005) with VNC images compared with mixed kV images, but not for reader 2 (p=0.21).

Conclusions
Utilizing VNC images on DECT provided better agreement with final consensus infarct extent than regular "mixed kV images" for both readers. VNC images may therefore allow improved infarct delineation in patients who received IV contrast prior to transfer, which may alter treatment decisions.
Sub-analysis from the SELECT Trial: Correlation of NCCT ASPECT Scores by Individual Region with 90 day MRS in Patients with Successful Reprofusion

C Sitton1, D Pujara2, R Riascos3, A Sarraj4
1UTHSC Houston / UT Health, Houston, TX, TX, 2McGovern Medical School, Houston, TX, 3Univ. Of Texas - Houston, Houston, TX, 4UT Houston, Houston, TX

Purpose
Previous authors have demonstrated associations between involvement of specific ASPECTs areas and functional outcome. We wanted to establish if such associations existed in our large prospective data set.

Materials and Methods
SELECT was a multicenter, prospective cohort study enrolling anterior circulation LVO presenting up to 24 hrs. Imaging evaluation included pre-procedure CT ASPECTS, CTA (collateral score, ASPECTS, clot location), CT perfusion (CBV ASPECTS, RAPID parameters), pre and post mTICI, and infarct volume and ASPECTS on post-procedure CT or MRI within 72 hours. A simple regression model was applied to observe the effect of hypo density in individual aspect regions at preprocedural on the probability of good outcome in patients achieving recanalization following IAT. Good outcome was defined as a mRS of 0-2. The model was adjusted for total aspect score and for laterality.

Results
Hypodensity in the internal capsule was negatively associated with the probability of good outcome with an odds ratio of 0.34. The effect was less prominent when adjusting for both aspect score and lesion side, with an odds ratio of 0.42. The M1, M2, M3, and M5 regions showed weak correlation in the unadjusted analysis, but showed no correlation once total aspect score was taken into account. There was a positive correlation between good outcome and involvement of the caudate head with an odds ratio of 2.06, when adjusted for total ASPECTs score and lesion laterality.

Conclusions
Only involvement of the internal capsule showed any independent association with poor functional outcome. This is consistent with prior analyses and consistent with predictions made on the basis of functional neuroanatomy. Much larger sample sizes allowing for adjustment for a multitude of co-factors affecting outcome would likely be required to establish a weighted regional score. Correlation between positive outcomes and involvement of the caudate on NCCT warrants further investigation. It is could be that as total post-
procedure ASPECT score decreases, involvement of the caudate as part of that score represents a very small volume of tissue, and therefore may be associated with better outcome. There could also be bias related to rates of reperfusion.

Effect of CT aspects area involvement on probability of good outcome

( population limited to EVT )

<table>
<thead>
<tr>
<th>Overall</th>
<th>Unadjusted</th>
<th>Adjusted for ASPECTS score</th>
<th>Adjusted for ASPECTS score and lesion side (rt vs lt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C- Caudate</td>
<td>OR: 1.24, 95% CI: 0.71-2.18, P-value: 0.454</td>
<td>OR: 2.06, 95% CI: 1.06-4.02, P-value: 0.033</td>
<td>OR: 2.06, 95% CI: 1.06-4.02, P-value: 0.034</td>
</tr>
<tr>
<td>I- Insular ribbon</td>
<td>OR: 0.81, 95% CI: 0.51-1.29, P-value: 0.376</td>
<td>OR: 1.25, 95% CI: 0.68-2.28, P-value: 0.475</td>
<td>OR: 1.22, 95% CI: 0.67-2.24, P-value: 0.518</td>
</tr>
<tr>
<td>IC- Internal Capsule</td>
<td>OR: 0.34, 95% CI: 0.16-0.75, P-value: 0.007</td>
<td>OR: 0.43, 95% CI: 0.18-0.99, P-value: 0.047</td>
<td>OR: 0.42, 95% CI: 0.18-0.98, P-value: 0.046</td>
</tr>
<tr>
<td>L- Lentiform nucleus</td>
<td>OR: 0.84, 95% CI: 0.52-1.34, P-value: 0.456</td>
<td>OR: 1.14, 95% CI: 0.66-1.96, P-value: 0.642</td>
<td>OR: 1.12, 95% CI: 0.65-1.93, P-value: 0.695</td>
</tr>
<tr>
<td>M1- Anterior M1 cortex</td>
<td>OR: 0.61, 95% CI: 0.34-1.09, P-value: 0.093</td>
<td>OR: 0.85, 95% CI: 0.42-1.72, P-value: 0.654</td>
<td>OR: 0.9, 95% CI: 0.44-1.84, P-value: 0.773</td>
</tr>
<tr>
<td>M2- MCA cortex lateral to the insular ribbon</td>
<td>OR: 0.61, 95% CI: 0.35-1.04, P-value: 0.071</td>
<td>OR: 0.88, 95% CI: 0.43-1.81, P-value: 0.727</td>
<td>OR: 0.84, 95% CI: 0.41-1.74, P-value: 0.641</td>
</tr>
<tr>
<td>M3- Posterior MCA cortex</td>
<td>OR: 0.32, 95% CI: 0.08-1.23, P-value: 0.097</td>
<td>OR: 0.46, 95% CI: 0.11-1.88, P-value: 0.282</td>
<td>OR: 0.46, 95% CI: 0.11-1.89, P-value: 0.284</td>
</tr>
<tr>
<td>M4- Anterior MCA superior territory</td>
<td>OR: 0.68, 95% CI: 0.37-1.25, P-value: 0.215</td>
<td>OR: 1.01, 95% CI: 0.49-2.05, P-value: 0.995</td>
<td>OR: 1.04, 95% CI: 0.5-2.15, P-value: 0.917</td>
</tr>
<tr>
<td>M5- Lateral MCA superior territory</td>
<td>OR: 0.55, 95% CI: 0.28-1.08, P-value: 0.081</td>
<td>OR: 0.72, 95% CI: 0.35-1.5, P-value: 0.385</td>
<td>OR: 0.73, 95% CI: 0.35-1.51, P-value: 0.391</td>
</tr>
<tr>
<td>M6- Posterior MDA superior territory</td>
<td>OR: 0.88, 95% CI: 0.25-3.12, P-value: 0.848</td>
<td>OR: 1.29, 95% CI: 0.35-4.81, P-value: 0.703</td>
<td>OR: 1.36, 95% CI: 0.36-5.11, P-value: 0.648</td>
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1405

2:05PM - 2:11PM

Intraarterial clot localization in patients with acute ischemic stroke affects the venous microperfusion profile

T Faizy1, R Kabiri1, S Christensen2, M Leipzig1, G BROOCKS3, F Flottmann4, H Leischner5, M Lansberg6, G Albers7, M Wintermark8, J Fiehler9, J Heit10

1Stanford University, STANFORD, CA, 2GrayNumber Analytics, Lomma, Sweden, 3UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, 4University Medical Center Hamburg-Eppendorf, Hamburg, Hamburg, 5UNIVERSITY MEDICAL CENTER - HAMBURG, Hamburg, Hamburg, 6Stanford, Stanford, CA, 7Stanford University Medical Center, Palo Alto, CA, 8Stanford, San Carlos, CA, 9University Medical Center Hamburg-Eppendorf, Hamburg, AK, 10Stanford University, Stanford, CA

Purpose
The quality of cerebral microperfusion (CM) is strongly related to vessel occlusion location and the robustness of arterial intracranial collaterals (IC) in patients with acute ischemic stroke due to large vessel occlusion (AIS-LVO). Robust CM allows for transit of blood through the ischemic brain tissue into the veins. The venous microcirculation profile (VMP) may more accurately reflect tissue perfusion compared to arterial IC, but it is unclear to what extent the venous CM profile is affected by arterial clot localization during AIS-LVO. We determined, if the arterial vessel occlusion localizations predict VMP profile in AIS-LVO patients.

Materials and Methods
We performed a multicenter retrospective cohort study of consecutive patients who underwent thrombectomy for AIS-LVO treatment. Patient details were obtained from prospectively maintained stroke databases and the electronic medical record. Baseline CT angiography was used to localize vessel occlusion, which was dichotomized into proximal (internal carotid artery and proximal M1)
and distal (distal M1 and M2) occlusions. The primary outcome measure was VMP, which was determined on baseline CTA by the cortical vein opacification score (COVES). COVES venous opacification was scored for the vein of Labbé, sphenoparietal sinus, and superficial middle cerebral vein were scored as: 0, not visible; 1, moderate opacification; and 2, full opacification.

Results
394 patients met inclusion criteria. Median age was 76 (IQR: 65-82) and 49% were female. 206 patients (52%) had a proximal occlusion and 188 patients (48%) had a distal occlusion. Median COVES was 1 (range 0-5) for proximal occlusion and 3 (range 0-6) for distal occlusion patients. Ordinal logistic regression showed that patients with more distal vs proximal occlusions had increased odds of having a higher COVES scores (OR = 14.8863003, [95% CI, 9.579538- 23.58535]; p<.001).

Conclusions
The distinct arterial clot localization in AIS-LVO patients affects the cortical venous microperfusion profile. Venous microperfusion was found to be impaired in patients with proximal versus distal vessel occlusions. Figure Legend: In patient 1, poor opacification was detected in the vein of Labbé on the right side, whereas strong opacification was detected on the left side (COVES 0 right, COVES 2 left). In patient 2, strong opacification of the veins of Labbé was found on both hemispheres (COVES 2 on both sides). Red arrow= poor opacification; green arrow=strong opacification.

1533
2:12PM - 2:18PM

Estimation of Lesion Progression using CT based Quantitative Lesion Water Uptake - A Suitable Method to Select Patients for Thrombectomy in the Extended Time Window?

G BROOCKS¹, A Kemmling², H KNIEP³, G Thomalla⁴, J Fiehler⁵, T Faizy⁶, U Hanning⁶
¹UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany, ²University Hospital Kaiserslautern, Kaiserslautern, AK, ³UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, GERMANY, ⁴University Medical Center Hamburg, Hamburg, AK, ⁵University Medical Center Hamburg-Eppendorf, Hamburg, AK, ⁶Stanford University, STANFORD, CA

Purpose
Patients presenting in the extended time window may benefit from endovascular treatment (ET) according to recent trials; however,
selection for ET in this patient group has only been performed using automated perfusion imaging platforms, which are not comprehensively available and may overestimate ischemic core volume leading to exclusion of patients from ET. We hypothesized that quantitative lesion water uptake per time may serve as imaging biomarker of "tissue clock" and predicts clinical outcome in extended time window patients undergoing ET.

Materials and Methods
In this pilot study, 46 acute middle cerebral artery stroke patients presenting 4.5-24 hours after symptom onset, who received initial multimodal CT and underwent ET were analyzed. Quantitative lesion net water uptake (NWU) was calculated in admission CT and NWU per time was determined after dividing NWU by the logarithm of time from onset (NWU/time). Prediction of clinical outcome was performed using univariable receiver operating curve (ROC) analysis and multivariable logistic regression analysis. Clinical outcome was assessed using modified Rankin Scale scores (mRS) after 90 days.

Results
The mean (range) time from onset to imaging was 6.5 hours (4.5-15.5h) and the mean (SD) NWU/time was 11.8%/h (6.8). Based on ROC analysis, NWU/time above 8.9% identified patients with functional independence (mRS 0-2) with high discriminative power (area under curve [AUC]: 0.86, 95%CI: 0.67-0.96, p<0.0001). In multivariable logistic regression, the probability of poor outcome (mRS 5-6) was significantly associated with NWU/time (odds ratio: 1.32, 95%CI: 1.06-1.64, p=0.01), adjusted for recanalization status and ASPECTS.

Conclusions
Quantitative lesion water uptake per time could serve as imaging biomarker of "tissue clock" and may predict clinical outcome in patients undergoing ET in the extended time window. This method might be tested to select patients for late time window ET compared to CT perfusion based ischemic core assessments.

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CT Perfusion Imaging Using Bayesian-Based Deconvolution Method: Determination of the Optimal Threshold to Identify Core Infarct and Penumbra in Acute Ischemic Stroke

A Davis¹, B Bucciarelli², A Mitulescu², Y CHAIBI², S Campana², A Gallardo², M Felfli², S Lescic²
¹Olea Medical, Brentwood, TN, ²Olea Medical, La Ciotat, France

Purpose
CT perfusion (CTP) is commonly used during acute ischemic stroke (AIS) to quantify infarcted core and salvageable penumbra. Discrimination is achieved by software using various mathematical and hierarchal models that tag voxels below or above a specific threshold. Bayesian-based deconvolution is a probabilistic method providing more accurate estimation of hemodynamic parameters.
than singular value decomposition [1,2], but like all methods is dependent on source dataset. This study aims to identify best CTP threshold for defining core and penumbra using Bayesian modelling and optimized dataset sampling.

Materials and Methods
36 patients with clinical AIS, baseline CTP, cerebrovascular imaging, follow-up diffusion-weighted imaging (DWI) performed 18-48 hours after CTP included. Imaging independently reviewed by a neuroradiologist not involved in original interpretation or endovascular procedure. Subjects had complete recanalization (23 TICI 2b/3) or non-recanalization (13 TICI 0) to assess core and penumbra respectively. Best image down-sampling and smoothing determined via usual methodologies. Automatic segmentation performed applying combinations of best literature derived thresholds (CBF, CBV, MTT, TTP, Delay) to CTP datasets with absolute, relative or differential relationships using Olea Sphere® software v3.0SP20. Results compared with segmented DWI final infarct volumes using automated co-registration to provide volumetric and spatial accuracy. Receiver operating characteristic (ROC) curves and differential weighted ranking of sensitivity and specificity generated to assess predictive performance.

Results
Statistical and visual analysis showed best infarct core volume defined by relative CBF < 25% and differential TTP > 5 seconds; best penumbra volume by differential TTP > 5 seconds.

Conclusions
Consistent with literature, relative CBF is best predictor of core and improved with second parameter, TTP [3,4]. Differential or relative thresholds outperformed absolute [5]. Weighting specificity over sensitivity improved correlation with visual ground truth indicating statistical superiority does not equate with clinical superiority. TTP outperformed traditional time insensitive indicators suggesting novel influence of Bayesian modeling on deconvolution methods. Results indicate threshold selection within CTP software is critically dependent on dataset filtering, convolutional methodology and choice of differential, relative or absolute values which must be considered during CTP product analysis.
extent post-thrombectomy [2]. In this feasibility study, we assess the ability to estimate infarct core on VNC images post-processed from DECTA in patients presenting with suspected acute ischemic stroke (AIS). We hypothesize that there is no difference in Alberta Stroke Program Early CT Score (ASPECTS) between VNC DECTA and presentation noncontrast CT (NCCT).

Materials and Methods
IRB approval was obtained. Consecutive adult AIS thrombectomy patients imaged with NCCT and DECTA between 04/04/2017 and 09/24/2018 were included in this retrospective study. Patients were excluded if no large vessel occlusion was present, or if they had received IV contrast < 24h prior. VNC images were created from DECTA using post-processing software (Syngo.via, Siemens, Erlangen, Germany). The VNC, DECTA and NCCT images were scored using ASPECTS in a blinded fashion. Demographics, time of onset and time of scan were collected. Sensitivity, specificity, and Mann-Whitney U test between groups were calculated using statistical software.

Results
30/91 patients met inclusion criteria with an average age of 74.7 years. 12/30 (40%) patients were female. The VNC DECTA and NCCT ASPECTS were equal in 24/30 (80%) patients. In 29/30 (97%) patients the ASPECTS was the same or differed ≤ 1. No differences between ASPECTS score were noted between VNC DECTA and NCCT (p = 0.7466) and between DECTA and NCCT (p = 0.8067).

Conclusions
Using VNC of DECTA scans for ASPECTS estimation of infarct core is feasible, with scores similar to those obtained with conventional NCCT. A significant dose reduction could be achieved using VNC/DECTA. Further investigation in larger number of patients across the entire ASPECTS spectrum is warranted.
Comparison of DECTA VNC (a and c) versus NCCT (b and d). On the top row, hypodensity in the caudate body is clearly visualised on the VNC and NCCT images. On the bottom row hypodense lentiform nucleus and insular ribbon are well demonstrated on both VNC DECTA and NCCT.
Purpose

The utilization trends of brain CT Perfusion (CTP) using the RAPID automated post-processing platform is unknown outside of the scope of clinical trials.

Materials and Methods

We conducted a retrospective observational study to identify the number of CTP exams and mechanical thrombectomies (MT) performed at three hospitals within the University of Pennsylvania Health System between November 2017 and February 2019. A more in-depth chart review was conducted from January through June 2018 to identify the number of large vessel occlusions (LVO), MT, exam origin (inpatient versus emergency department), and final diagnoses. We also compared the outcomes of subjects with RAPID CTP use over a four-month period relative to no CTP use in the prior year.

Results

1875 RAPID CTP exams were performed over a 16-month period relative to a CTP use in the prior year. Between January and June 2018, there were 749 RAPID CTP exams, 181 LVO (24.2%), and 75 MTs (10.0%). Of these patients were more likely to have an LVO if ordered by inpatient relative to emergency department providers (OR 2.46, 95% CI:1.75–3.46, p-value=0.001). The rate of subsequent MT was also higher when CTP was ordered by inpatient services (OR 1.83, 95% CI:1.13–2.30, p-value=0.013). Nonlinear seasonal trends in CTP were observed (F_15^2=9.385, p-value=0.003), but there was no change in MTs with time. The most common diagnoses associated with the exams were stroke (43%), transient ischemic attack (11.5%), and seizure (6.3%). There was no statistical difference in age, sex, baseline NIHSS, mTICI and groin to revascularization time, % of failed to revascularize, infarct location, or post-reperfusion hemorrhage between CTP and non-CTP groups. The post intervention rates mTICI3 was higher in the RAPID CTP (65%) than in the control group (40%) subjects, but overall mTICI scores were not different between groups (p < 0.161). There was a trend to attempt MT at a later time from stroke onset in the CTP (19.8 hours) vs. non-CTP group (12.2 hours) (p=0.07). Nevertheless, the 90-day mortality was lower in the CTP vs. non-CTP group (23% vs. 45%, p < 0.03).

Conclusions

The majority of CTP exams performed at UPHS were confounded by stroke-mimicking presentations, did not have LVO, and most (90.9%) did not proceed to MT; this was more likely to happen if the exam was obtained by emergency compared to inpatient providers. Improved selection with CTP may be associated with lower mortality rates at 90 days.

Scientific Abstract Session: Head & Neck Soft Tissue Neck/Thyroid

1702

Predictive Value of Pretreatment Semi-quantitative 18F-FDG PET/CT Parameters in Patients with Oropharyngeal Squamous Cell Carcinoma

Y Koksel1, M Gencturk1, M Reynolds1, A Spano2, Z Cayci1
1University of Minnesota, Minneapolis, MN; 2University of Minnesota, Minneapolis, Minnesota, MN

Purpose

Indicators of outcome for head and neck squamous cell cancer (HNSCC) is historically mostly derived from clinical and pathologic features of tumors. However, tumor FDG uptake has also shown to be associated with various cellular characteristics. Thus, analyses of metabolic parameters, which can be independent of morphologic changes, show promises to predict individual tumor behavior. The aim of this study is to establish the prognostic value of 18F-Fluoro-D-glucose positron emission tomography/computed tomography (FDG-PET/CT) parameters in prediction of response to treatment and determining overall survival in oropharyngeal squamous cell carcinoma patients undergoing chemoradiotherapy.

Materials and Methods

Pretreatment PET/CT images of seventy-five biopsy-proven oropharyngeal squamous cell carcinoma patients were retrospectively reviewed and PET parameters including standardized uptake value (SUV) max, SUV peak, SUV mean, total lesion glycolysis (TLG) and metabolic tumor volume (MTV) of primary cancer site were measured. Kaplan-Meier survival analysis of these parameters were performed for overall survival (OS) and receiver operating characteristic (ROC) analysis was performed to predict response to treatment.

Results

Sixty-five out of 75 responded to the therapy, whereas 10 patients did not. Mean (SD) values for SUVmax, SUVpeak, SUVmean, TLG and MTV were 14.22 (5.6), 11.41 (4.87), 6.73 (2.1), 143.1 (144.1) and 19.48 (15.32), respectively. Cox regression analysis determined that tumor SUVmax, SUVpeak, SUVmean, TLG and MTV were independently correlated with OS (p < 0.05) with a
hazard ratio 1.125, 1.177, 1.337, 1.045, 1.005, respectively. On ROC analysis, SUVmean was the best predictor of treatment response followed by SUVpeak, MTV, TLG and SUVmax.

Conclusions
Pretreatment semi-quantitative PET/CT parameters could be used in predicting the treatment response and have prognostic value on overall survival in oropharyngeal squamous cell carcinoma patients undergoing chemoradiotherapy.

2554 1:37PM - 1:43PM

Leprosy of the Great Auricular Nerve: A Rare Cause of Thickened Spinal Nerve Brunch

D Kaya¹, S Su¹, N Dailey¹, L Ginsberg², M Chen³
¹UT Texas MD Anderson Cancer Center, Houston, TX, ²M.D. Anderson Cancer Ctr., Houston, TX, ³MD Anderson Cancer Center, Houston, TX

Purpose
A case presentation highlighting the clinical, pathological and radiological features of a rare cause of enlargement of the greater auricular nerve (GAN) in a patient with pathologically proven leprosy.

Materials and Methods
A 49-year-old male presented with a 14 month history of progressive swelling on the left side of his neck with facial and ear numbness as well as formication across the scalp. He was initially diagnosed with trigeminal neuralgia and lymph node swelling at an outside institution and treated with gabapentin and antibiotics, without improvement. On physical exam, the patient had palpable, cord-like lesion in the left neck with diminished sensation to light touch along left jawline and left ear. He did not have any cutaneous lesions to suggest a primary skin malignancy.

Results
Ultrasound examination revealed elongated fusiform hypoechoic lesion in the left lateral neck suspicious for nerve sheath tumor. Contrast enhanced CT imaging of the neck revealed enlargement and enhancement of the left great auricular nerve extending to the left C2-C3 neural foramen. A nerve sheath tumor was suspected and the patient underwent surgical resection of the mass. Upon review of the pathology, granulomatous inflammation with necrosis involving the nerve was noted. Identified rare Fite-Faraco positive organisms possibly mycobacterium prompted PCR from the surgical specimen which was positive and confirmed diagnosis of leprosy. Upon additional review of the patient's history it was learned that the patient lived on a farm where Armadillos were present, though he denied direct contact or ingestion of armadillo meat, known modes of leprosy transmission.

Conclusions
Leprosy of the peripheral nerves in the head and neck may have imaging characteristics that can be mistaken for peripheral nerve sheath tumor or perineural spread from cutaneous malignancy. Awareness of this entity, particularly in areas where the carrier of this disease process, the armadillo, is endemic, may be helpful to include in the differential.
Utility of MDCT in the evaluation of bone involvement in buccal cancers.

H Kale\textsuperscript{1}, A Raut\textsuperscript{2}, S Adamane\textsuperscript{2}, K Pal\textsuperscript{2}  
\textsuperscript{1}KDA Hospital, Mumbai, India, \textsuperscript{2}KDA hospital, Mumbai, Maharashtra

Purpose
Studies to evaluate utility of imaging in assessment of bone involvement by oral malignancies have revealed varying results. Many of these studies were performed using thicker sections and older generation scanners. The purpose of this study is to evaluate the utility of CT in determination of bone involvement by buccal cancers with use of thin-section MDCT.

Materials and Methods
A retrospective study was conducted at Kokilaben Dhirubhai Ambani Hospital(KDA hospital) and Medical Research Institute. Inclusion Criteria: Buccal mucosal cancers which abut the adjacent bone who subsequently underwent surgery at KDA hospital. Histopathology is available. Exclusion Criteria: Treatment prior to scan Streak artifact A total of 44 patients fit the criteria. The CT studies were evaluated by 2 radiologists with between 15-20 years of experience in head and neck radiology. Radiologists were blinded to the pathology report. The imaging findings were compared with the pathology report. True positive, true negative, false negative and false positives were tabulated. Sensitivity, specificity, accuracy, negative predictive value (NPV) and positive predictive rate (PPV) were subsequently calculated from this data.

Results
Thin section MDCT shows high sensitivity for the detection of bone involvement in buccal cancers with lower specificity. True positive (19), true negative (13), false positive (10) and false negatives (2) Sensitivity=90.48\% Specificity=56.52\% PPV=65.52\% NPV=86.67\% Accuracy=72.73\% 

Conclusions
Thin-section newer generation MDCT scans are accurate in the evaluation for bone involvement in buccal cancers. The sensitivity for evaluation of bone invasion is high. The specificity is lower and imaging findings may be confounded by presence of bone thinning usually from dental caries and periodontal disease.
Adult hypopharyngeal spindle cell rhabdomyosarcoma

S Amemasor¹, K Traylor¹, P Wangaryattawanich²
¹University of Pittsburgh, Pittsburgh, PA; ²University of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
Rhabdomyosarcomas (RMS) are rare soft tissue malignancies with the lungs, bone and lymph nodes being common sites of metastasis. CT, MRI and PET are important to the diagnosis as well as determining regional extent and distant disease. Clinical management includes surgery.

Materials and Methods
50-year old patient without significant risk factors presented to the ED with tracheal hemorrhage. During emergent tracheostomy placement a hypopharyngeal mass was identified. It was subsequently found that patient had been having 3 months of progressive dyspnea, sore throat and dysphagia.

Results
Top: Coronal and axial CECT soft tissue neck: Heterogeneously enhancing hypopharyngeal mass measuring 3.7 x 2.4 x 3.3 cm.
Bottom left: 18F-FDG PET/CT: Fused axial PET/CT demonstrating a markedly FDG avid hypopharyngeal mass. Bottom right: Gross path: Fleshy, tan grey with areas of necrosis.

Conclusions
RMS are rare soft tissue malignancies with the lungs, bone and lymph nodes being common sites of metastasis. CT, MRI and PET are important to the diagnosis as well as determining regional extent and distant disease. Clinical management includes surgery.
chemotherapy and/or radiotherapy. The differential of hypopharyngeal masses includes squamous cell carcinoma (SCC), lymphoma, and hemangiosarcoma which have marked FDG avidity and enhancement. In counter distinction to RMS, SCC is more infiltrative with less enhancement, lymphoma has bulky cervical lymphadenopathy and hemangiosarcomas have central flow voids. RMS, on the other hand, has marked enhancement, is relatively well-circumscribed, and has marked FDG avidity. Vascular malformations can also occur in this location, however, would only have mild FDG uptake. Our patient underwent total laryngectomy and bilateral neck dissections confirming RMS. After 1 cycle of chemotherapy he declined additional therapy due to side effects. He had uneventful post-surgical course, however, was found to have lung and bone metastasis at one-year follow up PET/CT. He is scheduled to undergo chemotherapy and radiation.

(Filename: TCT_1608_Slide1.JPG)

1442

Utility of CT as a Predictive Tool for Estimating Lymph Node Yield in Patients Affected by Head and Neck Malignancies

J Litchman1, X Wu2, M Servos3, R Halter4, C Rees5, J Paydarfar1, D Pastel1

1Dartmouth Hitchcock Medical Center, Lebanon, NH, 2Massachusetts General Hospital and Harvard Medical School, Boston, MA, 3Geisel School of Medicine at Dartmouth, Hanover, NH, 4Thayer School of Engineering and Geisel School of Medicine at Dartmouth, Hanover, NH

Purpose
Head and neck malignancies account for approximately 550,000 incident cases and 380,000 deaths worldwide annually (1). In the setting of invasive head and neck malignancies, excision of lymphatic tissue from the neck ("neck dissection") has important implications with respect to staging and treatment. Lymph node yield (the number of lymph nodes present in a neck dissection specimen) and lymph node ratio (the number of cancerous nodes divided by total lymph node yield) have both been shown to have prognostic significance (2-5). However, both lymph node yield and lymph node ratio are highly variable across the population (5). Because of this heterogeneity, it may be difficult to determine whether an adequate tissue sample has been obtained intraoperatively.
Furthermore, at present, there are no validated tools to estimate either lymph node yield or lymph node ratio based on pre-operative data. Here, we propose to use pre- and post-operative contrast-enhanced neck CT scans to quantify lymphatic tissue volume in individuals undergoing level 2-4 neck dissection (in the context of invasive tonsillar and tongue base malignancies) for the purpose of developing a pre-operative tool to estimate lymph node yield.

Materials and Methods
Utilizing imaging segmentation software, neck lymphatic tissue volumes were quantified from pre- and post-operative contrast-enhanced CT scans (Fig 1) in a cohort of 6 individuals with invasive malignancies of the tonsil or tongue base who underwent level 2-4 neck dissection in 2018. Patients who had prior radiation therapy were excluded from the study. For consistency, all neck dissections were performed by a single head and neck surgeon. Lymph node yield was obtained from the surgical pathology report prepared at the time of neck dissection. Linear regression models were used to correlate reported lymph node yields to the calculated lymphatic volumes on pre- and post-operative CT scans.

Results
CT-derived pre-operative lymphatic volume (Fig 2) and volume difference (Fig 3) following surgery exhibit a positive correlation with lymph node yield. The average surgical lymph node yield was 28.8 ± 7.6. The average pre- and post-operative lymphatic volumes are displayed in Table 1.

Conclusions
Preliminary results in 6 patients demonstrate that CT-derived lymphatic tissue volumes can potentially serve as a useful pre-operative tool in guiding head and neck surgeons on the adequacy of a lymph node dissection in patients with invasive cancers of the tonsil and tongue base.

(Filename: TCT_1442_UtilityofCTasaPredictiveToolforEstimatingLymphNodeYieldinPatientsAffectedbyHeadandNeckMalignancies.jpg)

2126
An Aggressive, Recurrent Case of Desmoid-type Fibromatosis.

A Reis¹, S Shamir², W Mallon¹, O Haken³, M Mansouri³, S Boone¹, K Wattamwar³, A Erdfarb³, J Burns³, K Shifteh³
¹Montefiore Medical Center, New York, NY, ²Montefiore Medical Center, BRONX, NY, ³Montefiore Medical Center, Bronx, NY

Purpose
Desmoid-type fibromatosis (DF) is a rare neoplasm that infrequently involves the head and neck. We aim to review the case and imaging findings of a patient with aggressive recurrent desmoid-type fibromatosis involving the posterior chest wall, paraspinal muscles and scalp.

Materials and Methods
28 year old male diagnosed with desmoid-type fibromatosis following an excisional biopsy of a right posterior chest wall mass in
The surgical pathology revealed myofibroblastic proliferation, consistent with DF. The patient subsequently underwent multiple excisions of posterior chest wall and neck masses and developed recurrent masses while on NSAID therapy. In 2014 the patient was also found to have developed multiple paraspinal masses. Biopsy of these masses confirmed the suspected diagnosis of DF. The patient received chemotherapy and underwent paraspinal excisions and proton beam therapy. In 2016, the patient developed additional areas of DF including the scalp. The patient's fibromatosis continued to progress despite treatment with surgery, radiation and chemotherapy. In 2018 the patient was started on oral Sorafenib and subsequent PET/CT scans and MRI have revealed response to treatment.

**Results**

There are several nodular scalp lesions which are hypointense on T1 and T2WI without significant enhancement. In addition, multiple lesions are also noted in the cervical and thoracic regions some of which do demonstrate abnormal enhancement.

**Conclusions**

Desmoid-type fibromatosis is a rare, locally aggressive infiltrative neoplasm [1,2]. Desmoid tumors do not have the potential for metastasis and usually recur locally, however our patient's tumors recurred locally and also spread to involve the paraspinal muscles and scalp [1-3]. DF involving the head and neck accounts for approximately 10 percent of all desmoid tumors and can behave more aggressively than tumors located elsewhere [1]. Treatment for DF has recently shifted from first line surgery and radiation to include systemic targeted therapy which has halted the progression of our patient's tumors [3]. The response to therapy can be managed with MR imaging by monitoring size of tumors, degree of enhancement and T2 signal intensity [3]. Desmoid-type fibromatosis shows characteristic nonenhancing low signal intensity bands on MR images as demonstrated by our case [4].

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**Gorlin-Goltz Syndrome**

H Kang¹, Y Kim¹

¹Seoul Veterans Hospital, Seoul, Korea, Republic of
Purpose
Gorlin-Goltz syndrome (GGS) is a rare multisystemic disease inherited in an autosomal dominant pattern. It is a rare phakomatosis characterized by multiple odontogenic keratocysts, basal cell carcinoma of the skin, and skeletal anomalies such as frontal bossing, vertebral anomalies, palmoplantar pits, and falx cerebri calcification. In this article, we present a 54-year-old man who was admitted to our clinic with mass lesion on right mandibular angle which was diagnosed as odontogenic keratocyst and left paranasal nodular lesion that was diagnosed as basal cell carcinoma. On brain computed tomography, dense falx cerebri calcification was seen. The patient was diagnosed to have GGS.

Materials and Methods
A 54-year-old man was admitted to our hospital with a chief complaint of swelling in the left facial region since 3 months. Swelling slowly progressed in to the present size which caused facial asymmetry. On physical examination, there was a focal swelling involving right mandibular area. On palpation, the swelling was firm in consistency and nontender. On facial computed tomography (CT), 2.7 x 3.7cm sized soft tissue lesion with calcified focus was seen in the left paranasal area. And the patient had 6.5 x 6.2cm sized bulging contour cystic mass lesion in the right mandibular body and ramus which showed expansile and multilocular cystic necrosis nature with remodeling and erosive change on adjacent bony compartment and several small cysts in the right mandibular angle (Fig. 1A-C). On brain CT, dense ectopic calcifications were seen in the falx cerebri (Fig. 1D). As jaw cyst and dense falx cerebri calcifications were present we were of a suspicion whether this is associated with a syndrome such as GGS. The partial resection of the mandibular cyst was done. Histological examination revealed epithelial proliferation of the stratified squamous epithelium and luminal proliferation which revealed the presence of OKC. Total resection of the left paranasal nodular lesion was done. On histopathologic examination of a full-thickness biopsy specimen obtained from the lesion, a tumoral structure composed of basaloid cells was observed in the dermis and the cells showed palisade arrangement in the edges. Histological diagnosis was BCC. All these findings were compatible with the diagnosis of GGS.

Results
Figure 1. A 54-year-old male patient with left paranasal swelling and right mandibular body and ramus mass lesion. A. On facial computed tomography (CT), 2.7 x 3.7cm sized soft tissue lesion with calcified focus was seen in the left paranasal area (arrow). B-C. On facial CT, the patient had 6.5 x 6.2cm sized bulging contour cystic mass lesion in the right mandibular body and ramus which showed expansile and multilocular cystic necrosis nature with remodeling and erosive change on adjacent bony compartment and several small cysts in the right mandibular angle. D. On brain CT, dense ectopic calcifications were seen in the falx cerebri.

Conclusions
GGS is a rare autosomal dominant disorder that involves multiple organ systems including the jaws, skeleton, and skin. It is characterized by multiple BCCs, jaw cysts, and skeletal anomalies, and falx cerebri calcification. Knowledge of the GGS findings is important for early diagnosis of this syndrome so that optimal treatment can be rendered and thus the progression to a threatening condition can be prevented.
Black Hairy Tongue Mimicking Ulceration on CT Imaging

E Unlu1, L Ginsberg1

1MD Anderson Cancer Center, Houston, TX
Purpose
To describe the imaging finding of black hairy tongue, a rare benign asymptomatic medical condition, resulting from decreased apoptosis of the epithelium, with consequent elongation of the filiform papillae with a typical carpet-like appearance and black, green or yellow pigmentation of the dorsum of the tongue (1). It is associated with smoking, radiotherapy, immunosuppression, poor oral hygiene, trigeminal neuralgia, and xerostomia.

Materials and Methods
A 73-year-old male treated for floor of mouth squamous cell carcinoma with surgery subsequent chemoradiation underwent post-treatment CT imaging. There was an approximately 3 cm area of apparent abnormal soft tissue containing air bubbles on the dorsal surface of the tongue, worrisome for an ulcerative process. After consultation with the primary physician, this finding was correlated with a darkened, brownish-looking coating felt clinically to represent so-called black hairy tongue. To our knowledge, this is the first report describing the CT finding of black hairy tongue.

Results
CT soft tissue of the neck reveals 3 cm area of apparent abnormal soft tissue containing air bubbles on the dorsal surface of the tongue, suspicious for an ulcerative process. The picture shows brownish-looking coating on the posterior dorsal tongue.

Conclusions
On CT examination, black hairy tongue may have the appearance ulcerative process. Obviously, correlation with clinical examination is necessary to avoid misinterpreting this finding as an ulceration. Knowledge of clinical examination will assist the radiologist in making the correct diagnosis of black hairy tongue.

(Filename: TCT_2540_BlackHairyTongue.jpg)

2711

Perineural Tumor Spread prior to the Development of a Detectable Primary Malignancy, and the Undying Myth of “Bell’s Palsy”

B Wang¹, L Ginsberg²
¹MD Anderson Cancer Center, Houston, TX, ²M.D. Anderson Cancer Ctr., Houston, TX

Purpose
The purpose is to illustrate the imaging findings of a case of perineural tumor spread prior to the development of a detectable primary malignancy. This report is intended to increase awareness in the neuroradiology community of this entity and the potential impact on patient management.

Materials and Methods
Patient is a 61-year-old male with history of left facial nerve paralysis for the past 2.5 years that was first diagnosed as Bell's palsy. At that time he had imaging that was read as normal. He noticed 3 months ago the development of large left parotid mass that has expanded rapidly. He endorses left sided otalgia and facial pain, difficulty opening his mouth, and facial nerve paralysis. He has history of a previous pre-cancerous lesion removed from his left cheek overlying the current rapidly expanding left parotid mass. Patient underwent a parotidectomy, and the pathology was metastatic squamous carcinoma from skin cancer.

Results
The initial outside CT from August 2017 was read as negative, but in retrospect there was enlargement of the left facial nerve compatible with perineural spread even though no parotid or dermal tumor was present at the time. On the CT from February 2019, the patient had a 4.5 cm parotid malignancy that was invasive of the masseter muscle. On the MRI from March 20, the lesion was isointense on T1 and T2 and enhanced brightly following gadolinium administration. The lesion was very irregular in shape and was clearly invasive in all directions beyond the confines of the gland. There was invasion of the masseter as well as the pterygoid aspect.
of the masticator space. There was perineural tumor spread along the auriculotemporal branch of V3, with tumor clearly within and probably just above the left foramen ovale.

Conclusions
Perineural spread (PNS) of head and neck tumors is a well-described phenomenon whereby a lesion can migrate away from the primary site along the neural sheath. By this mechanism, tumor can spread a considerable distance and result in significant impact on treatment and prognosis. It is crucial that radiologists search for PNS whenever imaging the head and neck cancer patient, particularly those with unexplained cranial neuropathy, even when there is no detectable tumor. In any patient with persistent facial neuropathy, it is most definitely NOT Bell's palsy; a thorough search for parotid disease and perineural tumor must be conducted. If there is a history of skin malignancy, perineural tumor spread is of particular concern.

(Filename: TCT_2711_PNSImagefinal.jpg)
Purpose
Follicular thyroid carcinoma (FTC) is difficult to differentiate based on cytology and ultrasonogram features. Also, repetitive benign biopsy results make unnecessary follow up. It is known that Telomerase reverse transcriptase (TERT) promoter and RAS mutated FTC have poor prognosis. Purpose of this research is to investigate whether ultrasonographic features, pre OP bx results of FTC with RAS, TERT promoter mutation nodule are different from FTC without mutation.

Materials and Methods
This study included 104 patients with surgically confirmed FTC with available gene mutation tests. We categorized patients into four groups (no mutation, TERT mutation only, RAS mutation only and TERT + RAS mutations). US images were evaluated in terms of nodule size, internal composition, orientation, margin, homogeneity, echogenicity, calcification and hypoechoic rim. Preoperative biopsy results and follow up size changes were evaluated.

Results
In TERT or RAS mutated FTC, the proportions of heterogenous echotexture was more frequently observed (P=0.0129). TERT + RAS mutated FTC didn't show size increase during follow up period, which have higher distant metastasis or recurrence rate. Pre-operative biopsy results or other ultrasonogram image findings did not show significant differences among groups.

Conclusions
A statistically significant difference was found between TERT/RAS mutated and nonmutated FTC regarding the heterogenous echotexture (P=0.0129). Clinical stability or benign preoperative biopsy results may not guarantee its prognosis. Genetic screening for TERT promoter and RAS mutations with FTC might help the prediction of mortality and recurrence.

ASSR Programming: Infections, Tumors and Mimics
2592
4:45PM - 4:50PM

Spinal Cord Myelination: Is it Visualizable on MRI?

T English 1, S JAVED 1, M KHAN 2, D Lin 3, R Nadgir 2
1Johns Hopkins, Baltimore, MD, 2JOHNS HOPKINS HOSPITAL, BALTIMORE, MD, 3Johns Hopkins University School of Medicine, Baltimore, MD

Purpose
Brain white matter myelination on T1 and T2 weighted conventional MRI is well documented, but relatively little is known about the myelination pattern of the spinal cord during early development. The aim of this study is to examine the nature of frequently observed T2 hyperintense signal within the lateral aspects of the spinal cord on cervical spine MRI performed on otherwise normal neonates.

Materials and Methods
319 consecutive MRIs of the cervical spine from April 2013 to October 2017 performed on patients between day of life 1 and 2 years of age were retrospectively reviewed. Age (corrected for gestational age), clinical indication, scanner type and magnet strength, type of pulse sequence were recorded. Studies of suboptimal image quality and with underlying cord pathology (e.g. trauma, tumor, myelitis, syrinx) were excluded. Two readers examined the spinal cord signal along the lateral aspect where white matter resides and classified as normal expected T2 signal (Group 1) and high T2 signal (Group 2) by consensus. Groups 1 and 2 were then analyzed with respect to age distribution and gender using unpaired t-test and 2-way ANOVA. Statistical significance was set at a=0.05 with correction for multiple comparisons.

Results
After exclusion, a total of 227 studies were analyzed and categorized into Group 1 (N=166, 82F) and Group 2 (N=61, 20F). Group 1 (normal T2 lateral cord signal) showed significantly higher mean age of 54.5± 30.3 weeks compared to Group 2 (high T2 signal) with mean age of 12.6 ± 20.1 weeks (P<0.0001, unpaired t-test). There is no significant difference in mean age between genders within either Group 1 (82F/84M, P=0.363) or Group 2 (20F/41M, P=0.124).

Conclusions
T2 hyperintense signal in the lateral aspects of the cervical spinal cord is seen in a much younger cohort at mean age of 12.6 weeks, typically within the first 30-45 weeks of life, but absent in the older cohort during the first 2 years of life. These findings suggest T2 high signal in the lateral cord represent incompletely myelinated spinal cord white matter, similar to what has been observed in cerebral white matter maturation during the first few years of development. The overall variability in the age distribution of these findings may recapitulate the wide age ranges of developmental milestones in this dynamic process, but may also be limited by the imaging technique and subjectivity in visual assessment.
Common Data Element (CDE) in Reporting Spinal Instability Neoplastic Score (SINS): Is There Room For Improvement in Spine Oncology Radiology Reporting?

A Patel¹, K Al-Dasuqi², V ZOHRABIAN³, A Malhotra⁴, I Ikuta⁵
¹Yale New Haven Hospital, Hartford, CT, ²Yale School of Medicine, New Haven, CT, ³YALE SCHOOL OF MEDICINE, NEW HAVEN, CT, ⁴Yale University School of Medicine, New Canaan, CT, ⁵YALE UNIVERSITY SCHOOL OF MEDICINE, MILFORD, CT

Purpose
There has been a push to utilize dictation macros which include Common Data Elements (CDE) for evidence-based reporting in radiology. The Spinal Instability Neoplastic Score (SINS) is one such disease-specific example in spine oncology. In order to deliver more accurate, timely, and actionable findings to providers, we CDE reporting macros could improve our reporting to a community standard as it relates to SINS. SINS was initially developed for assessing patients with spinal neoplasia and identifying those that may benefit from surgical intervention. As a project of quality improvement, we will evaluate our current baseline reporting practices relative to the CDE macros to evaluate the necessity of implementing CDE macro reporting.

Materials and Methods
All MRI spine reports from 1/1/2019 - 5/1/2019 were reviewed prior to implementation of CDE macros. Exams were excluded if not specifically for spinal neoplastic lesions and if no prior CT of the spine was available to allow for description of lesion quality. Five radiologically related CDE's for the SINS were marked as either present or absent from each report, as well as the percentage of all 5 CDE's in each report.

Results
55 reports met inclusion criteria. The most commonly reported CDE is location of the spinal lesion (94%). The least reported CDE element is characteristics of the bony lesion (14%). Completeness of reports for inclusion of all 5 radiology-related CDE elements 5%.

Conclusions
Based on our current approach to describing spinal lesions, we do not completely mention the radiographic findings related to the SINS, and there is wide variability. Going forward, we will design a CDE-based macro that we hope to incorporate into our workflow in order to bring our group towards a community standard of evidence-based actionable reporting. Furthermore, we hope that these CDE macros will hopefully facilitate research into natural language processing, machine learning, and deep learning as it relates to artificial intelligence in radiology.
Utility of quantitative T1 signal evaluation (T1 bone marrow/CSF signal ratio) on routine MRI lumbar spine sequences in prediction of decreased spine bone density.

H Kale¹, S Yadav²
¹KDA Hospital, Mumbai, India, ²Kokilaben Dhirubhai Ambani hospital, Mumbai, MH

Purpose
MRI of the spine is performed for a myriad of spine pathology. MRI is ideal in evaluation of bone marrow due to its high soft tissue contrast. Bone marrow signal is dependent on many factors and undergoes changes with age. Osteoporosis is a metabolic disease of bone tissue. In osteoporosis, there is both a decrease in bone mass as well as a change in bone architecture. Dual-energy x-ray absorptiometry (DEXA) is an accepted technique for diagnosis of decreased bone density. Osteopenia/osteoporosis is frequently under-diagnosed especially in men. A few studies have shown an association between MRI bone marrow signal and osteoporosis. No easily applicable parameters for estimating bone density are available on routine MRI sequences. T1 signal intensity ratio of vertebral body/CSF may be a useful quantitative measure for predicting decreased bone density. Early suspicion of bone loss, especially unexpected, may help in timely appropriate treatment and prevention of adverse outcomes such as compression fractures.

Materials and Methods
A retrospective study was conducted at Kokilaben Dhirubhai Ambani Hospital and Medical Research Institute. Inclusion Criteria: • Patients of either sex presenting for routine clinic visits as a part of annual health check up. • Age group selected: 18 and above. Exclusion Criteria: • Heterogeneous bone marrow signal. • Previously known bony pathology • Significant degenerative disease producing bone marrow changes • Known malignancy • Severe anemia Data Collection Method: The data recorded was; Age/Sex of the patient, BMD value in gm/cm² for the lumbar spine and T1 Bone marrow vertebral bodies (L1-L5)/ T1 CSF signal intensity ratio.

Statistical Methods: Correlation Analysis

Results
After use of inclusion and exclusion criteria a total of 36 patients were selected for the study. These patients ranged in age between 45 yrs. to 73 yrs. Of these there were 20 men and 16 women. The T1 bone marrow /T1 CSF signal intensity ratio varied between 1.308 and 2.927 (mean: 1.869). The Pearson correlation coefficient is r = -0.619 (p-value of 0.0001) which shows a statistically significant negative moderate correlation between the T1 bone marrow /T1 CSF signal intensity ratio and bone density.

Conclusions
T1 bone marrow /T1 CSF signal ratio on routine MRI sequences may indicate possible decreased bone density. This ratio may be of substantial benefit in cases of unsuspected osteoporosis/osteopenia.
Scientific Abstract Session: Adult Brain Miscellaneous 2
1521
3:30PM - 3:36PM

Cerebral Fat Embolism Syndrome in Sickle Cell Disease: A Case-Based Discussion of Imaging Findings, Clinical Considerations and Pathophysiology.

K Golden¹, J Rodriguez², B Huang³, S Hung¹
¹University of North Carolina School of Medicine, Chapel Hill, NC, ²UNC Chapel Hill, Durham, NC, ³N/A, N/A

Purpose
This Excerpta presentation will be a case-based discussion of fat embolism syndrome (FES) as a rare and frequently overlooked complication of sickle cell disease.

Materials and Methods
A 47-year-old female with underlying hemoglobin SC disease presented with an ST-elevation myocardial infarction. The following morning, the patient became unresponsive with new right-sided gaze deviation. Lab data were suggestive of hemolysis with down trending hemoglobin and platelets. Non-contrast head CT and CTA were negative. Brain MRI demonstrated findings suggestive of cerebral FES. An echocardiogram showed no evidence of an intracardiac or intrapulmonary shunt. Red cell exchange transfusion was quickly arranged.

Results
Brain MRI demonstrated numerous punctate foci of restricted diffusion and corresponding T2-weighted hyperintensity within the cerebral white matter, basal ganglia, brainstem and cerebellum in a "starfield" pattern. Corresponding foci of signal hypointensity
were present on susceptibility-weighted imaging, compatible with microhemorrhage. Additionally, the calvarial and clival marrow signal was heterogeneous with patchy restricted diffusion, reflecting chronic anemia and multiple bone infarcts.

Conclusions

In sickle cell disease, FES occurs in the setting of vaso-occlusive crisis and bone infarction as fat droplets and other marrow elements enter the venous circulation. A presenting triad of neurologic compromise, hypoxemia and petechial rash is classic. The two main theories for cerebral involvement in patients lacking a right-to-left shunt will be discussed in this Excerpta presentation. Typical MRI findings in cerebral FES include numerous punctate foci of restricted diffusion ("starfield" pattern) and T2-weighted hyperintensity within the supratentorial and infratentorial brain. These foci reflect small infarcts. Gradient-echo and susceptibility-weighted sequences demonstrate corresponding punctate foci of signal hypointensity reflecting microhemorrhage. The imaging differential is limited and includes cardiogenic, fat, or septic emboli; vasculitis; diffuse axonal injury; some tick and mosquito-borne infections; and tiny hemorrhagic metastases. Non-traumatic FES is a frequently overlooked clinical diagnosis with high associated morbidity and mortality. Timely initiation of exchange transfusion can help to prevent permanent neurologic disability and death. The radiologist must be familiar with the "starfield" pattern as an imaging presentation for this rare and serious complication.
No changes in T1 relaxometry after a mean of eleven administrations of gadobutrol
A Radbruch¹, K Deike-Hofmann²
¹University Hospital Essen, Essen, Germany, ²German Cancer Research Center, Heidelberg, Baden-Württemberg

Purpose
Quantitative T1 relaxometry is the benchmark in imaging potential gadolinium deposition and known to be superior to semi-quantitative signal-intensity-ratio analyses. However, T1 relaxometry studies are rare, commonly limited to a few target structures and reported results are inconsistent. We systematically investigated quantitative T1 relaxation times (qT1) of a variety of brain nuclei after serial application of gadobutrol.

Materials and Methods
qT1 measurements were performed in a patient cohort with a mean number of 11 gadobutrol applications (n=46) and compared to a control group with no prior GBCA administration (n=48). Thirteen target structures were evaluated including the dentate nucleus, globus pallidus (GP), thalamus, hippocampus, putamen, caudate, amygdala and frontal white matter. Subsequently, multivariate regression analysis with adjustment for age and previous cerebral radiotherapy was performed.

Results
No assessed site revealed a significant correlation between qT1 and number of gadobutrol administrations in multivariate regression analyses. However, a significant negative correlation between qT1 and age was found for the GP as well as anterior and lateral thalamus (p < 0.05 each).

Conclusions
No T1 relaxation time shortening was found in any assessed brain structure after serial injection of 11 doses gadobutrol.

1816 3:44PM - 3:50PM
The Incidence of Idiopathic Intracranial Hypertension in Headache Related Emergency Room Visits at Memorial Hermann Hospital System in Houston

S Khanpara¹, S Choi², A Aein¹, S Khalil³, R Riascos⁴, R Patel¹, A Kamali⁵
¹The University of Texas Health Science Center, McGovern Medical School, Houston, TX, ²The University of Texas Health Science Center at Houston, Houston, TX, ³University of Texas Health Science Center at Houston, Houston, TX, ⁴Univ. Of Texas - Houston, Houston, TX, ⁵UT Health, Houston, TX

Purpose
Idiopathic intracranial hypertension (IIH) may present with non-specific symptoms. No single imaging marker is sensitive and specific enough to diagnose IIH. In this study, we look at the imaging markers of IIH in patients presenting to the emergency department (ED) with primary complain of headaches to look for signs of IIH.

Materials and Methods
IRB approval was obtained. Total of 2942 patients presented to the ED with complaint of headaches in 2016 and 2017 after excluding MRI scans with intracranial mass, hemorrhage or hydrocephalus. A medical student, two residents and a neuroradiology fellow were trained to recognize five imaging signs of IIH, namely; optic nerve sheath distension (ONSD), flaring of the optic nerve sheath (FONS), flattening of the posterior globe (FPG), partial or complete empty sella (ES) and dilatation of the Meckel's cave (MCD). The cut-o value to decide ONSD and MCD was 6.5 and 4.2 mm. Patient's charts were also reviewed to look for opening CSF pressures if a lumbar puncture (LP) was performed. A cut off value of 25 cm water was used for elevated opening CSF pressure.

Results
276 patients (9.4%) had an elevated opening pressure (25 cm of H2O) on bedside or fluoroscopy guided LP. MCD was the most commonly observed abnormal imaging finding (494 patients). ONSD was seen in 120 patients, FONS in 74, FPG in 50 and ES in 36 patients. About 70 patients (3%) who did not undergo LP had a combination of ONSD + FPG + ES which is highly equivalent to IIH radiologically. This could represent the occult cases of IIH.

Conclusions
Approximately 10% of patients who presented to the emergency department at Memorial Hermann Hospital System (13 hospitals in Houston) with headaches and underwent brain MRI scan were positive for IIH. About 3% of patients who had obvious imaging signs of IIH did not undergo LP and we believe were missed on imaging (about 1/3 of patients). Radiologist should be more sensitive to clinical and imaging signs of IIH to prompt early diagnosis and treatment to avoid complications such as chronic headaches and vision loss.
Indentation of the Meckel’s Caves, Imaging Marker to Diagnose Idiopathic Intracranial Hypertension.

A Kamali1, A Aein2, S Choi3, S Khalili4, R Riascos5, R Patel2, A Gandhi6
1UT Health, Houston, TX, 2The University of Texas Health Science Center, McGovern Medical School, Houston, TX, 3The University of Texas Health Science Center at Houston, Houston, TX, 4University of Texas Health Science Center at Houston, Houston, TX, 5Univ. Of Texas - Houston, Houston, TX, 6Rice University, Houston, TX

Purpose
Clinical and imaging manifestations of idiopathic intracranial hypertension (IIH) should prompt early diagnosis and treatment to avoid complications such as chronic headaches and vision loss. Multiple diagnostic imaging criteria are reported to suspect diagnosis of IIH. However, each imaging finding lacks sensitivity, specificity, or both for diagnosis of IIH. Increased intracranial pressure results in dilatation of the perineural cisternal spaces such as the optic nerve sheaths and Meckel’s caves. Increased intracranial pressure may also result in protrusion of cisternal structures of Meckel’s caves through the skull base foramina. This may result in indentation or bilobed or indented appearance of the Meckel’s caves. We set out to investigate the sensitivity and specificity of Meckel's cave's indentation as an imaging marker for diagnosis of IIH.

Materials and Methods
Institutional IRB approval was obtained. We studied 75 patients (18-59 years old) with confirmed diagnosis of IIH and documented elevated opening CSF pressure (≥250 mm of H2O) were selected retrospectively from 2015-2018 at Memorial Hermann Hospital system in Houston for this study. Additional 75 age and sex matched healthy controls with negative brain MRI were also included in the study. We looked for indentation of the Meckel's cave on the coronal T2 weighted sequences in both groups. The indentation
considered positive if there is acute angle or bilobed appearance in the body of the Meckel's caves on the coronal T2 sequences (Fig. 1). The smooth curvature of the Meckel's cave considered negative for indentation (Fig. 1).

**Results**

Out of 75 patients with diagnosis of IIH, 57 (76%) had indented Meckel's cave (MC) and 18 (24%) were negative for indentation. In the healthy group, out of 75 subjects, 21 (28%) displayed indentation and 54 subjects (72%) were negative for indentation (Table 1). Positive indentation of the MC showed 76% sensitivity and 72% specificity for diagnosis of IIH. The positive predictive value (PPV) of indented MC for diagnosis of IIH was 73% and the negative predictive value (NPV) was 75%.

**Conclusions**

Indentation of Meckel's caves may be used as a relatively sensitive and specific MRI marker to suspect the diagnosis of IIH.

(Filename: TCT_2005_IndentationorbilobedappearanceofMeckelscaves.gif)

### Table 1. Meckel's cave indentation demonstrates 76% sensitivity, 72% specificity, PPV of 73% and NPV of 75% for diagnosis of IIH.

<table>
<thead>
<tr>
<th>INDENTATION OF MECKEL'S CAVE</th>
<th>YES</th>
<th>NO</th>
<th>TOTAL</th>
</tr>
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<tbody>
<tr>
<td>IIH</td>
<td>57</td>
<td>18</td>
<td>75</td>
</tr>
<tr>
<td>Healthy</td>
<td>21</td>
<td>54</td>
<td>75</td>
</tr>
</tbody>
</table>

(Filename: TCT_2005_IndentationorbilobedappearanceofMeckelscaves.gif)

### Changes in White Matter Microstructure in Normal Aging Measured by Diffusion Tensor Imaging


1IDI-IDIBGI, Girona, Girona, 2IDIBGI-IAS, Girona, Girona, 3QUIBIM, Valencia, Valencia, 4Canon Medical Systems, Center of Comparative Medicine and Bioimaging of Catalonia (CMCiB), Badalona, Barcelona, 5IDIBGI, Girona, Girona, 6University of Lleida-IRBLleida, Lleida, Lleida, 7IDIBGI-Hospital Universitari Dr Josep Trueta, Girona, Girona, 8University of Manitoba, Winnipeg, Manitoba, 9IDI-IDIBGI, Girona, Spain

**Purpose**

In white matter (WM) tracts, diffusion anisotropy declines in middle age. Normal aging exhibits decrease in myelin density and in the number of myelinated fibers. It is unclear whether regional WM vulnerability is global or it is accelerated in specific tracts. We aimed to investigate to what extent age-related changes occur within WM tracts using diffusion tensor imaging (DTI) in a healthy cohort population-based study.

**Materials and Methods**

We studied 1021 healthy individuals (548 males, 473 females; mean age 67 years [range age, 50-96]) enrolled in a population-based study to identify of aging biomarkers across a wide range of data from fields as imaging, biopsychosocial sphere, cardiovascular, metabolomics, lipidomics, microbiomics, and other age-related changes. DTI was acquired at 1.5 T using a single-shot spin echo sequence with echo-planar imaging (EPI), 60 contiguous slices, voxel size 2x2x2.5 mm3, TE/TR of 75/4500 ms/ms, a diffusion-weighting factor b=1000 s/mm2 and diffusion encoding along 16 directions. After removing DTI sequences with low quality, a total of 947 subjects were included in the analysis. Parametric maps were calculated. After coregistration and normalization tasks, DTI-metrics (fractional anisotropy, axial diffusivity, radial diffusivity and mean diffusivity) were extracted for each tract. The subjects...
were grouped into the following three age categories: 55-64 (210 males, 209 females), 65-75 (251 males, 201 females), and 75-96 years (87 males, 63 females). The comparisons of DTI-metrics according to the groups and gender were adjusted for the brain volume.

Results
DTI-metrics for participant groups were regionally variable. The WM tracts that experienced more changes in fractional anisotropy were the anterior portion of corona radiate (eta-squared, $\eta^2=0.178$), the genu of corpus callosum (eta $^2=0.166$), external capsule ($\eta^2=0.131$), posterior thalamic radiation ($\eta^2=0.127$) and anterior limb of internal capsule ($\eta^2=0.064$).

Conclusions
Our study supports regionally selective age-related changes in WM tracts measured by DTI-metrics. Further studies are required in order to find the reasons for these effects. Knowledge concerning the normal aging of white matter tracts would contribute to improve the understanding of abnormal changes in neurodegenerative diseases.

(Filename: TCT_2722_DTIandaging.JPG)

1831
4:05PM - 4:11PM

Ectopic Cerebellum Presenting As An Exophytic Thalamic Mass: Diagnosis Using Advanced MRI Techniques

J Kang1, M Lewis1, A Wong1
1Kaiser Permanente Los Angeles Medical Center, Los Angeles, CA

Purpose
Case reports of ectopic cerebellum are extremely rare, and the incidence and pathophysiology are not known. We present a case of ectopic cerebellum involving the thalamus, with diagnosis confirmed through conventional and advanced MRI techniques.

Materials and Methods
26-year-old female with no significant past medical history, presents with several months of a tingling feeling involving her left face and extremities. Physical examination reveals no focal neurologic abnormalities. Laboratory examination is unremarkable.

Results
Magnetic resonance (MR) evaluation of the brain reveals an exophytic mass arising from the left thalamus, measuring 1.9 x 1.9 x 2.3 cm, with signal characteristics similar to normal brain parenchyma on all sequences, and without appreciable contrast enhancement. Single voxel MR spectroscopy evaluation of the mass reveals a decreased N-acetylaspartate/Creatinine (NAA/Cr) ratio relative to the surrounding thalamic tissue, in a ratio similar to that expected for normal cerebellum4. Also, high resolution T2- weighted and FIESTA sequences were obtained through the lesion, which revealed fine complex internal architecture, including surface folds with intervening cerebrospinal fluid, and evidence of internal gray-white differentiation, strikingly resembling normal cerebellar architecture. A diagnosis of ectopic cerebellum was made and surgical biopsy was avoided.

ASNR20 Virtual Proceedings Page 896
Conclusions
We present a case report of an incidental finding of supratentorial ectopic cerebellum, in a patient with no associated neurologic deficits. We were able to utilize advanced MR imaging techniques to aid diagnosis and avoid unnecessary invasive biopsy or surgery.
Central Variant Posterior Reversible Encephalopathy Syndrome Mimicking a Pontine Glioma

O Alaslani, A Guarnizo, V Tsehmaister-Abitbul, T Nguyen, N Zakhari, C Torres

1University of Ottawa - The Ottawa Hospital, Ottawa, Ontario

Purpose
To review the clinical presentation, epidemiology and prognosis of central variant posterior reversible encephalopathy syndrome (PRES). To discuss the imaging findings of the central variant PRES and diagnostic challenges to establish a diagnosis.

Materials and Methods
A 53-year-old male transferred to our institution with expansile brainstem lesion on MRI suspicious for a glioma. The patient presented with 4 month history of visual hallucinations. On physical exam, he had a blood pressure of 219/125, right pronator drift and left side dysmetria. Enhanced MRI was performed with advanced imaging techniques. The imaging findings and clinical history were suggestive of central variant PRES. The blood pressure was controlled using antihypertensive medications with resolution of the symptoms. Follow up showed significant improvement of MRI findings. A second case of a 42-year-old female with history of chronic hypertension presented with 2-day history of dizziness, headaches and difficulty walking. On physical exam, she presented blood pressure of 212/115 and left side dysmetria. High blood pressure was also controlled with medication and there was subsequent improvement of the clinical and MRI findings.

Results
MRI examination of the first patient shows severe brainstem swelling and increased T2/FLAIR signal intensity (A). No significant abnormalities on perfusion maps (D) or MR spectroscopy (C). Follow up exam a month later showed improvement of the signal changes and edema (B). The second patient's MRI shows marked edema and diffusely increased signal intensity of the pons. 4 months follow up showed marked improvement of the abnormality. In both cases, the frontal, parietal and occipital subcortical white matter were spared.

Conclusions
Although PRES is a common and reversible disorder, atypical imaging presentation can be challenging and can mimic various medical conditions [5]. Typical imaging findings of PRES includes frontal, parietal, temporal, or occipital cortical/subcortical edema in more than 90% of cases [2]. Central-variant PRES was reported to occur in approximately 4% of PRES cases [5]. The combination of MRI findings with lack of brainstem signs in a patient with hypertension should alert the clinician about the possibility of central variant of PRES. [6] Differential considerations include rhombencephalitis, viral encephalitis, pontine glioma, myelinolysis, tumefactive demyelination and basilar thrombosis. Imaging findings and symptoms usually resolve with appropriate treatment.
Visualization of Sinking Skin Flap Syndrome in Post-Craniectomy Patients by Upright Computed Tomography

K Yoshida¹, Y Yamada², M Yamada², K Kosugi¹, Y Yokoyama², H Fujiwara², K Yoshida¹, M Toda¹, M Jinzaki²
¹Department of Neurosurgery, Keio University School of Medicine, Tokyo, Japan, ²Department of Radiology, Keio University School of Medicine, Tokyo, Japan

Purpose
Sinking skin flap syndrome or "syndrome of the trephined" is a rare complication of a craniectomy characterized by a new neurological dysfunction that typically worsens in the upright position and improves after cranioplasty. Neither its underlying pathophysiology nor the characteristic radiological signs have been fully elucidated yet. The recently-developed upright CT can offer images of quality comparable to those of a conventional supine CT, thus enabling anatomic visualization and detailed analysis regarding postural changes of the human body. We report preliminary findings from four craniectomy patients, including one sinking skin flap syndrome patient, obtained by this new modality.

Materials and Methods
Four post-craniectomy patients (4 men; mean age 51.8, range 33–66) underwent CT scans in the supine and sitting positions. Despite being free of symptoms in the supine position, in the upright position one patient had objective symptoms of slight hemiparesis and...
occasional faintness with a diagnosis of sinking skin flap syndrome and two patients had subjective symptoms of visual disturbance or dizziness. The other patient had no symptoms except for cosmetic and safety concerns. All the patients underwent cranioplasty resulting in a resolution of their symptoms.

Results
Upright CT images of the sinking skin flap syndrome patient showed a remarkable shift not only on the surface but also in the midline of the brain compared to the supine CT (Figure). Postural changes in the brain surface were evident in all patients. The degree of brain shift was significantly associated with the severity of the clinical symptoms. In this case series, no correlation between the postural brain shift and the craniectomy size or cerebrospinal fluid volume was evident.

Conclusions
Upright CT clearly visualized a postural brain shift, a possible marker for sinking skin flap syndrome, explaining why the symptoms are aggravated by the upright position. Craniectomy patients are influenced by the atmospheric pressure, but resulting displacement of the brain parenchyma differs between individuals. More cases are needed to determine what factors lead to remarkable postural brain shifts causing sinking skin flap syndrome.
Imaging in Asymptomatic Idiopathic Intracranial Hypertension - Finding the leak

R Purushothaman¹, G Vilanilam¹, R Samant¹, M Kumar¹, R Ramakrishnaiah¹
¹University of Arkansas for Medical Sciences, Little Rock, AR

Purpose
Imaging findings in patients with spontaneous CSF leak secondary to idiopathic intracranial hypertension (IIH) are not well recognized. We present various subtle imaging findings of spontaneous CSF rhinorrhea in a patient with IIH.

Materials and Methods
A 46-year-old woman with history of hypertension and obesity presented to a tertiary care center with left-sided intermittent rhinorrhea. The fluid was proven to be CSF by clinical and lab methods. There were no associated headache, anosmia, or ear discharge. She did not have prior trauma, sinus surgery, or central nervous system infections. On physical examination, she was afebrile with stable hemodynamics and no neurological deficits. She was evaluated with CT face and MRI brain with findings consistent with chronic idiopathic intracranial hypertension with CSF decompression through the left cribriform plate.

Results
CT of the face revealed fluid tracking along the left nasal septum with deep arachnoid pits along the skull base. Subsequent MRI brain showed enlargement of the CSF spaces involving the cranial nerve sleeves prominent along bilateral optic nerves, Meckel caves, Dorello's canals and the hypoglossal canals. Dural outpouching at the cribriform plate with prominent skull base arachnoid pits, CSF filled deep sella turcica and low-lying cerebellar tonsils were seen. There was no bulge of optic disc due to decompression due to CSF leak.

Conclusions
Spontaneous CSF rhinorrhea as a sole presentation of IIH is rare. It typically occurs in obese young females. Several mechanisms have been proposed, such as excessive CSF production, venous outflow obstruction and impaired CSF resorption. CSF otorrhea may the presenting symptom in patients with bone defects in posterior fossa while CSF rhinorrhea occurs in patients with defects in the cribriform plate. One possible mechanism is of skull base erosion in the setting of high CSF pressure over time. Additionally, IIH patients with CSF leak may not present with the classic IIH signs and symptoms, as the leak can alleviate excess pressure. Indeed, it is likely that the year-long CSF rhinorrhea might have masked the symptoms in our patient. Post-CSF leak repair, there is an increased rate of leak recurrence due to increased intracranial pressure (ICP). Hence measures to lower ICP should be undertaken (weight loss, acetazolamide, CSF shunting). The familiarity of subtle imaging findings of chronic IIH and spontaneous CSF leak will aid in the accurate diagnosis and appropriate clinical management.
CT Brain Study During Outpatient Follow-up in Patients with Mild Traumatic Subarachnoid Hemorrhage Does Not Alter Patient Care but increases Radiation Exposure and Economic Burden
H Valand¹, T Locke², N SONI¹, G Bathla⁴
¹American University of Intergrative Sciences, TORONTO, CANADA, ²University of Iowa, Iowa City, IA, ³THE UNIVERSITY OF IOWA, IOWA CITY, IA, ⁴Univ. Of Iowa Hospitals & Clinics, Iowa City, IA

Purpose
A CT brain study at outpatient follow-up after traumatic subarachnoid hemorrhage (tSAH) is a standard of care at many institutions across the U.S. We aimed to determine if a repeat follow up CT scan in patients with isolated tSAH and Glasgow coma scale (GCS) score between 13-15 at the time of admission alters patient care. In addition, cost effective analysis and additional radiation exposure were also assessed.

Materials and Methods
Single center retrospective analysis at level one tertiary care hospital. Medical records were scanned using specific ICD-10 codes for mild traumatic brain injury and revealed 703 patients who presented between January 2017-July 2019. Inclusion criteria included isolated tSAH, GCS between 13-15, neurologically stable and out-patient follow up visit. A total of 103 (14.65%) patients met the eligibility criteria.

Results
Average GCS score at admission was 14.73 + 0.61 and mean of hospital stay was 3.18 +3.63 days. The mean duration between the first hospital visit and the follow up CT brain was 46.73+9.73 days. Of 103 patients, 61 (59.22%) patients were on at least one blood thinner. At 6 weeks follow up, all 103 patients had a complete resolution of tSAH. One patient (0.97%) had a new trace subdural hemorrhage finding requiring another 6 weeks follow up CT, which resulted in a complete resolution. The mean follow-up scans after the index scan were 1.49 + 0.72 with mean additional radiation exposure of 2.47 + 1.29 mSv. An estimated $350 per head CT, $36,050 were spent on follow up imaging but made no difference in change in clinical decision making.

Conclusions
Repeat out-patient follow up head CT of neurologically stable patients with isolated tSAH and GCS score of 13-15 is unlikely to alter management, despite the additional radiation and healthcare costs.

Scientific Abstract Session: Brain Tumor 4
1783
Electron density of brain tumors on dual-layer spectral CT correlates with their cellularity
M Azuma¹, T Hirai¹, K Maekawa¹, Y Sato², H Takeshima¹
¹Miyazaki University, Miyazaki, Miyazaki, ²Miyazaki University, Miyazaki, AK

Purpose
Dual-layer spectral CT (DLSCT) acquires low- and high-energy data simultaneously and yields quantitative information including the electron density. We investigated whether the electron density of brain tumors on DLSCT scans reflects their cellularity and helps to discriminate between meningioma and schwannoma.

Materials and Methods
We included 15 patients with meningioma and 12 patients with acoustic schwannoma who underwent preoperative DLSCT. Two pathologists assessed the samples for tumor cellularity. On histological samples they estimated the cell count, the total and average number of nucleic areas per three high-power fields (x 400) by using color image-analysis software. Two radiologists measured the electron density and CT attenuation of the tumors on DLSCT scans and calculated the corresponding apparent diffusion coefficient (ADC) of the tumors on 3T diffusion-weighted MR images. The mean electron density, mean CT attenuation, and mean ADC of meningiomas and schwannomas were compared with the independent t-test. Receiver-operating characteristics (ROC) analysis was used to determine whether the electron density, attenuation, and ADC help to differentiate the tumors.

Results
The cell count and the total and average number of nucleic areas were significantly different between meningiomas and schwannomas (p<0.001, p=0.0015, and p=0.0015, respectively). The electron density, attenuation, and the ADC were also significantly different (p=0.0001, p=0.0007, and p=0.0001, respectively). ROC analysis showed that the diagnostic performance was highest for the ADC (AUC=0.963), followed by the electron density (AUC=0.818) and the attenuation value (AUC=0.805). There was no difference in the AUC between the ADC and the electron density.

Conclusions
The electron density of brain tumors on DLSCT scans as well as their ADC can be used to estimate their cellularity. It helps to discriminate between meningioma and schwannoma.
Adult Intraventricular Mass Presenting as a Rare Combined Tanycytic Ependymoma and Subependymoma

J Ryu¹, S MOHAN¹, M Nasrallah², A Hassankhani¹
¹Division of Neuroradiology, Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, PA, ²Division of Neuropathology, Department of Pathology, Hospital of the University of Pennsylvania, Philadelphia, PA

Purpose
Review imaging for a rare adult 4th ventricular combined tanycytic ependymoma and subependymoma.

Materials and Methods
60-year-old man with left arm pain for 3 months, headache for 1 month worsened by recumbency, and blurry vision for 1 week. MR imaging demonstrated a mass at the fourth ventricular obex with obstructive hydrocephalus and cervical syrinx formation. Pathology after suboccipital craniotomy and tumor resection revealed combined tanycytic ependymoma and subependymoma (WHO Grade II). Immunohistochemistry was positive for epithelial membrane antigen (EMA) and glial fibrillary acidic protein (GFAP). Post-operative course complicated by pseudo-meningocele formation and intracranial hemorrhages necessitating ventriculostomy drainage catheters.

Results
Sagittal T2, axial FLAIR, axial diffusion, and axial post contrast T1 demonstrates a 2 cm non-enhancing T1 hypointense T2/FLAIR hyperintense mass (arrows) centered at the obex of the fourth ventricle with obstructive hydrocephalus and cervical syrinx (square bracket) formation. No diffusion restriction or surrounding parenchymal edema.

Conclusions
Tanycytic ependymomas are rare indolent pediatric tumors found in the cervical spinal cord or supratentorial brain often treated with total resection and radiation (1). A similar case of adult ependymoma with tanycytic features within our institution presented as an intramedullary cervical spine mass. However, intraventricular tanycytic ependymoma is the rarest variant of ependymoma, with fewer
than 10 cases reported in the English literature; no imaging findings were reported for tumors within the fourth ventricle (2). This unique case of an adult intraventricular combined ependymoma portrays imaging findings for an atypical presentation of a rare tumor.
“Tumor not oriented in time and space!”: Adult onset extra-axial medulloblastoma

P Puac Polanco¹, A Guarnizo¹, N Zakhari¹, C Torres¹
¹University of Ottawa, Ottawa, ON

Purpose
To show the clinical presentation and imaging findings of extra-axial adult onset medulloblastoma.

Materials and Methods
55-year-old male patient with long history of headaches, vertigo and symptoms of glossopharyngeal neuralgia. The lesion was initially thought to represent either a schwannoma or metastasis on imaging, however after resection, pathology showed a diagnosis of Medulloblastoma, WHO grade IV, WNT-activated.

Results
Axial CISS image (A) shows a low signal intensity extra-axial right CP angle mass extending into the jugular foramen. The mass is associated with low ADC value (B) and avid enhancement on post-contrast axial T1WI (C).

Conclusions
Adult medulloblastoma is rare, accounting for <1% of all adult brain tumors. Extra-axial location is extremely rare and it has been suggested that this tumor originates from either proliferating remnant of the external granular layers of the cerebellar hemispheres or from germinal cells present along the posterior medullary velum.

The Diagnostic Performance of Multiparametric MRI Radiomics for Classification of Untreated Adult Gliomas

A Alsaedi¹, J Panovska-Griffiths², X Golay¹, S Bisdas¹
¹Department of Brain Repair & Rehabilitation, Queen Square, UCL Institute of Neurology, London, UK, ²Department of Applied Health Research, UCL, London, UK

Purpose
To assess the diagnostic performance of radiomics related to multi-parametric MRI for the WHO 2016 classification of primary gliomas.

Materials and Methods
Thirty-two adults with untreated gliomas were prospectively recruited and underwent multimodal MRI perfusion with pseudo-continuous arterial spin labelling (pCASL), dynamic susceptibility contrast-enhanced (DSC), and dynamic contrast-enhanced (DCE) MRI, as well as DWI for the WHO 2016 tumour classification. The DCE maps were generated using the modified Tofts model (mTK) and the Lawrence and Lee model (L&L). The entire tumour was segmented manually on FLAIR, while grey matter (GM) being used as an internal reference, was automatically segmented on a high-resolution T1-weighted volume. Histogram features (mean, standard deviation, 95th-percentile, kurtosis, skewness, median, inter-quartile range, mode, minimum, maximum, variance, entropy, median z-score, and slope of the cumulative distribution function) were extracted from absolute and normalised values (aT, rT, respectively).
Additional percentiles were measured from the ADC map. The generated data reduced using Kruskal-Wallis H test to determine the significant variables. Then, further reduction was applied using pairwise correlation and backward elimination. The final diagnostic performance was assessed using multinomial logistic regression, both for individual features as well as for combined features from each of the modalities.

Results
Figure 1 shows the diagnostic performance of the significant features separately and combined. Linked histogram features, mostly from rT, of ASL, ADC, DSC, and DCE, independently enhanced the diagnostic accuracy up to 100%. As an individual technique, DSC showed superior diagnostic performance (overall 100%), though utilising both ASL and ADC has similar accuracy (100%). The DCE-L&L performed better than ASL (87% to 100%, 78% to 93%, respectively), but not the DCE-mTK (64% to 83%). Notably, DCE-L&L attained identical diagnostic performance in term of IDH-status, grouping and sub-grouping (overall 100%) with DSC.

Conclusions
Our results suggest that either DSC as an individual modality or alternatively combined ASL and ADC have similar and excellent accuracy as non-invasive biomarkers for gliomas classes prediction. This alludes the use of multimodal radiomics for glioma classification.

(Filename: TCT_1617_Fig1-ASNR1.jpg)

1937

Imaging Characterization of Low Grade Glial Tumors

M Dumba¹, C KACHRAMANOGLOU², F Tona³, A Gontsarova⁴, C Limbäck⁵, W Jan⁶

Purpose
The 2016 World Health Organization Classification of Tumors of the Central Nervous System now requires molecular status and histology to get a final integrated tumor diagnosis. Molecular analysis is not always readily available; however, imaging remains a mandatory part of diagnostic assessment. We analyzed our cohort of biopsy proven IDH wild type grade 2 and grade 3 gliomas to ascertain if imaging features could predict the tumor molecular subtype.

Materials and Methods
A cohort of patients who had undergone biopsy at our Institution between 1st January 2016 and 31st May 2019 confirming 1p/19q co-deleted (oligodendroglioma) or non-1p/19q co-deleted (diffuse astrocytoma) tumors were retrospectively reviewed. We identified 91 patients. Pre-operative CT and conventional MRI examinations were assessed by 2 neuroradiologists blinded to the patients' tumor status and recorded the presence of the following imaging features: presence of calcification, matched signal hyperintensity on T2W
and FLAIR sequences, cortical involvement, location of the lesion and presence of contrast enhancement. Subsequently, statistical analysis was performed using SPSS software to identify potential imaging predictors of molecular status.

Results
Stepwise linear regression including location, the presence of calcification, the presence of matched/unmatched T2 and FLAIR signal hyperintensity, cortical involvement and presence of enhancement as predictors was performed. This revealed statistically significant predictors being the presence of matched/unmatched T2/FLAIR signal hyperintensity and calcification (R square 0.77, p < 0.001). The presence of matched/unmatched T2/FLAIR signal hyperintensity is independently predictive of molecular status (t = 7.3, P<0.001). The remaining predictors were not statistically significant and did not improve the regression model. Image illustrating non 1p/19q co-deleted tumor (top images) and 1p/19q co-deleted tumor (bottom images).

Conclusions
The presence of matched/unmatched T2/FLAIR signal hyperintensity is independently highly predictive of molecular status and can be considered as a potential imaging biomarker in the differential diagnosis of grade 2 and 3 1p/19q co-deleted (oligodendroglioma) and non-1p/19q co-deleted (diffuse astrocytoma) gliomas.
Apparent Diffusion Coefficient (ADC) features before, during, and after radiation therapy, and their association with early versus late progression in patients with glioblastoma

A Chan¹, S Daghighi¹, B Behrouzi¹, A Sahgal¹, H Soliman¹, C Tseng¹, S Myrehaug¹, H Mehrabian¹, J Conklin², S Symons¹, J Detsky¹, C Heyn¹, R Chan³, A Lau³, P Jabehdar Maralani¹

¹University of Toronto, Toronto, ON, ²Massachusetts General Hospital, Boston, MA, ³Sunnybrook Research Institute, Toronto, ON

Purpose
To investigate whether ADC texture features before, during, and after radiation therapy (RT) within T1 contrast-enhancing (T1C) and nonenhancing FLAIR hyperintense regions of glioblastoma (GBM) are associated with early versus late progression.

Materials and Methods
34 patients with gross total resection of de novo, IDH wild-type GBM underwent MRI at 4 timepoints: RT planning at 7-10 days before RT (D0), at the 10th (D10) and 20th (D20) RT fractions, and at 1 month after the end of RT (D30). All patients received 30 fraction 60 Gy RT with Temozolomide chemotherapy. All scans were performed on 1.5T Philips Ingenia system and contained volumetric T1 weighted post gadolinium (3DT1C), volumetric FLAIR (3DFLAIR) and DWI (b=0, 500 and 1000 s/mm²) sequences. Each scan contained ADC maps automatically generated by the scanner software. 3DT1C and 3DFLAIR were coregistered, resampled and resliced to DWI-b₀ space in each case using SPM12. Non-overlapping volumes of interest on T1C and non-enhancing FLAIR hyperintense regions were contoured on coregistered 3DT1C and 3DFLAIR, respectively, with necrotic areas excluded using manual segmentation and assisted by threshold-based methods. Shape and first order texture features were extracted and analyzed. Wilcoxon rank-sum tests were used to assess whether features were associated with the endpoint, which we defined as early versus late progression based on the median progression-free survival of 6.9 months after treatment with concomitant RT and temozolomide [1].

Results
As expected, several shape features, reflecting the shrinking of T1C and enlargement of FLAIR regions, respectively, over D0-D30 were observed. At D0, early progressors showed significantly higher values in 4 FLAIR features: 10th percentile, energy, median, and total energy (p<0.05). Skewness in T1C was also significantly higher at D0 of early progressors (Figure 1). At D20, higher minimum values in FLAIR regions were associated with early progression; similarly, at D30 higher mean absolute deviation and robust mean absolute deviation were higher in FLAIR regions. No features were associated with early progression at D10.

Conclusions
Several texture features at different time points were associated with early progression. Among all time points, nonenhancing FLAIR hyperintense regions at D0 had more texture features that were associated with early progression.
Prediction of pTE\textsubscript{RT} Mutation Status Using Preoperative MR Imaging Phenotypes in Glioblastoma

L. De Alba\textsuperscript{1}, O. Arevalo\textsuperscript{1}, A. Dono\textsuperscript{1}, T. Takayasu\textsuperscript{1}, Y. Esquenazi\textsuperscript{1}, L. Ballester\textsuperscript{1}, X. Zhang\textsuperscript{1}, C. Soto\textsuperscript{2}, J. Zhu\textsuperscript{1}, A. Kamali\textsuperscript{1}, R. Riascos\textsuperscript{1}

\textsuperscript{1}The University of Texas Health Science Center, McGovern Medical School, Houston, TX, \textsuperscript{2}National University of Colombia, Bogota, Colombia

\textbf{Figure 1.} Several first order features could significantly differentiate early versus late progression in patients at D0 MRI, including (A) 10th percentile value within the FLAIR region; (B) energy within the FLAIR region; (C) median value within the FLAIR region; and (D) skewness within the T1C region. Early progression is demonstrated in red, whereas those who progressed after 6.9 months are shown in blue. Shaded areas represent the interquartile range. Significant differences (p<0.05) are denoted with *. 

Abbreviations: A.U., arbitrary units.
Purpose
Glioblastomas (GBM) are divided into two subgroups: isocitrate dehydrogenase (IDH)-wildtype and IDH-mutant. Different molecular subtypes have varied response to treatment and prognosis. The combination of pTERT mutation and wild-type isocitrate dehydrogenase 1 (IDH1) is the most common genotype occurring in more than 80% of GBM, and is associated with a worse prognosis. Noninvasive preoperative identification of a TERT mutation can help customize treatment with telomerase targeted therapies and predict prognosis. Our purpose is to evaluate if imaging features in preoperative MR can help distinguish between GBM IDHwt: pTERT-mutated and pTERT-wildtype.

Materials and Methods
Preoperative MR imaging scans of 146 patients with GBM IDHwt with known pTERT status were retrospectively included (84 IDHwt-pTERTmut, 62 IDHwt-pTERTwt). MR imaging features were evaluated by using Visually Accessible Rembrandt Images (VASARI), and semiautomatic segmentation was performed (volumetric measurement of the enhancement, FLAIR hyperintensity, and necrosis). Association between pTERT status and MR features was evaluated by Fisher’s exact test for categorical variables. The Wilcoxon rank-sum test and AUC were used for continuous variables. For AUC, a value higher than 0.75 was considered significant.

Results
Only one volumetric feature and two VASARI features demonstrated statistical significance for distinguishing pTERTmut from pTERTwt. The pTERTwt tumors demonstrated higher total tumor volumes than the pTERT mutant counterpart (P=0.044). Regarding the T1/FLAIR ratio, pTERTwt tumors demonstrated higher percentages of expansive and mixed patterns, whereas pTERTmut showed a higher percentage of infiltrative pattern (P=0.009). Percentage of restricted diffusion pattern was higher for pTERTmut than for pTERTwt (P=0.020). No AUC values were significant.

Conclusions
Preoperative MR imaging features did not reach statistical significance for discrimination between pTERTmut and pTERTwt genotypes when used as single variables. Nevertheless, other VASARI and volumetric features such as FLAIR volume, enhancement volume, enhancement quality, presence of cysts and presence of satellite lesions demonstrated a tendency to represent discriminating imaging biomarkers. Further investigation with larger sample sizes may eventually find stronger surrogates for different GBM genotypes.
<table>
<thead>
<tr>
<th>Feature</th>
<th>pTERT mutant (N=84)</th>
<th>pTERT wildtype (N=62)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAIR cm3, median (IQR)</td>
<td>101 (56, 135)</td>
<td>122 (70, 167)</td>
<td>0.07</td>
</tr>
<tr>
<td>Enhancement cm3, median (IQR)</td>
<td>16.8 (10.3, 29.9)</td>
<td>24.5 (9.8, 41.3)</td>
<td>0.06</td>
</tr>
<tr>
<td>Necrosis cm3, median (IQR)</td>
<td>5.05 (1.60, 11.50)</td>
<td>7.92 (1.99, 12.30)</td>
<td>0.31</td>
</tr>
<tr>
<td>Tumor volume FLAIR+Enh+Nec, median (IQR)</td>
<td>123 (68, 178)</td>
<td>157 (104, 218)</td>
<td>0.044</td>
</tr>
<tr>
<td>F1 - Tumor location</td>
<td></td>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td>Frontal</td>
<td>23 (28%)</td>
<td>23 (37%)</td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>38 (45%)</td>
<td>23 (37%)</td>
<td></td>
</tr>
<tr>
<td>Insular</td>
<td>2 (2%)</td>
<td>2 (3%)</td>
<td></td>
</tr>
<tr>
<td>Parietal</td>
<td>18 (21%)</td>
<td>9 (15%)</td>
<td></td>
</tr>
<tr>
<td>Occipital</td>
<td>2 (2%)</td>
<td>2 (3%)</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>1 (1%)</td>
<td>3 (5%)</td>
<td></td>
</tr>
<tr>
<td>F2 - Side</td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Right</td>
<td>48 (57%)</td>
<td>29 (47%)</td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td>2 (2%)</td>
<td>3 (5%)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>34 (41%)</td>
<td>30 (48%)</td>
<td></td>
</tr>
<tr>
<td>F3 - Eloquent brain (Yes)</td>
<td>40 (48%)</td>
<td>34 (55%)</td>
<td>0.41</td>
</tr>
<tr>
<td>F4 - Enhancement quality</td>
<td></td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>Marked/avid</td>
<td>74 (88%)</td>
<td>58 (94%)</td>
<td></td>
</tr>
<tr>
<td>Minimal/mild</td>
<td>9 (11%)</td>
<td>2 (3%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (1%)</td>
<td>2 (3%)</td>
<td></td>
</tr>
<tr>
<td>F5 - Proportion enhancing, median (IQR)</td>
<td>15.76 (10.20, 21.05)</td>
<td>17.42 (11.48, 21.99)</td>
<td>0.36</td>
</tr>
<tr>
<td>F6 - Proportion nCET, median (IQR)</td>
<td>77.9 (71.3, 85.9)</td>
<td>77.0 (70.1, 82.9)</td>
<td>0.34</td>
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<tr>
<td>F7 - Proportion of Necrosis, median (IQR)</td>
<td>4.17 (2.03, 8.22)</td>
<td>4.85 (1.94, 7.69)</td>
<td>0.78</td>
</tr>
<tr>
<td>F8 - Cysts (Yes)</td>
<td>7 (8%)</td>
<td>11 (18%)</td>
<td>0.13</td>
</tr>
<tr>
<td>F9 - Multifocal/Multicentric (Yes)</td>
<td>9 (11%)</td>
<td>6 (10%)</td>
<td>1.00</td>
</tr>
<tr>
<td>F10 - T1/FLAIR ratio</td>
<td></td>
<td></td>
<td>0.009</td>
</tr>
<tr>
<td>Expansile</td>
<td>45 (54%)</td>
<td>38 (61%)</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>7 (8%)</td>
<td>13 (21%)</td>
<td></td>
</tr>
<tr>
<td>Infiltrative</td>
<td>32 (38%)</td>
<td>11 (18%)</td>
<td></td>
</tr>
<tr>
<td>F11 - Enhancement thickness</td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td>Solid</td>
<td>5 (6%)</td>
<td>4 (6%)</td>
<td></td>
</tr>
<tr>
<td>Thick</td>
<td>61 (73%)</td>
<td>47 (76%)</td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>17 (20%)</td>
<td>8 (13%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (1%)</td>
<td>3 (5%)</td>
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</tr>
<tr>
<td>F12 - Definition of enhancing margin</td>
<td></td>
<td></td>
<td>0.83</td>
</tr>
<tr>
<td>Well defined</td>
<td>61 (73%)</td>
<td>43 (69%)</td>
<td></td>
</tr>
<tr>
<td>Poorly defined</td>
<td>22 (26%)</td>
<td>19 (31%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>F13 - Definition of the non-enhancing margin</td>
<td></td>
<td></td>
<td>0.26</td>
</tr>
<tr>
<td>Well defined</td>
<td>11 (13%)</td>
<td>13 (21%)</td>
<td></td>
</tr>
<tr>
<td>Poorly defined</td>
<td>73 (87%)</td>
<td>49 (79%)</td>
<td></td>
</tr>
<tr>
<td>F16 - Hemorrhage (Yes)</td>
<td>56 (67%)</td>
<td>37 (60%)</td>
<td>0.39</td>
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<tr>
<td>F17 - Diffusion characteristics</td>
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<td>0.020</td>
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<tr>
<td>Facilitated</td>
<td>31 (37%)</td>
<td>16 (26%)</td>
<td></td>
</tr>
<tr>
<td>Restricted</td>
<td>42 (50%)</td>
<td>26 (42%)</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>11 (13%)</td>
<td>20 (32%)</td>
<td></td>
</tr>
<tr>
<td>F18 - Pscl invasion (Yes)</td>
<td>42 (50%)</td>
<td>33 (53%)</td>
<td>0.74</td>
</tr>
<tr>
<td>F19 - Ependymal extension (Yes)</td>
<td>24 (29%)</td>
<td>16 (26%)</td>
<td>0.85</td>
</tr>
<tr>
<td>F20 - Cortical involvement (Yes)</td>
<td>70 (83%)</td>
<td>53 (85%)</td>
<td>0.82</td>
</tr>
<tr>
<td>F21 - Deep WM invasion</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td>Brainstem</td>
<td>3 (4%)</td>
<td>1 (2%)</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>16 (19%)</td>
<td>16 (26%)</td>
<td></td>
</tr>
<tr>
<td>Internal capsule</td>
<td>16 (19%)</td>
<td>17 (27%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>49 (58%)</td>
<td>28 (45%)</td>
<td></td>
</tr>
<tr>
<td>F22 - nCET crosses midline (Yes)</td>
<td>12 (14%)</td>
<td>11 (18%)</td>
<td>0.65</td>
</tr>
<tr>
<td>F23 - nCET crosses midline (Yes)</td>
<td>3 (4%)</td>
<td>5 (8%)</td>
<td>0.28</td>
</tr>
<tr>
<td>F24 - Satellites (Yes)</td>
<td>34 (40%)</td>
<td>17 (27%)</td>
<td>0.12</td>
</tr>
<tr>
<td>F25 - Calvarial remodeling (Yes)</td>
<td>1 (1%)</td>
<td>3 (5%)</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Association was evaluated by Fisher’s exact test for categorical variables and Wilcoxon rank sum test for continuous variables.

(Filename: TCT_2068_DeAlba.jpg)
Role of Quantitative Diffusion-weighted MR imaging (DWI) in differentiating between skull base Chordoma and Chondrosarcoma in Real-Time Interpretation

P Rabiei¹, O Arevalo¹, S Khanpara¹, R Riascos¹, A Kamali¹
¹The University of Texas Health Science Center at Houston, Houston, TX

Purpose
Chordoma and chondrosarcoma of the skull base are very rare tumors with a combined incidence of 0.03 per 100,000 persons in the U.S. Although they have distinct origins and histopathologic features, it continues to be difficult for radiologists to differentiate them from each other on preoperative brain imaging. Here we examine the role of quantitative DWI in distinguishing these two entities.

Materials and Methods
This retrospective study comprised of 21 patients with pathology-proven skull base tumors (11 Chordoma and 10 Chondrosarcoma) referred to the Memorial Hermann Hospital during 2014-2019 for further evaluation. The intra-tumoral foci with the greatest degree of restricted diffusivity underwent quantitative apparent diffusion coefficient (ADC) measurement by region of interest (ROI) placement in Centricity PACS (4.11c GE Healthcare Barrington, Illinois) by two blinded interpreters. Complementary MR sequences (T1-postcontrast, SWI, T1WI, and T2WI) were used to avoid possible necrotic, cystic, or hemorrhagic/calcific components. Median ADC values were compared with the Wilcoxon Rank-Sum Test. Patient ages and genders in the two groups were compared with two-sample t-test and Fisher's exact test respectively.

Results
MR images of 6 Females and 5 Male diagnosed with Chordoma (age range of 36 to 74 and Mean of 58.2 years) and also 5 females and 5 males with the diagnosis of Chondrosarcoma (age range of 24 to 61 and Mean of 47.7 years) were evaluated in this study. Between the two groups, there was no statistically significant difference in patient age or gender. The ROI area size difference between the two interpreters did not impact the study. The median ADC values (averaged between two interpreters) in the Chordoma group was significantly lower than the median ADC value in the Chondrosarcoma group (p-value=0.002). The median ADC values (lower quartile-upper quartile) were 629 (602-729) for the Chordoma group and 1641 (1568-1754) for the Chondrosarcoma group. (Table 1. and Figure 1.)

Conclusions
Quantitative diffusion-weighted MR imaging can aid diagnostic accuracy when attempting to differentiate clival tumors such as Chordoma and Chondrosarcoma in real-time interpretation.
CNS Lymphoma Masquerading as Progressive Multifocal Leukoencephalopathy-Immune Reconstitution Inflammatory Syndrome in a Patient with AIDS

J Patel¹, P FIESTER², D Haymes¹
¹University of Florida College of Medicine - Jacksonville, Jacksonville, FL, ²University of Florida College of Medicine - Jacksonville, JACKSONVILLE, FL

Purpose
Several AIDS-defining diseases of the central nervous system can present with characteristic imaging findings, sometimes allowing for a high degree of confidence in the diagnosis. However, this is not always the case, and particularly so in patients who have been recently started on Highly Active Anti-retroviral Therapy; in these patients the potential development of immune reconstitution inflammatory syndrome (IRIS) with associated clinical deterioration and worsening imaging findings can create a diagnostic challenge. This excerpt presents an interesting case of development of CNS lymphoma in a patient with AIDS who was initially suspected to have PML-IRIS, and underlines the complementary importance of imaging follow-up and laboratory markers in management.

Materials and Methods
A 50 year-old man with history of AIDS presented to the ED with right-side weakness. His CD4 count was 97 cells/mm3. MRI showed confluent FLAIR hyperintensity in the left parietal white matter without enhancement or mass effect, and PML was suspected.
He refused lumbar puncture for CSF analysis. HAART was started, but his right extremity weakness progressed. Follow-up MRI 2 months after presentation showed progression of FLAIR abnormality extent, new mass effect, and new enhancing abnormality, and PML-IRIS was suspected. One month later, he presented with further cognitive decline and right arm flaccidity, and repeat MRI showed resolution of the enhancement in the white matter, but worsened mass effect. Due to no enhancing abnormality being present and his debilitated status, biopsy was not recommended by the neurosurgery service. CSF was PCR positive for Epstein-Barr virus, which was diagnostic for CNS lymphoma. Palliative whole brain radiation was used in hope of neurological improvement. Although the mass effect resolved and white matter abnormality progression was halted, there was no neurologic improvement and hospice was ultimately recommended.

Results
See case report section and caption in uploaded image.

Conclusions
This case demonstrates the diagnostic challenge in patients with AIDS during the time period immediately following initiation of HAART. Clinical suspicion and expectation for IRIS in this time should not exclude other differential diagnoses, such as lymphoma in this case. Close clinical and imaging follow-up are prudent. In addition, PCR for EBV in CSF is highly sensitive and specific for AIDS-associated primary CNS lymphoma and such laboratory markers should be considered by the radiologist.

Polymorphous Low-Grade Neuroepithelial Tumor of the Young (PLNTY): A Recently Described Epileptogenic and Calcified Tumor of Childhood and Young Adulthood

D Treister¹, S Cha²
¹UCSF, San Francisco, CA, ²University of California San Francisco, San Francisco, CA

Purpose
Polymorphous Low-grade Neuroepithelial Tumor of the Young (PLNTY) was first described in 2017 as a distinct low-grade neuroepithelial tumor primarily involving children and young adults and presenting with seizure. Recent work in the pathology literature describes a unique combination of histopathologic, genetic, and epigenetic aberrations which define this tumor. We report a confirmed case of PLNTY and discuss imaging features which may allow for a prospective diagnosis. Important differential considerations of calcified epileptogenic tumors including oligodendroglioma, ganglioglioma, and calcifying pseudoneoplasm of the neuraxis (CAPSON) are discussed.

Materials and Methods
A 38-year old previously healthy male presented to urgent care after an unwitnessed first time syncopal episode. The patient denied any previous history of seizures and complained of a mild headache. Head CT revealed a mass in the right temporal lobe and he was
referred to our institution for further evaluation. In conjunction with the outside CT, findings from the brain MRI resulted in a preoperative diagnosis favoring oligodendroglioma. Final surgical pathology after gross total resection characterized the tumor as a PLNTY. Tumor genome sequencing was concordant revealing a FGFR2 fusion mutation, one of two mutations which has been described in this tumor.

Results
Non-contrast CT (A) demonstrated a large predominantly cystic mass in the right temporal lobe with bulky calcification and mild local mass effect. Contrast-enhanced MRI of the brain demonstrated a FLAIR (B) hyperintense cystic mass with confluent central and peripheral susceptibility (C) related to calcification and chronic blood products, respectively. Precontrast and postcontrast (D) T1-weighted images demonstrated a large component of intrinsic T1 shortening and faint enhancement along the medial aspect of the tumor.

Conclusions
PLNTY is a testament to the evolving classification of CNS tumors. Tumor classification has important prognostic and therapeutic implications, making familiarity with emerging tumor types important to the radiologist. PLNTY is a tumor with characteristics imaging findings including large calcification, cystic components, minimal enhancement, cortical location resulting in seizures, and predominant temporal lobe involvement. This tumor should be considered in the differential diagnosis of young patients with tumor-related seizures, particularly in the presence of these ancillary findings.

(Filename: TCT_2143_Image2.gif)

Scientific Abstract Session: Functional/Perfusion
2454

Normative Values of Brain MRS Metabolites in Early Childhood

F Goncalves1, A Goldman-Yassen1, C Alves1, S Teixeira1, S Andronikou1, A Vossough2
Purpose
MRS is a helpful MR modality in the assessment of certain neurometabolic and neurodevelopmental disorders. Normal MRS spectra have been well-defined in older children and adults. However, many of these disorders present and are evaluated during early childhood. MRS spectra of children evolve during early brain maturation and the normal spectrum appears as disease based on criteria derived from older individuals. Easily accessible normal values according to the age of the child being evaluated is not widely available to radiologists interpreting these studies. The main purpose of this study is to provide a guideline for the normal MRS metabolite values across an age spectrum early in life, so deviations from normal can be more readily identifiable and prevent misinterpretation of the MR spectroscopy.

Materials and Methods
MR spectra from 116 children ranging in age from 0 to 200 months were obtained. Patients had a normal brain MRI. Quality control measures were applied and suboptimal spectra due to various artifacts were excluded. The spectra were analyzed on a standard processing platform, and quantitative analysis was also performed using LCModel software. Metabolite values across the age range were evaluated. The major metabolites included were n-acetylaspartate (NAA), choline (Cho), creatine (Cr), myoinositol (mI), and lactate (L). Minor metabolites were also evaluated if the spectra were of high quality. Average values and confidence intervals were calculated across the age range. Non-linear regression models for assessment of changes over time were constructed for each metabolite.

Results
Plots of change in the major metabolites across the early years of life were depicted with confidence intervals. There was a predicted increase in NAA and decrease in Cho. Very small amounts of lactate were present normally. Changes in other metabolites were also depicted. A general estimation of the changes in the metabolites could be derived.

Conclusions
MRS values change dramatically in the first few years of life. Knowing the normal values in the early stages of life is challenging. Having a set of normal values with an indication of the normal variation based on a young patient's age is very helpful to the interpreting physician using MR spectroscopy in selected patients.

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IVIM Perfusion Correlates with Quantitative CBF at Baseline, Hypercapnia and Infarct.

M Liu1, Y Jeong1, G Christoforidis1, N SAADAT2, S Roth3, T Carroll1
1University of Chicago, Chicago, IL, 2UNIVERSITY OF CHICAGO MEDICAL CENTER, CHICAGO, IL, 3University of Illinois College of Medicine, Chicago, IL

Purpose
The purpose of this work is to compare IVIM perfusion measurement to quantitative CBF at baseline, under hypercapnia and after MCAO occlusion.

Materials and Methods
Intravoxel Incoherent Motion (IVIM) has the potential to simultaneously assess diffusion, CBF, and CBV without the need for contrast agent administration. IVIM requires a DWI acquisition with several b-values and has lagged in its development due to long scan times and questions as to the sensitivity to white matter perfusion (CBF ~ 25 ml/100g/min) and oligemic and/or ischemic tissue (CBF < 18 ml/100g/min). With the development of newer "accelerated" acquisitions, and commercially available post-processing algorithms, there is renewed interest in IVIM as a clinically useful neurovascular imaging technique. Canines (20-30 kg) were instrumented under x-ray guidance and a series of MRI perfusion and diffusion scans were acquired under normal breathing, hypercapnia and MCAO. Anesthesia was maintained using isoflurane, propofol and rocuronium. Diffusion weighted images (DWI) for IVIM were collected at 10 b-values from 0 to 1000 and 3 directions with 50 slices to cover the entire head (2D single shot EPI, TR/TE= 3056/91 ms, slices/thickness= 2 mm, SENSE Factor=2, spatial resolution = 1.25 mm x 1.25 mm x 2.0 mm). Quantitative DSC CBF images were acquired within 5 minutes of the IVIM scans. Multi-phase, single shot EPI, FOV/matrix = 160/128, 5 2.0 mm thick slices, 50 measurements, with a 3 ml iv Gd with fast T1 maps were acquired before and after the contrast scan. IVIM images, were fit to: S(b)=f_e'(-D^*(b)^f)+(1-f) e'(-(D+b)^f) to yield 2D parametric images of fD* which were normalized to baseline qCBF, then compared to hypercapnia, and post-MCAO. The per-unit change in CBF was calculated based on arterial CO2 and used to calculate cerebrovascular reserve. Regions of interest were compared using standard scatterplots.

Results
We found that a strong correlation (r2> 0.85) existed between IVIM and qCBF over (0 – 250 ml/100g/min). The correlation existed under CO2 challenge and MCAO. Scatterplots are shown in Figure (1A,B). CVR correlations (1C) were also strong (r2=0.85). Bland-Altman shown in B, D exhibit minimal bias, particularly at low CBF.

Conclusions
We found that IVIM perfusion correlates strongly with quantitative perfusion values over a range of physiologic conditions with no loss of sensitivity in white matter or in severely hypoperfused tissue. The IVIM linearity lends itself to quantification of CVR.
Inter-observer variability of reference tissue selection for normalized relative cerebral blood volume (nrCBV) measurements in treated glioma patients

K Patel¹, C Cankurtaran¹, T Hijaz¹, A Korutz¹, B Liu¹
¹Northwestern University, Feinberg School of Medicine, Chicago, IL

Purpose
To evaluate inter-observer variability of different reference tissues used for normalized relative CBV (nrCBV) measurements of normal appearing white matter (NAWM) in DSC-MRI of treated glioma patients.

Materials and Methods
In this retrospective study, two observers measured rCBV of NAWM in DSC-MRI images of 36 treated glioma patients. Treatment regimens include radiation and temozolomide. nrCBV is calculated as ratio of the rCBV in the tumor hotspot with the CBV of a reference tissue at the contralateral side for normalization. One observer annotated the tumor hotspot that was kept constant for all measurements. Both observers measured 12 reference tissues of normal appearing white and gray matter. The centrum semiovale (CS) was measured in 3 locations (anteriorly, middle, and posteriorly). A mean value was calculated from the 3 CS measurements and a nrCBV was also calculated as the ratio to this mean centrum semiovale reference. Inter-observer variability was evaluated using the intraclass correlation coefficient (ICC), coefficient of variation (CV) and Bland-Altman analyses.

Results
For inter-observer, the ICC ranged from 0.51–0.99 (fair–excellent). The CV ranged from 8.29–44.56 %. For white matter reference tissue, the average of 3 measurements in the centrum semiovale showed excellent inter-observer agreement (ICC=0.95) and lowest CV (9.2 %) compared to all other white matter regions measured for the purposes of normalization reference tissue. Bland-Altman analysis showed that mean difference for the average of 3 measurements in the centrum semiovale was close to zero. For gray matter reference tissue, the caudate nucleus showed the least inter-observer variability with excellent inter-observer agreement (ICC=0.99), lowest CV (8.29 %), and mean difference close to zero on Bland-Altman analysis compared to all other gray matter regions measured as normalization reference tissue. However, when observers were allowed to freely choose the best normal appearing white matter (bNAWM) for reference tissue from any location in the brain, the inter-observer agreement was poor (ICC=0.51), had high CV (44.56 %), and had high mean differences on Bland-Altman analysis.

Conclusions
Using the mean of 3 measurements in the contralateral centrum semiovale as reference tissue for nrCBV provides the lowest inter-observer variability. If normalizing to gray matter, using the caudate as reference tissue shows the lowest inter-observer variability.
Intraindividual comparison of wash-in and wash-out pattern using gadobutrol (Gadovist) and gadoterate meglumine (Dotarem) on dynamic contrast enhancement MRI in post-treatment glioma

J Kim¹, J Park², H Kim³
¹Kangbuk Samsung Hospital, Seoul, Korea, Republic of, ²Asan medical center, Seoul, Seoul, ³Asan Medical Center, Seoul, Seoul

Purpose
To evaluate and compare the enhancement pattern of one-molar gadobutrol (Gadovist) and half-molar gadoterate meglumine (Dotarem) in recurrent glioma patients by using model-free and pharmacokinetic parameters obtained from dynamic contrast enhanced MRI at 3 T.

Materials and Methods
Total 32 patients with pathologically proven low- or high-grade glioma who underwent concurrent chemoradiation therapy (CCRT) after the biopsy or surgical resection were enrolled in this prospective study. Patients underwent DCE perfusion study twice using gadobutrol and gadoterate meglumine. Quantitative assessment of the wash-in and wash-out pattern of the tumor was performed by calculating the initial area under curve (IAUC) of the time signal intensity (SI) from 30 to 340 dynamics. This model-free parameter was compared intraindividually among the one-molar and half-molar contrast agent. The pharmacokinetic parameters including the volume transfer constant (Ktrans), rate transfer constant (Kep), blood plasma volume per unit volume of tissue (Ve), and extravascular extracellular space per unit volume of tissue (Vp) were also calculated to compare among the study subjects.

Results
There was no significant intra-individual difference in the wash-in pattern using the model-free DCE parameters of IAUC 30, 60, 90, 120, and 160 between gadobutrol and gadoterate meglumine. The wash-out pattern of the contrast agent was also compared between the two contrast agents, which also showed no significant difference. However, when comparing the DCE parameters obtained from the pharmacokinetic model, the wash-in rate was significantly larger and wash-out rate was significantly lower with gadobutrol compared to gadoterate meglumine. Kep was significantly larger with gadoterate meglumine, while there was no significant difference in the Ktrans, Ve, and Vp.

Conclusions
The pharmacokinetic DCE model demonstrated significant different wash-in and wash-out rate between gadobutrol and gadoterate meglumine in post-treated glioma patients, whereas model-free parameters showed no significant intra-individual difference.
Intraindividual comparison of model-free and pharmacokinetic parameters on dynamic contrast enhancement MRI between gadobutrol and gadoterate meglumine

<table>
<thead>
<tr>
<th>Dynamic contrast enhancement model</th>
<th>Parameters</th>
<th>Gadobutrol</th>
<th>Gadoterate meglumine</th>
<th>P value</th>
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<tr>
<td>Model-free method</td>
<td>IAUC30</td>
<td>3.91 ± 2.38</td>
<td>4.27 ± 2.02</td>
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<tr>
<td></td>
<td>IAUC100</td>
<td>21.50 ± 12.82</td>
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<td></td>
<td>IAUC200</td>
<td>39.08 ± 23.30</td>
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<td></td>
<td>IAUC300</td>
<td>56.68 ± 33.77</td>
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<td></td>
<td>IAUC400</td>
<td>74.25 ± 44.24</td>
<td>80.79 ± 39.17</td>
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<td></td>
<td>IAUC500</td>
<td>91.84 ± 54.71</td>
<td>99.91 ± 48.46</td>
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<td></td>
<td>IAUC600</td>
<td>109.44 ± 65.19</td>
<td>119.06 ± 57.76</td>
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<td></td>
<td>IAUC700</td>
<td>127.04 ± 75.66</td>
<td>138.21 ± 67.07</td>
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<td></td>
<td>IAUC800</td>
<td>144.66 ± 86.13</td>
<td>157.37 ± 76.37</td>
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<td>IAUC900</td>
<td>166.69 ± 98.74</td>
<td>179.04 ± 83.13</td>
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<td>IAUC1000</td>
<td>184.76 ± 109.43</td>
<td>198.43 ± 92.13</td>
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<td></td>
<td>IAUC1100</td>
<td>202.85 ± 120.13</td>
<td>217.84 ± 101.13</td>
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Pharmacokinetic method

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Calculation</th>
<th>Gadobutrol</th>
<th>Gadoterate meglumine</th>
<th>P value</th>
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<tr>
<td>Ktrans, min⁻¹</td>
<td>0.016 ± 0.009</td>
<td>0.017 ± 0.008</td>
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<tr>
<td>Kep, min⁻¹</td>
<td>0.127 ± 0.042</td>
<td>0.132 ± 0.041</td>
<td>.594</td>
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<td>Va (%)</td>
<td>17.797 ± 10.057</td>
<td>17.271 ± 7.436</td>
<td>.813</td>
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<tr>
<td>Ve</td>
<td>1.108 ± 0.674</td>
<td>1.263 ± 0.600</td>
<td>.559</td>
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<tr>
<td>Wash-in rate</td>
<td>0.825 ± 0.655</td>
<td>0.289 ± 0.644</td>
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<tr>
<td>Wash-out rate</td>
<td>0.0010 ± 0.0008</td>
<td>0.0021 ± 0.0025</td>
<td>.024</td>
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</table>

Note: Data are means ± standard deviations. P values are from paired t test when the variables satisfied normality or from Wilcoxon-signed rank tests otherwise, according to Shapiro-Wilk test.

1527

Differentiation of Progressive Disease from Pseudoprogression Using 3D PCASL and DSC MR Imaging in Patients with Glioblastoma

P. Manning¹, D Piccioni¹, S Parthiban¹, M Rajaratnam¹, S Daghighi¹, N Bahrami¹, D Bolar¹, C McDonald¹, N Farid¹

¹UCSD - UNIVERSITY OF CALIFORNIA SAN DIEGO, San Diego, CA

Purpose
To use 3D pseudocontinuous arterial spin labeling (3D PCASL) and dynamic susceptibility contrast-enhanced (DSC) MRI to differentiate progressive disease (PD) from pseudoprogression (PsP) in patients with glioblastoma (GBM).

Materials and Methods
Thirty-two patients with GBM who developed progressively enhancing lesions within the radiation field following resection and...
Chemoradiation were included in this retrospective, single-institution study. The updated modified RANO criteria were used to establish PD or PsP. Following 3D PCASL and DSC imaging, perfusion parameter estimates of cerebral blood flow (ASL-nCBF and DSC-nCBF) and cerebral blood volume (DSC-nrCBV) were calculated. Additionally, contrast enhanced volumes were measured. Mann-Whitney-U tests were used to compare groups. Linear discriminant analysis (LDA) and area under receiver operator characteristic curve (AUC) analyses were used to evaluate performance of each perfusion parameter and to determine optimal cut-off points.

Results
All perfusion parameter measurements were higher in patients with PD compared to PsP (p < 0.001, p = 0.003, p = 0.002), and contrast enhanced volumes were not significantly different between groups (p > 0.447). All perfusion parameters demonstrated high AUC (0.954 for ASL-nCBF, 0.867 for DSC-nrCBF, and 0.891 for DSC-nrCBV), however, ASL-nCBF demonstrated the highest AUC and misclassified the fewest cases (N = 6). Cases correctly classified by ASL but misclassified by DSC tended to occur along the skullbase at areas of increased susceptibility (Figure).

Conclusions
Both 3D PCASL and DSC perfusion techniques have nearly equivalent performance for the differentiation of progressive disease from pseudoprogression in patients with GBM. However, 3D PCASL is less sensitive to susceptibility artifact and may allow for improved classification in select cases.
Automated Detection of Average Cerebral Tissue Attenuation Peak: First Step Towards Developing An Adaptive CT Perfusion Protocol

C Chung1, M Vaz2, K Nieboer3, B Barnes4, E Krupinski1, T Lee5, A Prater1
1Emory University School of Medicine, Atlanta, GA, 2GE Healthcare, Milwaukee, WI, 3University Hospital Brussels, UZ Brussel, Brussels, Belgium, 4Froedtert Hospital, Milwaukee, WI, 5Robarts Research Institute, London, ON

Purpose
CT perfusion (CTP) is increasingly used in stroke centers; however, standardizing 'one size fit all' acquisition parameters is difficult due to institution-specific optimization of exam quality, radiation dosage and imaging time. A protocol that adapts to individual
patient's cerebral perfusion kinetics presents an alternative strategy for standardization. We hypothesize that average cerebral tissue attenuation, processed in real-time to allow for protocol adjustment, can be used as a surrogate for cerebral perfusion. We present novel results in developing and validating an algorithm for automated detection of tissue uptake curve (TUC) peak, as a first step towards realizing a real-time adaptive CTP protocol.

Materials and Methods
205 one-slab CTP exams were obtained retrospectively from three separate institutions. Postprocessing by an expert reader with the CT perfusion 4D Neuro software (GE Healthcare) generated reference arterial (AIF) and venous (VOF) time-attenuation curves. A rule-based algorithm for automated detection of single-slice average cerebral tissue attenuation without ROI placement was developed based on this dataset and validated using a separate single institution dataset of 100 consecutive one-slab CTP exams. Algorithm success is defined as detection of TUC peak that falls between reference AIF and VOF peaks. Diagnostic quality of the development dataset was evaluated, with sufficiency defined as inclusion of entire AIF and VOF contrast boluses and acquisition of passes no more than 2.5 seconds apart through the VOF peak.

Results
Automated TUC peak detection algorithm was successful in 202 of 205 (99%) of exams in the development dataset and 93 of 100 exams in the validation dataset. Algorithm failure (inability to detect TUC peak) in the development dataset was attributed to poor contrast bolus and patient motion. Assuming successful TUC peak detection would allow protocol adjustments to achieve sufficient exam quality, this algorithm would improve exam quality from the current 72 - 98% to 97- 100%, with projected radiation dose and imaging time savings of up to 40% and 100 seconds respectively.

Conclusions
The novel algorithm demonstrates feasibility in automated TUC peak detection and highlights the utility of TUC as a surrogate for AIF/VOF in an adaptive CTP protocol. Optimization of input signal-to-noise ratio is projected to improve algorithm performance. Efforts to optimize protocol adjustment paradigm based on TUC peak times are underway.

2248
4:12PM - 4:18PM

Automated CT Perfusion Pitfalls in the Real World: A Single Center Experience

C Chung1, M Cooper1, R Hu1, R Peterson1, J Allen1
1Emory University School of Medicine, Atlanta, GA

Purpose
Automated CT perfusion (CTP) processing software improves data availability to front-line physicians and streamlines interpretation, leading to its rapid incorporation into routine stroke workup. Acute stroke clinicians are increasingly aware of the technical and diagnostic challenges inherent to this technique; however, the incidence and clinical significance of such pitfalls in real-world practice remain unclear. We present our experience utilizing a CTP-based imaging workflow for acute stroke workup in a major comprehensive stroke center.

Materials and Methods
Consecutive CTP exams obtained for evaluation of suspected stroke in a major comprehensive stroke center were retrospectively reviewed. Exams were performed on one of four different CT scanners, utilizing either a one-slab (8 cm) or two-slab (4 cm each) protocol with total scan time of 86.2 s at 1.8 s/pass. Studies were reviewed for technical pitfalls including patient motion, delayed/poor contrast bolus, inadequate coverage, and erroneous arterial/venous ROI placement. Diagnostic pitfalls including core infarct/tissue at risk misclassification using set thresholds, tissue at risk overestimation due to proximal flow limitation and leukoaraiosis, missed small infarcts, stroke mimics, and chronic infarcts were evaluated via comparison of automated CTP results to final neuroradiology interpretation for the exam as well as findings on concurrent CT/CTA and follow up CT/MRI. Clinical decision for endovascular reperfusion and final diagnosis were reviewed based on electronic medical record.

Results
Of the 120 cases reviewed, 53 involved a large vessel occlusion (LVO), of which 33 underwent endovascular reperfusion. 65% of CTP exams demonstrated one or more pitfalls, including 33 with suboptimal technique. Missed small infarcts was the most commonly encountered pitfall (23%), followed by patient motion (17%) and core infarct not meeting rCBF < 30% threshold (16%). Within the cohort of 78 exams demonstrating pitfalls, while 46 resulted in erroneous automated results, overall LVO interpretation was concordant with final diagnosis in all cases, and clinical decision for endovascular reperfusion remained appropriate in 97% of cases.

Conclusions
CTP is a computationally complex technique frequently involving technical and diagnostic pitfalls. As such, it should not be interpreted in isolation. Despite such shortcomings, automated CTP imaging is useful in guiding patient triage for endovascular reperfusion in the overwhelming majority of patients.

2817
4:19PM - 4:25PM

Comparison of prognosis prediction between dynamic contrast-enhanced MR imaging and dynamic susceptibility contrast-enhanced T2*-weighted perfusion in glioblastoma patients after standard treatment: focus on the nonenhancing component of the tumor
S Jo1, T Yun2, J Kim3, R Yoo4, E Lee5
1Hallym University Dongtan Sacred Heart Hospital, Hwaseong-si, Hwaseong-si, 2Department of Radiology, Seoul National University College of Medicine, Seoul, Seoul, 3Seoul National University Hospital, Seoul, Seoul, 4Seoul National University Hospital, Seoul, Korea, 5903lej@naver.com, Seoul, Seoul

Purpose
To identify candidate imaging biomarkers for early disease progression in glioblastoma multiform (GBM) patients by analysis of dynamic contrast-enhanced(DCE) and dynamic susceptibility contrast-enhanced T2*-weighted perfusion(DSC) MR parameters of nonenhancing region(NER) of GBM

Materials and Methods
Institutional review board approved this retrospective study. Seventy-six GBM patients who had undergone preoperative DCE, DSC MR imaging and received standard treatment were retrospectively included. According to the Response Assessment in Neuro-Oncology criteria, patient were classified into early progression (n=15) or non-progression (n=61) groups. We analysed the pharmacokinetic parameters of Ktrans, Ve, and CBV within non-enhancing T2 high SI lesions of each tumors. The best percentiles of each parameter form cumulative histograms were identified by the area under the receiver operating characteristic curve (AUC) and were compared using multivariated stepwise logistic regression.

Results
for the differentiation of 4months early disease progression, the highest AUC values were found in the 97th percentile of Ktrans(AUC 0.713), for the differentiation of 5months early disease progression, the highest AUC values were found in the 95th percentile of Ktrans(AUC 0.706), for the differentiation of 6month early disease progression, the highest AUC values were found in the 95th percentile of Ktrans(AUC 0.704), for the differentiation of 7months early disease progression, the highest AUC values were found in the 93th, 94th percentile of Ktrans(AUC 0.683) (all p < 0.05). The K median, The 96th PV of CBV, and age was the significant independent variables for progression free survival from the multivariate stepwise logistic regression analysis(p < 0.05). But, there is no statistically significant perfusion parameter including Ve of DCE, CBV of DSC MRI for differentiation of early progression

Conclusions
We found that the Ktrans of non-enhancing T2 high SI lesions in GBM patients holds potential as a candidate prognostic marker in future prospective studies. Key points (learning objectives) 1. DCE MR imaging provides candidate prognostic marker of GBM after standard treatment 2. Cumulative histogram was applied to include entire nonenhancing T2 high SI lesions 3. The 93th-97th percentile value of Ktrans was the potential biomarker. 4. There is less significant outcome prediction power of CBV of DSC MRI in this study.

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Apparent PCA territory hypoperfusion on arterial spin labeling MRI is a common artifact in patients with a unilateral fetal PCA.

A NOORBAKHSH1, D Bolar2
1UNIVERSITY OF CALIFORNIA, SAN DIEGO, SAN DIEGO, CA, 2N/A, N/A

ASNR20 Virtual Proceedings Page 926
Purpose
To determine whether apparent PCA territory hypoperfusion can be seen on arterial spin labeling (ASL) imaging in patients with a unilateral fetal PCA, but without underlying clinical or imaging pathology to suggest true hypoperfusion.

Materials and Methods
A search of MRI/MRA reports at our institution from 1/2017 to 3/2019 was performed with inclusion search term of "fetal PCA", and other terms to exclude patients with significant neuropathology. Of the resulting 70 patients with both MRI and MRA studies, 50 patients (age 25-93 yo, 17M, 33F) were included who had unequivocal unilateral fetal PCAs and diagnostic ASL scans, but without conventional imaging (DWI, FLAIR, or SWI) abnormality or clinical symptoms referable to the PCA territories. One patient was excluded due to basilar artery stenosis that resulted in ASL arterial transit artifact. The 50 cases were evaluated by two independent readers (a senior radiology resident and practicing academic neuroradiologist) for visually apparent PCA territory ASL hypoperfusion relative to other vascular territories. The ASL perfusion imaging protocol consisted of the GE product pseudocontinuous ASL with a 1.5s labeling duration and 2s post-labeling delay (PLD) (1).

Results
Eight of the fifty cases (16%) were identified by both readers to have visually apparent hypoperfusion in the PCA territory contralateral to the side of the fetal PCA. Agreement between readers was perfect (100%, κ=1).

Conclusions
Visually apparent PCA hypoperfusion on ASL is not uncommon in patients with a contralateral fetal PCA who have no clinical or conventional imaging findings referable to the territory to suggest true hypoperfusion. This apparent hypoperfusion is likely artifactual due to a longer arterial transit time of the ASL label to the non-fetal PCA territory, given a lower velocity in the supplying vertebral arteries relative to the higher velocity ICA supplying the fetal PCA territory. Consequently, at a PLD of 2s, at which time imaging begins, less label has been delivered to the non-fetal side resulting in apparent hypoperfusion. While quantitative differences in ASL perfusion have been described, this is the first study evaluating the frequency of PCA hypoperfusion in a clinical population with fetal-type PCA (2). It is important for radiologists to be aware that apparent hypoperfusion may arise from variant circle of Willis anatomy. The use of longer PLD times and/or velocity-based ASL approaches may correct this asymmetry and is an area of future research (3).
Figure 1: (A) Axial MIP MRA with confirmed right fetal PCA (arrow) and no visible P1 (rightward oriented vessel from the basilar is the SCA). (B) Associated ASL perfusion images demonstrating decreased perfusion signal in the contralateral PCA territory (arrowheads), including the thalamus (arrow).
Purpose
1. Evaluate the diagnostic accuracy of different MR perfusion methods (DSC, DCE, and ASL) in differentiating tumor recurrence from radiation necrosis. 2. Evaluate the reproducibility of different DCE methods (T1 mapping with MOLLI or SMART1 versus no T1 mapping) in differentiating tumor recurrence from radiation necrosis.

Materials and Methods
Eight patients who have received chemoradiation for high grade gliomas and who subsequently developed new enhancing lesion(s) on follow-up MR were enrolled. MR perfusion imaging (ASL, DSC, DCE) was performed using a 3T General Electric 750w MRI. Regions of interest (ROIs) were drawn around the area of new enhancement. A neuroradiologist verified the ROIs to ensure that adjacent vessels were avoided. Parameters such as relative cerebral blood volume (rBV), blood flow (CBF), leakage (K2), volume transfer constant (Ktrans), and plasma volume (Vp) were extracted from the ROI. Ktrans and Vp were calculated using two different T1 mapping methods (MOLLI and SMART1). The results from MR perfusion were correlated with histopathological data from subsequent surgery (reference standard) or with the results of serial follow-up MRIs and clinical examinations using the Response Assessment in Neuro-Oncology (RANO) criteria for those who do not undergo surgery.

Results
The values of CBF from ASL and Ktrans from SMART1 were higher in patients with tumor recurrence than in radiation necrosis: 485.03 vs. 214.56 (p=0.0253) and 0.12 vs. 0.02 (p=0.0245). ROC analysis of MR perfusion parameters showed high accuracy of Ktrans_MOLLI: 0.9, Ktrans_SMART1: 1.0, and CBF: 1.0 for distinguishing tumor recurrence from treatment-related changes. The mean % difference between Vp_MOLLI and Vp_SMART T1 was -26.5% with limits of agreement of ± 57.6%, while the mean % difference between Ktrans_MOLLI and Ktrans_SMART1 was -5.1% with limits of agreement of ± 49.2%. Thus, Ktrans is showing better reproducibility.

Conclusions
Ktrans_SMART1 and CBF are higher in patients with tumor recurrence versus treatment-related changes and showed high accuracy for distinguishing between tumor recurrence and treatment-related changes.

Scientific Abstract Session: Pediatrics Tumor
1169
3:30PM - 3:36PM
Association of Volumetric ADC Histogram Metrics with Progression-Free Survival and Treatment Response in Recurrent Pediatric Low-Grade Gliomas Treated with Selumetinib: A Report from the Pediatric Brain Tumor Consortium

S Vajapeyam1, D Brown2, A Ziae1, S Wu1, G Vezina1, J Stern1, A Panigrahy2, Z PATAY4, B Tamrazi3, J Jones9, S Haque10, D Enterline11, S Cha12, B Jones3, K Yeom14, A Onar-Thomas15, I Dunkel10, M Fouladi13, J Fangusaro16, T Poussaint1
1Boston Children's Hospital, Harvard Medical School, Boston, MA, 2Massachusetts General Hospital, Boston, MA, 3Boston Children's Hospital, Boston, MA, 4St. Jude Children's Research Hospital, Memphis, TN, 5Children's Nat'l Med Ctr., Washington, DC, 6Ann and Robert H. Lurie Children's Hospital of Chicago, Chicago, IL, 7Children's Hosp. of Pittsburgh of UPMC, Pittsburgh, PA, 8Children's Hospital Los Angeles, Los Angeles, CA, 9 Nationwide Children's Hospital, Columbus, OH, 10Memorial Sloan Kettering Cancer Center, New York, NY, 11Duke University School of Medicine, Durham, NC, 12University of California San Francisco, San Francisco, CA, 13Cincinnati Children's Hospital Medical Center, Cincinnati, OH, 14Stanford University, Palo alto, CA, 15St Jude Children's Research Hospital, Memphis, TN, 16Children's Healthcare of Atlanta and Emory University, Atlanta, GA

Purpose
To analyze baseline and longitudinal changes in ADC histogram metrics during treatment of recurrent pediatric low-grade glioma with selumetinib, a MEK 1/2 inhibitor, for associations with progression-free survival (PFS) and treatment response.

Materials and Methods
Patients aged 3–21 years with recurrent, refractory, or progressive pediatric LGG were enrolled into six unique strata and a treatment of selumetinib at 25 mg/m2/dose PO BID for up to two years [1]. Strata 1, 3 and 4 were analyzed for this abstract. Stratum 1 comprised patients with WHO grade I pilocytic astrocytoma harboring either one of the two most common BRAF aberrations (KIAA1549–BRAF fusion or the BRAFV600E mutation); Stratum 3 comprised patients with imaging characteristics suggestive of a pediatric LGG or a biopsy proven pediatric LGG (WHO grade I and II) and a clinical or genetic diagnosis of NF1 and Stratum 4 comprised optic pathway pediatric LGG not associated with NF1. Post-contrast T1, T2 FLAIR and ADC volumes were co-registered, and the 3-D FLAIR and enhancement tumor volumes identified on the registered ADC volume. Quantitative ADC histograms were generated from these ADC FLAIR and ADC enhancement volumes at baseline, 6, 12, 18 and 24 months into treatment, and also at progression. Histogram metrics assessed were the number of peaks (unimodal or bimodal), mean, median, mode, standard deviation, skewness, and kurtosis.
Results
25 patients were enrolled in each stratum. At baseline, there were statistically significant associations of ADC_FLAIR skewness (p=0.0249) and ADC_FLAIR kurtosis (p=0.0171) with PFS in Stratum 4, as well as statistically significant associations detected between ADC_enhancement skewness (p=0.0368) and kurtosis (p=0.0039) and PFS in Stratum 4. Stratum 4 patients with higher baseline skewness or kurtosis of ADC_FLAIR or ADC_enhancement showed shorter PFS. There were significant differences in the longitudinal changes of ADC_FLAIR mode over time between responders and non-responders in Stratum 1 (p=0.0217) and in Stratum 3 (p=0.0255) respectively. There were also significant differences in the longitudinal change of ADC_FLAIR mean (p=0.0168) and median (p=0.0316) between responders and non-responders in Stratum 1. Responders showed a greater decrease in these parameters over time than non-responders.

Conclusions
ADC histogram metrics in recurrent pediatric LGG demonstrate significant correlations with PFS and response to treatment with selumetinib.

Tumor Response Assessment in Diffuse Intrinsic Pontine Glioma: Comparison of Semi-Automated Volumetric, Semi-Automated Linear, and Manual Linear Tumor Measurement Strategies

L Gilligan¹, M DeWire-Schottmiller¹, M Fouladi¹, P de Blank¹, J Leach¹
¹Cincinnati Children's Hospital Medical Center, Cincinnati, OH

Purpose
2D measurements of diffuse intrinsic pontine gliomas (DIPG) are limited by variability, and volumetric response criteria poorly defined. Semi-automated 2D measurements may improve consistency, however impact on tumor response assessments is unknown.

The purpose of this study was to compare manual 2D, semi-automated 2D, and volumetric measurement strategies for DIPG.

Materials and Methods
This IRB-approved study evaluated DIPG patients through a phase I/II trial (NCT02607124). Clinical 2D cross product (CP) values were derived from manual linear measurements (CP=long axis*short axis) (Figure, top). Using dedicated software (Mint Lesion), tumor margins were traced and maximum CP and tumor volume were automatically derived (Figure, bottom). Correlation and bias between methods were assessed and response assessment per measurement strategy reported.

Results
10 patients (median age: 7.6 years) underwent 58 MRI exams. Correlation and mean bias (95% limits) of percent change in tumor size from prior exam were: Clinical and semi-automated CP: r=0.36, -1.5% (-59.9–56.8%); Clinical CP and volume: r=0.61, -2.1% (-52.0–47.8%); and Semi-automated CP and volume: r=0.79, 0.6% (-39.3–38.1%). Stable disease, progressive disease, and partial response rates per measurement strategy were: Clinical CP: 82%, 18%, 0%; Semi-automated CP: 54%, 42%, 4%; and Volume: 50%, 46%, 4%, respectively.

Conclusions
Manual 2D CP measurements may underestimate tumor size and disease progression compared with semi-automated 2D and volumetric measurements.
B-SSFP (CISS/FIESTA) Sequences Improve Detection of Residual Germ Cell Tumor for Treatment Planning

W Mehan¹, K BUCH², P Caruso³
¹Massachusetts General Hospital, Harvard Medical School, Boston, MA, ²MASSACHUSETTS GENERAL HOSPITAL BOSTON, MA, Boston, MA, ³MGH, Boston, MA

Purpose
Identification of partial versus complete response is important in the staging and management of pediatric patients with intracranial germ cell tumors (GCT). The purpose of this study is to assess the detection improvement of residual GCTs by adding a balanced steady-state free precession (b-SSFP) sequence (CISS/FIESTA) to our standard MRI protocol for detection of tumorous tissue in the postchemoreduction preradiation planning scan.

Materials and Methods
This was a retrospective study of 39 pediatric patients with GCT undergoing MR imaging evaluation for determination of the tumor response before radiation treatment. All patients underwent a standard MRI exam with b-SSFP sequence. Two neuroradiologists independently reviewed the standard sequences without the b-SSFP sequence and determined the presence or absence of residual tumor, 1 week later they repeated the task with the inclusion of the b-SSFP sequence.

Results
Patients ranged from 4 to 21 years of age (mean, 14.15 ± 4.26) with 31 males and 8 females. 8 patients were diagnosed with 2 lesions in different locations. Twenty cases, seen as a partial response (PR) seen on the b-SSFP sequence, showed a complete response (CR) on the other sequences. The interrater agreement improved after adding the b-SSFP sequence to the protocol. There was a significant difference between the number of CR and PR between the recordings with and without the b-SSFP sequence as well as for the consensus recordings (P<0.0001, Fisher's exact test).

Conclusions
The b-SSFP sequence improves the detection of residual chemotherapy-reduced CNS GCT and increases the agreement and confidence of the interpreting neuroradiologist. Therefore, the b-SSFP sequence may be an important adjunct to the standard MRI protocol for radiation planning.
Correlating genetic signature of pilomyxoid astrocytomas and pilocytic astrocytomas with qualitative and quantitative MR imaging characteristics

S Abi Fadel\(^1\), E Erson Omay\(^1\), R Bronen\(^2\), R Fulbright\(^3\), A Mahajan\(^3\), M Aboian\(^4\)  
\(^1\)Yale New Haven Hospital, New Haven, CT, \(^2\)Yale University School of Medicine, New Haven, CT, \(^3\)Yale University - MEDDRA, New Haven, CT, \(^4\)Yale University - MEDDRA Radiology, New Haven, CT

Purpose
Pilomyxoid astrocytomas (PMA) are predominantly located in hypothalamus/chiasmatic region and are believed to be more clinically aggressive than pilocytic astrocytomas (PA), although recent 2016 WHO classification questioned its histologic classification as grade II tumors and placed them into I/II category. In our study, we describe the genetic signature and MRI characteristics of PMA as compared to PA.

Materials and Methods
We identified 12 pediatric and adult patients with pathologically proven PMA (7), supra-sellar PA (3) and PA with myxoid features (PAM) (2). Three of the tumors had whole exome somatic and germline sequencing. ADC (10-3 mm\(^2\)/s) maps were analyzed with Visage Imaging software (Pro Medicus Limited, Visage7). Qualitative MRI characteristics of location, size, enhancement, edema, T2 and T1 intensity, and multifocality were assessed by neuroradiology attending and fellow. Study was approved by Institutional Review Board (IRB).

Results
All of the PMA were supratentorial and majority (71%) displayed classic imaging characteristics such as location within hypothalamus/chiasmatic region, avid enhancement, predominantly solid composition and central necrotic components. Among the PMA (7 total), 3 cases were found to have KIAA1549-BRAF fusion, 1 case BRAFV600E mutation, 2 cases had wildtype BRAF, and 1 case unknown. The BRAF wildtype tumors had atypical imaging features with intraventricular extension of tumor, involvement of frontal lobe parenchyma and one tumor demonstrating increase in size and development of enhancement on 5 year follow up. Whole exome sequencing of BRAF wildtype tumors identified novel somatic truncation mutation in NF1 R1534X and R1513X with wildtype germline NF1; second tumor demonstrated mutations that were not previously found in intracranial neoplasms. Among PAM (2 total), one was BRAF wildtype with mutations in PTCH1 (Met956Val) and PTPN1 (Ala72Val) and demonstrated atypical features of intratumoral hemorrhage on presentation. Among PA in our cohort (3), one was positive for KIAA1549-BRAF, one was BRAF wildtype (optic nerve glioma). DWI was heterogeneous for most of the tumors with no significant difference in ADC mean or minimum values between PMA and PA.

Conclusions
BRAF wildtype PMA and PA demonstrate atypical tumor localization and are associated with novel genetic mutations on whole exome sequencing. On the contrary, presence of KIAA1549-BRAF fusion or BRAFV600E mutation within PMA and PA correlates with classic qualitative imaging characteristics.
Figure 1: a) Qualitative Imaging characteristics of PMA, PA and PAM. b) Axial T1 post contrast weighted image demonstrates a homogeneously enhancing midline suprasellar mass with extension into the right lateral ventricle. c) Imaging characteristics of BRAF wildtype tumor followed over 5 years. T1WI post contrast demonstrates T1 hypointense non-enhancing right frontal lobe mass at diagnosis in 2013 with interval development of contrast over time. d) Quantitative features of pilomyxoid astrocytomas with emphasis of ADCmean, in comparison with pilocytic astrocytomas and pilocytic astrocytomas with myxoid features.
Desmoplastic Infantile Astrocytoma Misdiagnosed as a Porencephalic Cyst

K Launier1, B Tamrazi2
1Children's Hospital Los Angeles, Los Angeles, CA, 2N/A, N/A

Purpose
We present a case of desmoplastic infantile astrocytoma of infancy initially diagnosed and managed as a porencephalic cyst. This discussion will highlight the important imaging features of this rare infantile tumor that distinguish this entity from a simple cyst.

Materials and Methods
A male full-term infant initially presented with increased head circumference with downward gaze deviation at 5 weeks of age and was thought to have a large right porencephalic cyst exerting mass effect on the right lateral ventricle that was resulting in hydrocephalus. A right VP shunt was placed, followed by a left VP shunt two months later, followed by a right shunt revision one month later when the head circumference continued to increase in size, after which he re-presented with increased downward gaze deviation with new nystagmus and lethargy. He presented to our tertiary medical center and was found to have a large cystic mass with a superficial solid component and a ventricular catheter traversing the mass, resulting in intracranial hemorrhage. The mass was resected with a pathologic diagnosis of desmoplastic infantile astrocytoma with focal anaplastic features positive for the TPM3-NTRK1 fusion gene.

Results
On the initial non-contrast head CT at 43 days old, there was a large, right hemispheric cystic mass with a posterior peripheral soft tissue component with associated midline shift and enlargement of the left lateral and third ventricles. The cystic component of the mass was slightly more dense than CSF (9HU vs 4 HU). Post-procedural non-contrast CT head at 3 months old demonstrates a ventricular catheter traversing the cystic mass, which has now hemorrhaged. MR brain with contrast at 4 months old found a large right hemispheric enhancing mass with intratumoral and intraventricular hemorrhage with cerebellar tonsillar herniation.

Conclusions
Desmoplastic infantile ganglioglioma or, as in this case, desmoplastic infantile astrocytoma of infancy where there was primarily an astrocytic component to the tumor, is a rare tumor seen in predominantly male infants. The typical presentation is with macrocephaly or seizures. Imaging often reveals a large, cystic and solid tumor in the cerebral cortex. The solid component can calcify and avidly enhances. In this case, the cystic component of the mass was slightly more dense than the CSF in the lateral ventricle and exerted significant mass effect, which would not typically be seen with a porencephalic cyst.
Newly Defined High-grade Neuroepithelial Tumor with BCOR Exon 15 Internal Tandem Duplication: Differentiating from Other Pediatric Brain Tumors

A Taliaferro1, Y Li1, D Solomon1, S Cha1
1University of California, San Francisco, San Francisco, CA

Purpose
High-grade neuroepithelial tumor with BCOR exon 15 internal tandem duplication (HGNET-BCOR) is a newly defined malignant pediatric brain tumor molecular subtype which was not included in the 2016 WHO CNS tumor classification. The purpose of our study was to characterize unique imaging features of this tumor including quantitative ADC, and to differentiate it from similar appearing pediatric brain tumors.

Materials and Methods
This retrospective cross-sectional study included patients with HGNET-BCOR, medulloblastoma (SHH-activated and group 3 or 4), and atypical teratoid/rhabdoid tumor (ATRT), each with molecular diagnoses between 2005 and 2019. The MRI for each patient at initial presentation was used for quantitative evaluation of ADC values. All images were reviewed by two board-certified neuroradiologists, blinded to the final diagnosis, for T2-weighted characteristics, enhancement, susceptibility, cystic change, peritumoral edema, mass effect, and spinal involvement. Statistical analysis was performed using one-way ANOVA and Kruskal-Wallis test for parametric and non-parametric continuous variables, respectively. Fisher's Exact Test was used for categorical variables.

Results
Ten patients with HGNET-BCOR, ten patients with medulloblastoma, and ten patients with ATRT were included in this study, with ages ranging from eight months to fourteen years. HGNET-BCOR demonstrated minimally reduced diffusion (mean minimum ADC 611.0 mm²/s), T2 prolongation relative to surrounding brain parenchyma (70%), no or heterogeneous enhancement (100%), no or mild magnetic susceptibility artifact (90%), intratumoral cysts (60%), no peritumoral edema (80%), and mild or moderate associated mass effect (90%). 50% of HGNET-BCOR patients with spinal imaging had spinal involvement. HGNET-BCOR had significantly greater mean ADC value (795.8 mm²/s) than ATRT (556.3 mm²/s, P = 0.001) and medulloblastoma (606.5 mm²/s, P = 0.025). No significant differences were observed in T2 characteristics, enhancement, cystic change, peritumoral edema, or spinal involvement between tumor subtypes.

Conclusions
HGNET-BCOR is a newly defined malignant pediatric brain tumor characterized on neuroimaging by minimally reduced diffusion, T2 prolongation relative to the brain parenchyma, and minimal enhancement, susceptibility artifact, or peritumoral edema. Additionally, HGNET-BCOR had significantly higher diffusivity compared to medulloblastomas and ATRTs, which can be useful in distinguishing amongst these malignant pediatric brain tumors.
Habenulae – Why Should We Care?

A Smyth1, J Potts1, M Halverson1

1BC Children's Hospital, Vancouver, British Columbia

Purpose
Occasionally there are pediatric cases in which a pituitary infundibular region abnormality is present, raising diagnostic considerations including germ cell tumor and Langerhans cell histiocytosis, and in which it is difficult to discern if the pineal gland is abnormal. Synchronous pineal and infundibular involvement would suggest germ cell tumor. Observations that increase certainty regarding pineal involvement would be useful in these cases. Change in appearance of the habenulae may help indicate pineal region.
involvement in patients in which pineal involvement is otherwise occult on MRI. This project investigates if the normal habenulae can be assessed on standard protocol MRI brain scans. We examine if there is agreement between readers in relation to habenular involvement by pineal region tumors and intracranial germ cell tumors.

**Materials and Methods**

**Objective 1:** Two pediatric radiologists reviewed 50 consecutive MRI brain studies in pediatric patients, without pineal region pathology, to assess if the habenulae can reliably be assessed on MRI brain studies. Habenulae were graded as 0 if they were not visible, 1 if they were partially visualized, and 2 if they were well visualized. Objective 2: Two pediatric radiologists independently analyzed the index MRI brain examinations in all patients diagnosed with a pineal region tumor or an intracranial germ-cell tumor at a single pediatric institution, over a 16 year period, for habenular involvement. 41 cases were reviewed. Cohen's Kappa coefficient test was calculated to assess inter-rater agreement.

**Results**

1: On reviewing MRIs without habenulae pathology, the habenulae were well seen in 98% (49/50) of the MRI studies on the 1mm axial T1 images. The habenulae were well seen in 66% (33/50) of the MRI studies and partially seen in the remaining, on the 4mm axial T2 images. 2: There was excellent inter-rater agreement in relation to habenular involvement by tumor with a Cohen kappa coefficient 0.87, 95% confidence limits of 0.77 to 0.96.

**Conclusions**

The habenulae can reliably be assessed on 1mm axial T1 slices. There is a high level of agreement in interpretation of habenular involvement in pineal region tumors and intracranial germ cell tumors. Including review of the habenulae in all MRI brain studies will assist the reader in becoming familiar with the normal appearance of the habenulae. This may be useful in detecting subtle changes of the habenulae as early indications of pineal region disease involvement.

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**A Rare Presentation of Rosette-Forming Glioneuronal Tumor in a Child**

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Purpose
- Report a case of Rosette-forming glioneuronal tumor (RGNT) presenting as a diffuse leptomeningeal process involving the spine and without a primary mass in a child. - Emphasize its characteristic imaging features and the radiologic differential diagnosis. - Describe the 3-year natural history of this child's disease.

Materials and Methods
An 8-year-old boy who recently emigrated from Mexico presented with a 3-year history of seizures and ataxic gait. Initial MRI of the brain performed in Mexico 3 years prior, suggested a basilar cistern arachnoid cyst. His clinical course and history of having a father who worked at a pig farm were concerning for neurocysticercosis, but the imaging features were atypical of this disease. Serologic and cerebrospinal fluid (CSF) testing for neurocysticercosis were negative. A biopsy was obtained, and a diagnosis of Rosette-forming glioneuronal tumor was rendered. Molecular testing demonstrated mutations in FGFR1 p.K656E and PTPN11 p.E69K. The CSF was negative for tumor.

Results
Brain MRI: Brain Leptomeningeal nodular and cystic foci involving the basal cisterns, sylvian fissures, anterior hemispheric fissure, and the 3rd and 4th ventricles. There is no primary mass lesion identified suggesting a primary leptomeningeal process. The lesions closely follow CSF signal on the T1 and T2 weighted sequences however are much more conspicuous on the FIESTA sequence where they appear hypointense to CSF. There is also severe communicating hydrocephalus which is a common associated finding in primary leptomeningeal tumors. Spine MRI: Diffuse enhancement along the surface of the cord with a large deposit in the terminal thecal sac. The thecal sac is distended with mild scalloping of the dorsal vertebral bodies.

Conclusions
To our knowledge, this is the first reported pediatric case of RGNT presenting as a diffuse leptomeningeal process without a primary mass. The diagnosis of this entity is challenging, mainly in early disease, since the imaging findings can be similar to other etiologies, such as infectious etiologies. RGNT is a WHO grade I tumor that was first reported as a localized tumor of the 4th ventricle, but has now been encountered in many other anatomical locations. CSF dissemination is a rare complication. Histologically, they show overlapping features of pilocytic astrocytoma and neurocytoma, whereas genetically, they are characterized by FGFR1 alterations, often in combination with a PIK3CA mutation, but occasionally with a PTPN11 mutation as seen in our case.
Intracranial Myxoid Mesenchymal Tumor with a Rare EWSR1-CREB1 Translocation

J Ma¹, N Chuang², J Chen³, D Malicki⁴, V Goodwill¹, J Crawford⁴
¹UC San Diego Health System, San Diego, CA, ²San Diego Imaging, Rady Children’s Hospital, San Diego, CA, ³San Diego Veterans Administration Health System, San Diego, CA, ⁴UC San Diego and Rady Children's Hospital, San Diego, CA

Purpose
To present a case and imaging appearance of a rare, recently described EWSR1-CREB rearranged primary brain tumor. To discuss the clinical, histomorphologic, immunophenotypic, and cytogenetic characteristics in the context of the current literature. To our knowledge, tumors with EWSR1 fusion with CREB1 have only been reported in four intracranial myxoid tumors in current literature (4, 5, 6).

Materials and Methods
An otherwise healthy 14-year-old female initially presented to neurology clinic with several months of predominantly left-sided headaches associated with nausea, vomiting, lightheadedness, sensitivity to smells, weakness, and trouble walking. The patient was developmentally normal with normal neurological and ophthalmologic exams, and her headaches may have been triggered by school-related stress and menstruation. Six months later, the patient presented to ophthalmology clinic with blurred vision of the left eye for one month, and ongoing left hemispheric headaches. Papilledema was observed, and she was referred to a pediatric ER for further evaluation. MR imaging of the brain and entire spine were performed, revealing a left supratentorial extra-axial mass. Gross total resection of the mass was performed by neurosurgery the next day. Histology, immunohistochemistry, fluorescence in situ hybridization (FISH), and next-generation sequencing (NGS) were performed. Final pathologic interpretation described an "excellent" example of a recently characterized intracranial tumor of young patients, known as EWSR1-rearranged myxoid mesenchymal tumor. This lesion exhibited typical abundantly myxoid proliferation of bland cells with spindled to epithelioid features, occasionally associated with amianthoid-type collagen. Characteristic co-expression of EMA and desmin, and EWSR1 gene fusions with either CREB1 or CREM were observed. The morphologic, immunohistochemical, and molecular genetic features of these tumors appear identical to those of myxoid angiomatoid fibrous histiocytomas.

Results
MRI of the brain revealed a large homogeneous, T2-hyperintense, enhancing, extra-axial mass with increased diffusivity along the left posterior cerebrum. Mass effect and adjacent vasogenic edema without brain invasion were present. MRI of the entire spine was normal.

Conclusions
We report a rare intracranial myxoid mesenchymal neoplasm with a rare EWSR1-CREB1 translocation. We provide histomorphologic, immunophenotypic, and cytogenetic features of this entity and its clinical presentation in a child.

Evaluation of MRI Features for Differentiating Primary Choroid Plexus Tumors in Children

F Goncalves¹, J Martin-Saavedra¹, C Alves¹, S Teixeira¹, S Andronikou¹, A Vossough²

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Purpose
To evaluate the diagnostic accuracy of various MRI features for differentiating primary choroid plexus (CP) tumors in children.

Materials and Methods
Retrospective single-institution review of brain MRI scans in 26 pediatric patients with confirmed supratentorial CP tumors. Imaging features were evaluated by three neuroradiologists in consensus, blinded to the final pathology. The features included: location, margins, vascularity and vessel distribution, internal architecture, T2 signal, diffusivity, contrast enhancement pattern, parenchymal invasion, surrounding vasogenic edema, ventricular septations/entrapment, susceptibility, mass effect, intracranial CSF seeding, and arterial territory infarct at time of presentation. Readers also provided their impression of whether the features were in keeping with a papilloma, carcinoma, both, or if there were atypical features. Diagnostic accuracy of MRI features was tested for differentiation between papilloma and carcinoma (chi-squared test), and a multivariate diagnostic logistic regression model was also constructed.

Results
The median (interquartile range) age was 1.23 (0.55-3.53) years. Fourteen (54%) were male. There were eighteen CP papillomas and eight CP carcinomas. 77% of the lesions were located in the lateral ventricles and 27% in the third ventricle. The margins of the tumors were smoothly lobulated in 39% and cauliflower-like in 61%. T2 signal was high in 42% and intermediate to low in 58%. Restricted diffusion was present in 19% of tumors. Imaging signs of overt invasion was present in 31%. Vasogenic edema surrounding of the adjacent parenchyma was seen in 31%. Susceptibility due to calcium/blood was present in 73%. Intracranial CSF seeding and metastases were present in 15%. The most salient independent, statistically significant differentiating imaging features included T2 signal of the mass, the shape of tumor margins (smoothly lobulated vs. cauliflower), presence of overt parenchymal invasion, surrounding edema, and presence of metastases. The multivariate diagnostic feature model showed an area under the curve of 0.93. Optimum cutoff sensitivity and specificity of 100% and 77% was achieved.

Conclusions
A subset of MRI features was helpful in differentiating papillomas and carcinomas. Diagnostic performance of the multivariate model was very good. A combination of MRI features can be used to develop relatively accurate predictive diagnostic models for differentiating supratentorial primary CP tumors in children.

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Chronic Reactive Astroglisis: An Unexpected Cause of Chronic Weakness and Abnormal Involuntary Twitching

O Haken1, W Mallon2, S Benitez3, S Boone2, K Wattamwar3, M Mansouri1, S Shamir4, A Reis5, J Burns3, K Shifteh3
1Montefiore Medical Center, Fresh Meadows, NY, 2Montefiore Medical Center, New York, NY, 3Montefiore Medical Center, Bronx, NY, 4Montefiore Medical Center, BRONX, NY, 5Montefiore, New York, NY

Purpose
To present a case of chronic reactive astrogliosis in a child who underwent a lengthy workup and brain biopsy and highlight the clinical, neuroimaging, and histopathologic findings.

Materials and Methods
14-year-old boy with sickle cell trait referred for chronic progressive left-sided weakness and involuntary twitching. MRI showed extensive right sided signal abnormality concerning for demyelination, inflammatory etiologies such as neurosarcoidosis or neuro-Behet, rhomboencephalitis as well as infiltrative neoplasm. In the ED, he was found to have left-sided hyperreflexia, sensory deficits, increased muscle tone, and decreased muscle bulk. He demonstrated abnormal gait and left sided twitching. Lengthy workup including infectious, rheumatologic, and metabolic etiologies such as EBV, lyme, mycoplasma, HIV, syphilis and ENA/ANA was negative. Lumbar puncure was normal. MR spectroscopy showed active turnover. He underwent a brain biopsy which showed chronic reactive astrogliosis without evidence of neoplastic process. Postoperatively, he did well and was discharged home. He did continue to complain of further left-sided weakness.

Results
Linear patchy abnormal hyperintense T2 and FLAIR signal involving the right corona radiata, right greater than left basal ganglia, internal capsules and thalamus, genu of the corpus callosum, course of the optic tracts, midbrain, pons and right brachium pontis. No mass effect, volume loss, abnormal enhancement or susceptibility artifact associated with these areas. MR spectroscopy suggestive of active brain turnover with decreased normal brain tissue. No increased/decreased perfusion on MR perfusion

Conclusions
Chronic reactive astrogliosis, characterized by hypertrophy, proliferation and change in phenotype of astrocytes, is an enigmatic process which plays a role in inflammation and tissue repair. It is a response to CNS injury and seen in neuropathologies like stroke, TBI, tumor growth and neurodegenerative disease. The molecular and morphological changes that the astrocytes undergo are poorly understood but exert beneficial and detrimental effects. Reactive astrocyte phenotype is dependent on the inducing injury and therefore is a highly heterogenous state with both loss of normal functions and gain of abnormal effects as in our patient. We present chronic reactive astrogliosis in a setting worrisome for neoplastic process. Recognition of the imaging pattern is important in order to consider reactive astrogliosis in one's differential and pursue appropriate workup.
SILAN Programming: Cerebrovascular Disorders in Children

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Interhemispheric Perfusion Asymmetry from Circle of Willis Arterial Maturity in Normal Population

C Jain¹, A Kumar², S VYAS², P Singh²

¹PostGraduate Institute of Medical Education & Research (PGIMER), New Delhi, Delhi, ²Postgraduate Institute of Medical Education and Research, Chandigarh, India., Chandigarh, Chandigarh

Purpose

Angiographic and cadaveric studies have evidenced variations in circle of Willis (CoW) previously. Age related changes in cerebral haemodynamics may be attributable to vascular variations. The purpose of this study is to assess the completeness of circle of Willis with age using non-invasive high-resolution MR-angiography and corroborate findings with cerebral perfusion using arterial spin labelling (ASL) technique.

Materials and Methods

This is a single center, prospective study conducted between January 2017 and June 2019. Patients segregated into three age groups: ≤5 years, 5 to 18 years and >18 years underwent time-of-flight (TOF), contrast enhanced MR angiography (CE-MRA) and pseudocountinuous ASL sequences. Angiographic data is assessed on both source and MIP images and mean signal intensity on ASL obtained by ROI placement in bilateral frontal, parietal, occipital, temporal lobes and bilateral cerebellar hemispheres.
Results
A total of 189 patients with non-vascular symptomatology are included (mean age 17.9 ± 6.9 years, 43.39% (82/189) female). Complete CoW is seen in 106 (56.08%) patients on TOF and 100 (52.91%) on CE-MRA. TOF and CE-MRA show no statistically significant superiority over the other in demonstrating CoW. Qualitatively, third and fourth order branches are better seen on CE-MRA with higher mean diameters. Anterior and posterior collateral pathways (anterior communicating, ACoA and posterior communicating arteries, PCoA) are more prevalent in younger population. The completeness of CoW decreases with increasing age, group 1 (54/60, 90% on TOF; 51/60, 85% on CE), group 2 (39/64, 60% on TOF; 37/64, 56.92% on CE) and group 3 (13/65, 20.31% on TOF; 12/65, 18.75% on CE); p value <0.0001. Mean signal intensities in ASL show statistically significant decrease in cerebral and cerebellar perfusion with advancing age. Higher cerebellar to frontal perfusion signal change is seen in group 1 than groups 2 and 3. Presence of fetal posterior cerebral artery (PCA) leads to ipsilateral low and contralateral hyperperfusion on ASL and flow asymmetries between the occipital lobes.

Conclusions
Complete CoW is more common in paediatrics than adults. Cerebral perfusion shifts from hindbrain to forebrain due to regression of bilateral PCoA as age advances. Presence of fetal PCA leads to perfusion asymmetries in occipital lobes. Presence of bilateral PCoAs may account for a lower incidence and better functional outcomes of stroke in paediatrics.
Assessment of Fast Echo-planar Brain Imaging for Pediatric Patients in the Acute Setting

B Applewhite¹, S Moum¹, K BUCH¹, P Caruso¹, O Rapalino¹, W Mehan¹, M Gee¹, S Skare², T Sprenger³, A Guidon⁴, S RINCON¹
¹Massachusetts General Hospital, Boston, MA, ²Karolinska University Hospital, Solna, Stockholm, SWE, ³GE Healthcare, Solna, Stockholm, SWE, ⁴GE Healthcare, Boston, MA

Purpose
Pediatric imaging faces diagnostic and logistic challenges, namely neuroradiologists are often weighing fast scan times with sequence selection to answer pertinent clinical questions. Moreover, pediatric emergency departments face challenges with complex imaging orders, concerns regarding patient sedation, and prolonged times to discharge in the setting of negative acute cases. Fast MRI techniques have recently emerged, affording diagnostic brain MRI sequences without the need for sedation in pediatric patients. This investigation aims to determine the utility of novel fast echo-planar imaging (EPIMix MRI) techniques for the evaluation of pediatric patients in the acute setting.

Materials and Methods
This was a retrospective study with IRB approval. Thirty (n=30) patients presenting to the Massachusetts General Hospital Emergency Department from October 2018 to August 2019 received an EPIMix MRI exam in addition to requested diagnostic sequences. The additional 90 second sequence on a 1.5T GE scanner afforded axial: diffusion, ADC, susceptibility, T2, FLAIR, and T1 sequences. Preceding diagnostic sequences included either a quick brain triplanar T2 SSFSE (n=2) or conventional diagnostic MRI exam (n=28). Two neuroradiologists independently reviewed the EPIMix MRI, triplanar T2 SSFSE MRI, and conventional diagnostic MRI exams, specifically evaluating for acute processes (i.e. infarction, intraparenchymal hemorrhage, mass lesion, hydrocephalus, midline shift, and pathologic fluid collection).

Results
Retrospective analysis of fast echo-planar (EPIMix) MRI sequences in the evaluation of 30 pediatric patients (ages 3-20) presenting in the MGH Emergency Department shows concordance with conventional MRI exams for the evaluation of infarction, intracranial hemorrhage, mass lesion, hydrocephalus, midline shift, and pathologic fluid collection. No acute findings were missed on EPIMix MRI sequences.

Conclusions
Pilot data suggests that fast EPIMix brain MRI technique may be comparable in evaluation of pediatric patients in the acute setting without the need for sedation or radiation.

Impact of Model based Iterative Reconstruction on Image Quality and Radiation Doses in Paediatric Head CT

K SODHI¹, P ATTRI², A SAXENA², A BHATIA²
¹Post Graduate Institute of Medical education & Research (PGIMER), Chandigarh, India, ²Post Graduate Institute of Medical education & Research (PGIMER), Chandigarh, IN

Purpose
To study the potential of model based iterative reconstruction (MBIR) technique on image quality and CT dose reduction in children undergoing computed tomography (CT) head examinations.

Materials and Methods
This was a prospective study which was approved by our institutional ethics committee. 40 children (age range of 5 to 16 years) with history of seizures underwent contrast enhanced CT scan according to the MBIR technique while 40 children (controls) underwent CT head with the other non-MBIR protocol. Images were reviewed separately by two pediatric radiologists, who were blinded. CT dose index (CTDI) volume, mean dose-length product, and mean effective dose was recorded for both MBIR and non-MBIR groups. Image quality, image noise and diagnostic acceptability of two image sets was also recorded. Mann-Whitney U-test, Student t-test and kappa tests were utilized for statistical analysis.

Results
In the MBIR group, mean CTDI volume, the mean dose-length product and mean effective dose was reduced by more than 70% when compared to the non-MBIR group. No significant difference was however demonstrated in image quality, image noise and diagnostic acceptability in between the two groups.

Conclusions
Model based Iterative reconstruction technique is highly effective in reducing radiation dose in pediatric head CT examinations without any significant difference in diagnostic acceptability, image quality and image noise.
Refractory Cerebrospinal fluid leakage: A Novel approach

R Abdalla1, D Robinson Cantrell2, A Mozafarykhamseh3, M Hurley4, S ANSARI5, A Shaibani6
1Northwestern University, Chicago, IL, 2N/A, N/A, 3Northwestern University - Feinberg School of medicine, Chicago, IL, 4Northwestern University Feinberg School of Medicine, Chicago, IL, 5NORTHWESTERN UNIVERSITY FEINBERG SCHOOL OF MEDICINE, CHICAGO, IL, 6Northwestern University Feinberg School of Medicine, Chicago, IL

Purpose
Background and Purpose Cerebrospinal fluid (CSF) leaks whether post-dural puncture or spontaneous presents with low-pressure positional headaches. Epidural blood patching at the level of the leak is the standard of care for treating CSF leaks with multiple reports of success with using fibrin glue and mixed blood/fibrin patches. However, in many cases the symptoms are refractory to treatment due to challenges in identifying the site of leakage or presence of multiple leakage sites especially with spontaneous leaks. We describe a novel technique of treatment of refractory CSF leakage using peripherally inserted central catheter (PICC) lines in the epidural space.

Materials and Methods
Two patients presenting with recurrent attacks of progressive positional headache (one post traumatic and the other spontaneous) were proven by myelograms to be secondary to CSF leak. After failure of conservative management, epidural blood patch was decided.

Results
In the post-traumatic patient, contrast was seen in the ventral epidural space extending from the C6 level inferiorly to the T4 level centered at the T1/T2 disc space and 2 sites of leak were suspected one at C7/T1 and the other between T3 and T6 level. After 5 unsuccessful attempts of epidural blood and fibrin patches and failed hemilaminectomy with transpedicular repair over a 2-month period, a 4 F sheath was placed at L2/3 level followed by navigation of a diagnostic catheter over a guide wire to the upper thoracic levels, the catheter was then exchanged for a 4F PICC line and 13 cc of fibrin glue was injected all the way from T4 level down to L2/3 level. Following treatment, the patients' symptoms significantly improved and no further treatment was required. In the other case of spontaneous CSF leak, 4 leakage sites were suspected; patient underwent 4 epidural blood and fibrin glue patches at various levels between T1 and L4, with none of which was successful in resolving the symptoms. Again, a PICC line inserted at L3/4 level was navigated to the craniovertebral junction followed by fibrin glue injection in the epidural space from the craniovertebral junction down to the upper lumbar level was successful in achieving symptoms resolution. No post-procedure complications occurred in both patients.

Conclusions
Epidural patches using peripherally inserted central catheter (PICC) lines is a safe and effective approach for treatment of refractory CSF leaks when multiple or unconfirmed sites of leakage are suspected.

Diagnostic yield of lateral decubitus digital subtraction myelogram for assessment of CSF leaks with stratification by brain MRI scoring

D Kim1, C Carr1, P Morris1, F Diehn1, V LEHMAN2, G Liebo3, J Morris4, J Verdoorn1, J Benson2, W Brinjikji1
1Mayo Clinic, Rochester, MN, 2MAYO CLINIC, ROCHESTER, MN, 3MAYO CLINIC - ROCHESTER, MN, 4ROCHESTER, MN, 5N/A, N/A

Purpose
Digital subtraction myelography (DSM) is an excellent diagnostic tool for assessment of various types of CSF leaks, and lateral decubitus DSM is increasingly being used with several publications reporting excellent diagnostic yield. We assessed diagnostic yield of lateral decubitus DSM at our institution and reviewed prior brain MRI of these patients to evaluate the validity of the brain MRI grading system by Dobrocky et al.

Materials and Methods
All patients who underwent lateral decubitus DSM at our institution in a 1-year period were included in this study. Exams performed for post-operative/post-procedure CSF leaks were excluded. Total of 62 patients met the inclusion criteria totaling 145 lateral DSM exams. Neuroradiologists who routinely perform lateral decubitus DSM evaluated the DSM images and brain MRI exams, with two readers per exam. All discordant reads were reconciled by a third reader.

Results
Of the 62 patients, lateral decubitus DSM identified the site of the leak in 33 (53%) patients. One patient had two separate leaks, one on each side, but the rest had one leak. Of the 34 leaks, 30 (88%) were CSF-venous fistulas, 3 (9%) were proximal nerve root sleeve tears, and 1 (3%) was distal nerve root sleeve tear. 24 (71%) were on the right side and 10 (29%) were on the left. Using the brain MRI scoring system by Dobrocky et al., of the 41 patients with high probability score, leak was found in 28 (67%), and of the 11
patients with intermediate probability score, leak was found in 5 (45%) patients. No leak was identified in the 9 patients with low probability. Interobserver agreement for DSM image interpretation was 85 (95% CI = 0.7-0.99) and interobserver agreement for the items in the brain MRI scoring system (venous sinus distension, pachymeningeal enhancement, subdural collection, suprasellar cistern effacement, preponine cistern effacement, mamilllopontine distance 6.5 mm or less) ranged from 0.52 to 0.80. AUC of ROC for the brain MRI scoring system in our cohort was 0.7 with J point at 5. Using the score of 5 as a cutoff, the sensitivity/specificity and PPV/NPV for the brain MRI scoring system were 84.9%/51.7% and 66.7%/75.0%, respectively.

Conclusions
Lateral decubitus DSM has a high diagnostic yield in patients referred for high clinical suspicion for spontaneous spinal CSF leaks without epidural fluid collection. Pretest probability of these patients can be further stratified using the brain MRI scoring system to improve diagnostic yield and to decrease number of negative studies.

**2691**

**CSF Compliance Curves in Patients with Spontaneous Intracranial Hypotension due to Suspected CSF-Venous Fistulas**

M Caton¹, W Dillon¹, V Shah¹
¹University of California San Francisco, San Francisco, CA

**Purpose**
Spontaneous intracranial hypotension (SIH) is a debilitating but potentially curable disease that can result from CSF venous fistulas (CVFs). CVFs are challenging to diagnose as their visualization may be position, volume, and pressure dependent [1]. CSF pressure/volume (PV) dynamics likely influence detection of CVF, but this relationship is poorly understood. The pressure-volume index (PVI) allows estimation of CSF compliance which is known to be a non-linear (exponential) function [2]. PVI can be reliably calculated using bolus-response measurements and is thus advantageous for routine myelography [3]. The purpose of this study was to investigate the CSF compliance and PVI using bolus CSF pressure augmentation in patients with suspected CVF to improve the diagnosis of SIH.

**Materials and Methods**
We reviewed 8 consecutive patients between January 2018 and October 2019 with clinical and brain imaging features of SIH suspected to have an underlying CVF. Patients had no extradural collection on conventional myelography and underwent dynamic decubitus positive pressure myelography. Opening CSF pressure was recorded, and intrathecal pressure was raised through serial infusion of normal saline (NS) in 1-5ml boluses. PV curves were constructed when CSF pressure augmentation was performed. From PV curves, we estimated CSF compliance as 1/slope of the line of best fit estimated with using linear regression (Fig 1A) [4]. The PVI was calculated for each patient according to the method of Marmarou [5].

**Results**
25 myelograms were performed in 8 patients (50% female, mean age 61.2y). Definite CVF was identified in 5/8. Data were available to calculate PV curve in 7/8 patients. Estimated compliance ranged from 0.68-4.3 ml / mm pressure (H20) (mean = 1.79). We observed a spectrum of PV curve shapes including patterns that were linear, linear with abrupt pressure loss, sigmoid (1B), and exponential. In cases with pressure loss, we inferred that a pressure threshold for the presumptive leak was reached (1C, black arrows). Change in PV curve morphology was observed after epidural blood patch. Mean PVI in this population (61.2 +/- 31.4ml) was higher than normal/control values reported by Shapiro (PVI = 25.9 +/-3.7ml) [2].

**Conclusions**
This study describes a method of estimating CSF compliance during dynamic myelography in patients with suspected CVF. Elevated PVI and PV curve morphology may help diagnose CVF and inform the practice of spine interventionalists treating these patients.
Health Policy Programming: Neuroradiology: Key Player or Cost Center

2018

National Medicare Trends in the Utilization of Functional Neuroradiology Imaging

A Gandhi¹, A Karambelkar¹, N Jain-Lakhani¹, S Faro¹, R Gorniak¹, A Flanders¹
¹Thomas Jefferson University Hospital, Philadelphia, PA

Purpose
Functional neuroradiology is a rapidly growing subspecialty in the field of radiology. We aim to assess the functional neuroradiology utilization trends among the Medicare population from 2007-2018. In addition, utilization trends at a tertiary care hospital were compared with the national Medicare data.

Materials and Methods
Medicare Part B Physician/Supplier Procedure Summary master files from 2010-2018 and Part B National Summary Data Files from 2007-2018 were analyzed for all Current Procedural Terminology, version 4 (CPT-4) codes related to functional neuroradiology (70554, 70555, and 96020). The files provided total procedure volume and Medicare payments, from which utilization rate could be calculated. Medicare specialty codes were used to determine provider specialty. Medicare place-of-service codes were used to identify locations where services were provided. Total procedure volume at a tertiary care hospital from 2012 to 2018 was compared to the national Medicare trends.

Results
Total utilization rate and payment of functional neuroradiology services within the Medicare population increased 192% and 216% from 2007 to 2018, respectively. Volume, utilization, and payments peaked in 2014 with a 278% utilization rate increase since 2007. This peak is largely attributable to neurologists holding a significant increase and majority share of CPT code 96020 claims (neurofunctional testing selection and administration during noninvasive imaging) during 2013-2014. However, neurologists' percent share of 96020 claims has downtrended since 2014 with radiologists and psychologists holding a 59% and 40% of these claims in 2018, respectively. Radiologists consistently hold greater than 90% share of CPT code 70554/70555 claims (functional brain MRI without/with physician or psychologist administration) for the past decade. Although functional neuroradiology imaging is typically performed in the outpatient setting, there has been a steady rise of services at inpatient and emergency department facilities. At the...
tertiary care hospital, there is a 21% increase in 70554/70555 claims from 2012 to 2018. These 70555 services at this hospital account for 99% of the imaging volume versus fewer than 40% in the national Medicare Part B Radiology claims.

Conclusions
Utilization of functional neuroradiology services has increased with radiologists as the largest provider specialty. Thus, functional neuroradiology should be integrated into training and clinical practice.

Value of Acute Neurovascular Imaging in Patients with Transient Ischemic Attacks

R Jalilianhasanpour1, N Ali1, S Hause1, D Yousem2
1Johns Hopkins Medical Institution, Baltimore, MD, 2Johns Hopkins Medical Institution, Owings Mills, MD

Purpose
Current guidelines recommend acute neurovascular imaging including magnetic resonance angiography (MRA) and/or computed tomography angiography (CTA), as part of the routine work-up in patients presenting with transient ischemic attacks (TIAs). Given the controversies regarding the cost-effectiveness of various vascular imaging strategies in patients presenting with TIA symptomatology, we sought to determine 1) the value of immediate CTA/MRA imaging in ED, 2) whether the neurovascular studies led to a difference in medical management, and 3) the potential of converting to outpatient Doppler ultrasound examinations (DUS) in TIA patients.

Materials and Methods
This retrospective cohort study was approved by our institutional review board. A database of the Emergency Department was used to identify 300 patients who presented with transient neurological deficits and underwent neurovascular imaging between March 2015 to March 2018. We collected patient demographics, risk factors, types of neuroimaging utilization, encounter characteristics, investigative tests, and subsequent diagnostic and management dispositions. Additional information about recurrence of TIA and follow up neurologic events were also investigated over the subsequent 3 months for each patient.

Results
The total rates of positive MRAs/CTAs for severe intracranial and cervical vessel stenoses were 8% and 5.3 % respectively. Severe intracranial stenoses were demonstrated in 15.2% of patients with DWI positive scans and 1.9% of DWI negative scans. Moderate to severe cervical vessel stenoses rate was also higher in patients with DWI positive scans (10.9%) compared to those who have DWI negative scans (0.6%). All patients were treated with multi-pronged medical therapies with no immediate surgical intervention. Subsequent stroke occurred in 2 cases during the 3-month follow-up period: in one patient vascular imaging were negative and atrial fibrillation was identified as the potential source of TIA, and the other patients’ MRA only showed mild abnormalities of brain and neck vasculature with no evidence of severe stenosis or ischemia at the time of initial ED presentation.
Conclusions
Neurovascular studies are often negative in patients with TIA symptoms. In these patients, particularly those with DWI negative brain scan, the value of the acute MRA/CTA comes into question. High value care may be better delivered by neurovascular imaging as an outpatient rather than in the ED. Converting to an outpatient DUS could be a strategy for optimal trade-off between costs and effectiveness and would also yield benefits to the patient and hospital with reducing the risk of IV contrast and/or radiation exposure as well as the time savings on scanner and ED length of stay.

Repeat Head CT for Neurologically Stable Patients with Mild Traumatic Subarachnoid Hemorrhage at Time of Transfer from Another Facility Does Not Alter Patient Care.

H Valand¹, T Locke², N Soni³, G Bathla⁴
¹American University of Integrative Sciences, Toronto, Canada, ²University of Iowa, Iowa City, IA, ³THE UNIVERSITY OF IOWA, IOWA CITY, IA, ⁴Univ. Of Iowa Hospitals & Clinics, Iowa City, IA

Purpose
Obtaining a repeat CT brain study in trauma patients at the time of transfer from a different facility is relatively common. Oftentimes, this is done as a part of standard trauma protocol and is done with the intent of evaluating for interval changes. We aimed to determine if a repeat brain CT at time of transfer from other facility would alter management in patients with isolated traumatic subarachnoid hemorrhage (tSAH) and Glasgow coma scale (GCS) between 13-15 who were otherwise neurologically stable. In addition, cost effective analysis and radiation exposure calculations were also conducted.

Materials and Methods
Single center retrospective analysis at level one tertiary care hospital. Medical records were scanned using specific ICD-10 codes for mild traumatic brain injury and revealed 523 patients who presented between January 2017-July 2019. Inclusion criteria included isolated tSAH, GCS between 13-15, neurologically stable and presence of both external CT Brain study and repeat CT study at time of transfer. A total of 97 (18.55%) patients met the eligibility criteria.

Results
Average GCS score was 14.74 + 0.60 and mean time difference between the external study and the first in-house CT was 6:30 hours + 1:40 hours. At the time of inhouse scan, 73/97 (75.26%) patients had stable tSAH, 19 (19.59%) patients had a decrease in SAH while 5 (5.15%) patients had interval increase in SAH. Additionally, 1 (1.03%) patient developed a small subdural hematoma. All 97 patients had complete resolution of SAH on the 6 weeks follow up scan. None of the six patients with increased SAH/new subdural hemorrhage required any surgical intervention. Of 97 patients, 53 (54.64%) patients were on at least one blood thinner. At $350 per head CT, $33,950 were spent on in house repeat head CT imaging but made no difference in clinical decision making. The mean radiation exposure for the in-house study was 1.77 + 0.26 mSv.

Conclusions
A repeat in house follow up head CT of neurologically stable patients with isolated tSAH and GCS score of 13-15 at the time of transfer is unlikely to alter the clinical course of patients. In addition, it increases the radiation exposure and the overall financial burden on the healthcare system.

Highlighting the Typical MRI Appearance of Intracranial Administration of Stem Cell in Traumatic Brain Injury (TBI) Patients: An Initial Experience

O Arevalo¹, A Aein¹, M Haque², B Nejadnik³, S George², C Sitton¹
¹Department of Diagnostic and Interventional Imaging, McGovern Medical School, UTHealth, Houston, TX, ²Department of Neurology, McGovern Medical School, UTHealth, Houston, TX, ³SanBio Incorporated Company, Mountain View, CA

Purpose
Intracranial stem cell implantation is a promising treatment for sequela of stroke and TBI. Several clinical trials have been run to evaluate its clinical efficacy and safety. We aim to describe the typical post-injection MR imaging findings such as tract edema (TEd), tract enhancement (TEn), parenchymal enhancement (PEn), subdural hemorrhage (SDH), and parenchymal hemorrhages (PH) after intracranial injection of stem cells.

Materials and Methods
A retrospective evaluation of MRIs of 61 patients with stable chronic motor deficits due to TBI who were recruited for a phase II clinical trial (A Study of Modified Stem Cells in TBI STEMTRA, NCT02416492). The patients were randomized into experimental and control cohorts respectively. The intervention group received three intracranial injections of stem cells, and the control group.
received a partial burr hole craniotomy. Immediate postoperative (24-72 hours) and follow-up MRI at 1, 6, and 12 months were acquired on all the subjects. The MRIs were evaluated by two neuroradiologists. We aimed to highlight the typical MR appearance of first post-procedural (PP) and follow-up (FU) exams. We have described the incidence and evolution of TEd, TEn, SDH, PH, and PEn.

Results
Among 61 patients, 45 underwent implantation (experimental group) and 16 received sham surgery (control group). The tract was identifiable in 91% (41/45) of patients. The TEn was seen in the PP in 90% (37/41), which resolved in all patients during the FU exams. The TEd was defined as T2/FLAIR hyperintensity and categorized in table 1. The average volume of tract-associated edema in PP examinations decreased over time. The PEn, defined as the enhancement beyond the tract site, was seen in 24% (10/41), and also progressively decreased. The incidence of SDH in the first PP exam was 33% (15/45). The evolution of SDH during FU exams showed 87% resolution and 13% improvement. The percentage of PH in first PP exam was 20% (9/45). All patients with PH had a complete resolution in 6-month FU.

Conclusions
The intracranial stem cell injection showed no serious adverse events. TEd, TEn, SDH, PH, and PEn can be found in the initial PP MRIs; however, all of them either resolved or improved over 12 months. This data can be useful when planning the imaging follow-up workups in future clinical trials. Knowing the typical imaging appearance and natural history of the post-procedural findings will be useful for the radiologist in daily practice, as they may encounter patients who have undergone this procedure.
Alterations in Topological Organization of Brain Networks in Subacute Post-Concussive Central Vestibular Impairment Using Resting-State Brain fMRI Graph Theory Analysis

A Trofimova¹, J Smith², V Ahluwalia³, C Appleberry⁴, R Gore⁴, J Allen¹
¹Emory University, Atlanta, GA, ²Emory University, Atlanta, GA, ³GSU/GT Center for Advanced Brain Imaging, Atlanta, GA, ⁴Shepherd Center, Atlanta, GA

Purpose
Patients with post-concussive vestibular impairment (PCVI) frequently report symptoms in complex visual environments. We aimed to define topological organization of brain networks in PCVI using resting-state fMRI (rs-fMRI) graph theory analysis.
Materials and Methods
Prospective IRB approved study. Study group: 11 subjects with PCVI; control group: 10 age-matched healthy subjects. Exclusion criteria: age 50, moderate or severe TBI, seizure disorder, CNS surgery, peripheral neuropathy, developmental delay, drug/alcohol use chronic/in the last 24 hours. MRI acquired on 3.0T Siemens Trio, 12-channel head coil. Whole brain rs-fMRI parameters were: 3x3x3.5 mm3 resolution; TR/TE=2000/30ms, flip angle=90°, acquisition time 10 min. Subjects stayed relaxed with eyes fixated on a crosshair. Standard rs-fMRI data preprocessing and ROI-to-ROI graph theory connectome analysis using CONN Toolbox. ROIs included: frontal eye fields, inferior frontal gyrus, middle frontal gyrus, parieto-insular vestibular cortex, posterior hippocampus (pHC), anterior insula (aINS), multisensory orientation area (MSO), MT/V5, BA17/18, HOC5/V5. Maps were corrected for multiple comparisons using family-wise error correction (p<0.05).

Results
In the control group, right aINS was the main hub. In the study group, there were 14 hubs bilaterally. Highest global efficiency and clustering coefficient were in the right pHC (controls) and right MT/V5 (study group). Highest local efficiency and degree were in the right MSO and right aINS (controls). In the study group, highest local efficiency was in the right MSO and right MT/V5; highest degree – in BA17/18 and right MT/V5. The following metrics reached statistically significant group differences (but were not statistically significant when corrected for multiple comparisons, likely due to the sample size): study group had higher global efficiency in the right pHC (T(19)=+2.5, punc=0.01, pFDR=0.17), right aINS (T(19)=+1.86, punc=0.04, pFDR=0.3); higher network cost in the right pHC (T(19)=+2.03, punc=0.03, pFDR=0.3), right aINS (T(19)=+1.85, punc=0.04, pFDR =0.3); higher average path length in the left pHC (T(18)=+2.1, punc=0.03, pFDR=0.2), right BA17/18 (T(18)=+1.79), punc=0.05, pFDR=0.2); higher degree in the right pHC (T(19)=+2.03, punc=0.03, pFDR=0.3) and right aINS (T(19)=+1.85, punc=0.04, pFDR =0.3).

Conclusions
Patients with PCVI demonstrate alterations in topological organization of brain networks suggesting pathologic over-reliance on memory and visual input, underlying PCVI symptoms.

Figure 1. Graph theory brain networks analysis for PIVC Subjects>Controls contrast, punc<0.05. Study group demonstrated higher global efficiency, network cost and degree in the right posterior hippocampus (R_pHC) and right anterior insula (R_aINS) as well as higher average path length in the left posterior hippocampus (L_pHC) and right BA17/18.

Cerebral microbleeds in American football players at 3T and 7T MRI: The more Tesla the better?

C Deuschl1, O Kraff2, H Quick3, M Forsting3, A Radbruch4, E Janis5, C Behr3, C Oedekoven7
1University of Duisburg-Essen, Essen, NRW, 2Erwin L. Hahn Institute for Magnetic Resonance Imaging, Essen, NRW, 3Erwin L. Hahn Institute for Magnetic Resonance Imaging, Essen, NRW, 4University Hospital Essen, Essen, Germany, 5Institut für Versorgungsforschung und Klinische Epidemiologie, Marburg, Hessen, 6Universitätsklinikum Essen, Essen, NRW, 7Memory Clinic, Essen, NRW

Purpose
American football players (AFP) experience repetitive brain trauma during their career and are at risk for developing a condition known as chronic traumatic encephalopathy. Cerebral microbleeds (CM) are a typical finding of repetitive brain trauma and diffuse axonal injury and show a frequency of about 9% in retired AFP (1). To our best knowledge all neuroimaging studies on CM in AFP have been performed on 1.5 or 3 T MRI. Ultrahigh field MRI with 7T shows significantly more CM in patients with diffuse axonal injury than 3 T SWI (2). The purpose of our study is to evaluate the value of 7 T SWI compared to 3 T SWI for the detection of CM in AFP.
Materials and Methods
Eighteen AFP of the German Football League were enrolled in this prospective study (mean age: 23.9 years, range: 20-32 years, all male). All subjects underwent a MRI scan with SWI imaging of the brain on 3T and 7T. Ultra-high field MR examinations were performed on a 7 T whole-body MRI system (Magnetom 7 T, Siemens Healthcare GmbH, Germany). All examinations at 3 T were performed on a high-end clinical MR system (Magnetom Skyra, Siemens, Germany). Both MR systems were used in combination with 32-channel radiofrequency head coils. Image analyses were performed by two neuroradiologist in consensus reading on 3T MRI and on 7T MRI for number of CM and additional findings.

Results
The readers identified a total of 10 CM in 5 AFP at 3T MRI (Fig. 1A). At 7T MRI CM were confirmed in 3 of these AFP (Fig. 1B), moreover even eight smaller CM were additionally identified. The other two suspected CM at 3T in the other two AFP (Fig. 1C) were identified at 7T as atypical small intracerebral veins (Fig. 1D). As an additional finding a developmental venous anomaly (DVA) was found in one the AFP, which was well delineated in both 3T and 7T, whereas at 7T a more exact architecture of the DVA was definable.

Conclusions
Depiction of CM is improved at 7T SWI compared to 3T SWI. Moreover, 7T-SWI allows a more accurate differentiation of suspicious lesions and might help to more accurately distinguish between microbleeding and e.g. venous anomalies. 7T-SWI could help to understand pathophysiological processes in AFP, nevertheless larger studies at 7T are needed.

Can Fractional Anisotropy Measurements Diagnose Mild Traumatic Brain Injuries?

N Binesh\(^1\), f moser\(^1\)
\(^1\)Cedars-Sinai Medical Center, Los Angeles, CA

Purpose
Usual clinical brain scans cannot distinguish patients with mild traumatic brain injuries (TBI) from healthy controls. There are numerous papers that have explored DTI(1) (diffusion tensor imaging) for diagnoses and quantification of these injuries. Many researchers(2) have tried to use fractional anisotropy (FA) measurements to distinguish between normal brain and mild TBI, yet, there is no conclusive evidence that the FA measurement resulting from DTI can be used as a reliable imaging tool in diagnose of mild
Materials and Methods
We measured FA values at 27 location in brain: 4 on sulcus, 3 on corpus callosum (CC), 6 on Internal Capsule, 2 on Thalamus, 2 on occipital, 2 on cerebral peduncle, 2 on Temporal, 4 on brain stem at corticospinal tract (CST) and at postcentral sulcus (SPC) and 2 at medial cerebellar peduncles (MCP). For each of these we used a fixed area of interest (4mm) to measure FA. The FA values of 60 healthy volunteers were used as the baseline. The standard deviation (SD) of each measurement were calculated and used as the factor for deviation from the baseline.

Results
We run DTI on 712 patients. From the SD for each measurement we notice the most accurate measurements were on the following: CC, IC, CST, SPC and MCP. These had the lowest SD and easiest localization on the FA maps. Looking at the deviations in FA values, we noticed that only 30% of the patients showed deviation on one or more FA measurements. Farther the number of patients with deviation in more than one area, was below 10%. The low number of deviations, point to the fact that the overall fluctuation of FA from one person to another is large enough that masks changes (if any) in FA values as results of TBI. It is hard to justify that the deviation in just one area is the directly due to a mild trauma. It could easily be due to an artifact or low SNR. The deviation in more than one area, however, points to a real change and could help in diagnoses of mild TBI.

Conclusions
Here we studied the changes in FA values in patients with mild traumatic brain injuries and compared them to healthy controls. The measurements showed significant differences between the healthy controls and patients only in 10% of the cases. This could be due two reasons: 1) only in these patients there was a real injury, 2) the change in FA values due to mild TBI is less than the normal variation in FA.

2699

5:33PM - 5:39PM

Intra- and Inter-observer reliability of CT Angiography (CTA) for evaluation of Blunt Cerebrovascular Injury (BCVI)

A Malhotra¹, K SEIFERT², X Wu³, I Ikuta⁴
¹Yale University School of Medicine, New Canaan, CT, ²YALE NEW HAVEN HOSPITAL, MILFORD, CT, ³Yale University School of Medicine, New Haven, CT, ⁴YALE UNIVERSITY SCHOOL OF MEDICINE, MILFORD, CT

Purpose
CTA has largely replaced DSA (Digital Subtraction Angiography) as the initial screening modality for evaluation of BCVI in acute blunt trauma patients. However, there continues to be conflicting literature on the sensitivity and specificity of CTA, and the role of DSA subsequent to CTA. The goal of this study was to determine the inter- and intra-observer reliability of noninvasive screening modalities especially CTA for detection of BCVI.

Materials and Methods
After IRB approval, a retrospective cohort of 50 patients were selected with blunt trauma and skull base, cervical and/ or facial fractures, and CTA performed within 24 hours. 10 patients had a repeat CTA within 10 days, and 10 studies were randomly replicated. 10 patients who also had a subsequent MRA performed within 72 hours were also included. A total of 80 studies were de-identified and independently read by 3 fellowship-trained neuroradiologists, with 10, 5 and 2 years of experience respectively. Each reader was requested to report the Denver grading for 4 vessels- vertebral and carotid arteries bilaterally. Fleiss' multi-rater kappa was used to assess inter-reader reliability and Cohen's kappa to assess intra-reader reliability for each of the three readers.

Results
The inter-reader reliability was 0.0081 for carotid arteries and 0.056 for vertebral arteries among the three readers. Intra-reader reliability was 0.32 and 0.33 for carotid and vertebral arteries for reader 1, 0.65 and 0.43 for reader 2, and 0.10 and 0.20 for reader 3. Significant variability was also found with the original CTA report, even when excluding the outlier results.

Conclusions
Although CTA is frequently performed for determination and grading of BCVI, there is significant variability in interpretation, especially in the vertebral arteries and in the older population. This explains the heterogeneity in literature regarding poor sensitivity and high false-positive rates even in recent literature.

1632

5:40PM - 5:46PM

Incidence and Clinical Predictors of Intracranial Hemorrhage in Children with Non-Accidental Trauma

S Dakil¹, R Clarke², J Tweed³, C Greenwell⁴, T Booth³
¹University of Texas Southwestern and Children's Health, Dallas, TX, ²UT Southwestern Medical Center, Children's Health Dallas, Dallas, TX, ³Children's Health Dallas, Dallas, TX, ⁴Children's Health Dallas, Dallas, TX

Purpose
Although head CT is a recommended screening tool in suspected child physical abuse, it is sometimes difficult to justify the radiation
in neurologically normal children. The Pediatric Emergency Care Research Network (PECARN) criteria for neuro-imaging have been validated in all ages, but not in cases of suspected abuse. The purpose of this study was to evaluate the incidence of intracranial hemorrhage (ICH) in a population with suspected non-accidental trauma and a Glasgow coma scale score of 15. A secondary aim was to evaluate clinical variables that may demonstrate an increased incidence of ICH.

Materials and Methods
The study cohort, identified by search of the trauma registry of a tertiary trauma center, consisted of patients under 2 years of age who presented to the ED and were evaluated for non-accidental trauma with a GCS of 15 between January 2010 and December 2016. All subjects had a head CT within 24 hours of presentation. All CTs were independently reviewed by two radiologists, assessing for presence of ICH and skull fractures. Patient charts were reviewed to identify presenting signs and symptoms, and variables were analyzed. Abbreviated injury scores (AIS) for all body regions as well as injury severity scores (ISS) were extracted from the trauma registry.

Results
The study cohort consisted of 302 patients. Sixty-three (21%) had confirmed ICH. There was a significantly higher incidence of multi-episode vomiting, seizure, prolonged LOC, scalp bruising, suspicion of skull fracture, and altered mental status in the ICH group. Based on these clinical variables found to have a significant association with ICH, a model was built to maximize the sensitivity of predicting patients with ICH. The sensitivity of this model was 92%. Patients who presented with no variables that have an association with ICH accounted for 42% (n=129) of the population. The rate of ICH in this sub-population was 3.9%, and these patients had a significantly higher ISS score than the non-ICH patients in the subgroup.

Conclusions
In keeping with previous reports, a significant portion of patients in our cohort had occult head injury. Our study assessed the usefulness of certain readily accessible clinical screening criteria for determining need for head CT in this population. With a positive predictive value of only 34% there will still be some patients with normal head CTs, however with a negative predictive value of 96%, these criteria are useful for excluding those patients who do not need a head CT.
Table 1: Cohort Demographics of NAT Patients arriving to the ED with Normal Neurological Assessment

<table>
<thead>
<tr>
<th>Total Patients</th>
<th>302</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in Months</td>
<td>5.2 (2.4-9.2)</td>
</tr>
<tr>
<td>Male Gender</td>
<td>177 (59%)</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>100 (33%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>60 (20%)</td>
</tr>
<tr>
<td>Black</td>
<td>85 (28%)</td>
</tr>
<tr>
<td>Other</td>
<td>30 (10%)</td>
</tr>
<tr>
<td>Asian</td>
<td>1 (&lt;1%)</td>
</tr>
<tr>
<td><strong>Trauma Activation</strong></td>
<td></td>
</tr>
<tr>
<td>Stat</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Alert</td>
<td>11 (4%)</td>
</tr>
<tr>
<td>Eval</td>
<td>83 (27%)</td>
</tr>
<tr>
<td>Consult</td>
<td>266 (88%)</td>
</tr>
<tr>
<td><strong>Vomiting</strong></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>261 (86%)</td>
</tr>
<tr>
<td>Once</td>
<td>77 (25%)</td>
</tr>
<tr>
<td>Multiple</td>
<td>24 (8%)</td>
</tr>
<tr>
<td><strong>Documented Seizure</strong></td>
<td>14 (5%)</td>
</tr>
<tr>
<td><strong>Loss of Consciousness</strong></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>255 (88%)</td>
</tr>
<tr>
<td>Transient</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>Prolonged</td>
<td>4 (1%)</td>
</tr>
<tr>
<td>Facial Bruising</td>
<td>81 (27%)</td>
</tr>
<tr>
<td>Scalp Bruising</td>
<td>93 (31%)</td>
</tr>
<tr>
<td>Suspected Skull Fracture</td>
<td>81 (27%)</td>
</tr>
<tr>
<td>Other AMS</td>
<td>98 (33%)</td>
</tr>
<tr>
<td>One AMS Present</td>
<td>77 (25%)</td>
</tr>
<tr>
<td>Two or More AMS Present</td>
<td>21 (7%)</td>
</tr>
</tbody>
</table>

Table 2: Presenting Signs and Symptoms Associated With Presence of Intracranial Hemorrhage

<table>
<thead>
<tr>
<th>Associated Variable</th>
<th>No ICH</th>
<th>ICH</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vomiting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>216 (90%)</td>
<td>45 (71%)</td>
<td>ref</td>
</tr>
<tr>
<td>Once</td>
<td>11 (5%)</td>
<td>6 (10%)</td>
<td>0.1783</td>
</tr>
<tr>
<td>Multiple</td>
<td>12 (5%)</td>
<td>12 (19%)</td>
<td>0.0004</td>
</tr>
<tr>
<td><strong>Documented Seizure</strong></td>
<td>3 (1%)</td>
<td>11 (17%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td><strong>Loss of Consciousness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>237 (99%)</td>
<td>58 (92%)</td>
<td>ref</td>
</tr>
<tr>
<td>Transient</td>
<td>1 (&lt;1%)</td>
<td>2 (3%)</td>
<td>0.0885</td>
</tr>
<tr>
<td>Prolonged</td>
<td>1 (&lt;1%)</td>
<td>3 (3%)</td>
<td>0.0313</td>
</tr>
<tr>
<td>Scalp Bruising</td>
<td>61 (26%)</td>
<td>32 (50%)</td>
<td>0.0002</td>
</tr>
<tr>
<td>Suspected Skull Fracture</td>
<td>53 (22%)</td>
<td>28 (44%)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Other AMS</td>
<td>63 (26%)</td>
<td>35 (66%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>One AMS</td>
<td>52 (22%)</td>
<td>25 (40%)</td>
<td>0.0037</td>
</tr>
<tr>
<td>Two AMS</td>
<td>11 (5%)</td>
<td>10 (16%)</td>
<td>0.0012</td>
</tr>
</tbody>
</table>

AMS: Altered mental status; ICH: Intracranial Hemorrhage. Association between multi-level variables and ICH tested with logistic regression. Bi-level variables and ICH association tested with Chi-Squared or Fisher’s Exact Test as appropriate.

Table 4: Diagnostic Power of Model that Optimizes Sensitivity of Identifying Patients with ICH

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>ICH</th>
<th>No ICH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>58</td>
<td>115</td>
</tr>
<tr>
<td>Absent</td>
<td>5</td>
<td>124</td>
</tr>
</tbody>
</table>

**Diagnostic Power (95% CI)**
- Sensitivity: 92% (82% - 97%)
- Specificity: 52% (45% - 58%)
- Positive Predictive Value: 34% (30% - 37%)
- Negative Predictive Value: 98% (91% - 98%)

ICH: intracranial hemorrhage; CI: confidence interval. Diagnostic power in identifying patients who present with any positive findings of predictor variables that were found to be associated with ICH. Of the 129 patients who presented without any presence of predictor variables, 5 (4%) had ICH upon CT Head imaging.
Head CT Evaluation of Cranial Sutures in Pediatric Head Trauma: Identification of a New Sutural Finding Associated with Abusive Skull Fracture

S KRISI1, J Morris2, V Martich1
1Norton Children’s Hospital, Louisville, KY, 2University of Louisville School of Medicine, Louisville, KY

Purpose
Skull fractures are frequently seen with both abusive and accidental pediatric head trauma. Fracture line crossing the cranial sutures is a known association with abusive injury but can be difficult to identify only on skull radiographs. Radiation dose has traditionally limited head CT usage in children but modern low dose helical scan with iterative reconstruction (including 3D) has helped mitigate that concern. We studied the efficacy of head CT vs. skull radiographs in confirming fracture association with the cranial sutures as well as the significance of skull fracture extension to the sutures in abusive vs. accidental pediatric head trauma.

Materials and Methods
Retrospective radiographic review of abusive and accidental skull fractures was performed in children who received both skull radiographs and head CT scan for head trauma at a Children’s Hospital (2012-19). Statistical 2 proportion Z-test was used to determine efficacy of head CT vs. skull radiographs in assessing cranial suture involvement with skull fractures. Odds Ratio was used to test for significance of fracture extension to sutures in accidental vs. abusive head injury (significance set at p < 0.05).

Results
47 children with 56 abusive skull fractures and 47 children with 54 accidental skull fractures were evaluated, ages 1-48 months. 51 of 56 abusive skull fractures (91%) had terminal ends that contacted cranial sutures; 37 of the 51 (72%) touched ≥ 2 sutures, 11 of which touched ≥ 3 sutures. 43 of 54 (79%) accidental skull fractures contacted a suture, but only 2 of the 43 (5%) touched 2 sutures; none touched > 2 sutures (OR= 54.2, 95% CI= 11.54-254.4 p<0.0001). Of the abusive fractures that contacted a suture, 12 (23%) crossed the suture; none of the accidental fractures crossed sutures. Of the 12 abusive cases with fracture line that crossed a suture, 7 were confirmed only on CT (p < 0.01). In 21 of 47 abusive cases vs. 5 of 47 accidental cases, CT identified fractures that extended to cranial sutures (most commonly involving the sagittal suture) that were not definitive on skull radiography (p = .00022).

Conclusions
Skull fractures contacting the cranial sutures is a common component in both abusive and accidental pediatric head trauma. However, skull fracture contacting ≥ 2 cranial sutures is a significant imaging finding associated with abusive head injury not previously described. Head CT significantly aided in the identification of skull fractures crossing and touching cranial sutures in abusive cases.
Rare Cases of Pediatric Traumatic Abducens Nerve Palsy Complicating Retroclival Hematoma

F Berk¹, N Pham¹, J Chang¹, R Assadsangabi¹, V Ivanovic¹, A Ozturk¹, M Bobinski¹, O Raslan¹
¹University of California, Davis, Department of Radiology, Division of Neuroradiology, Sacramento, CA

Purpose
Neoplasm, inflammation, infection and trauma may affect the abducens nerve at any point along its path and result in ipsilateral esotropia. Retroclival epidural and subdural hematomas (RCH) are rare entities which may result in CNVI palsy. Our purpose is to present rare cases with RCH and traumatic CNVI palsy in the pediatric population.

Materials and Methods
Case 1: 8 years old female involved in motor vehicle accident (MVA), resulted in cerebral contusions, subdural and subarachnoid hemorrhages, RCH, atlantooccipital dissociation, and lower extremity fractures. The patient developed left lateral strabismus and change in voice tone and was referred to MRI to evaluate cranial neuropathy. The patient is still admitted with improving cranial neuropathy with rehabilitation therapy. Case 2: 10 years old female with a history of MVA, presented with diplopia after admission to the hospital. Initial CT head demonstrated RCH and MRI brain was ordered to evaluate the cranial neuropathy. Patient's symptoms were managed conservatively. The patient lost the recommended follow-up with Ophthalmology.

Results
Case 1: Figure 1 (A) Sagittal 3D SPGR. The RCH is confined by the attachment of the tectorial membrane to the mid axis, consistent with an epidural RCH. (B) Axial 3D SPGR. Asymmetric extension of the RCH into the left Dorello's canal, explaining patient's left esotropia. Case 2: Fig2 (A) Sagittal T1. In addition to the large epidural RCH, there is extension below the mid axis consistent with a combined epidural and subdural hematoma. (B) Axial T1. RCH encroaching and mildly displacing right CNVI. There is also encroachment on the left CNVI without displacement of the nerve.

Conclusions
RCH is rare in pediatric population. The most common etiology for RCH is a traumatic event that induces hypermobility of the neck. Subdural RCH has been reported less than epidural RCH. However, both may occur as demonstrated in one of our patients. Clinical presentation of RCH can be variable and usually misleading. CN VI palsy can occur secondary to direct trauma or by indirect pressure by blood products on the nerve as it as it passes over the petrous apex to the cavernous sinus. Increased or decreased intracranial pressure can also stretch CN VI which are tethered in Dorello's canal. Radiologist should be familiar with this rare but life altering traumatic complication in the pediatric population to avoid the morbidity resulting from the unnecessary delay in patient diagnosis and management.

(Filename: TCT_2193_RCHFigure600.jpg)
Brachial Plexus Birth injury: Fractional Anisotropy Correlation with Recovery in Patients with Pseudomeningoceles

Y Li¹, E Yuh², N Gupta³, J Strober³, C Chin⁴
¹UCSF, Corte Madera, CA, ²University of California at San Francisco, San Francisco, CA, ³University of California San Francisco, San Francisco, CA, ⁴N/A, N/A

Purpose

Birth-related injury of the brachial plexus (BPI) affects approximately 1-4/1000 live births, and 10-15% of patients will have persistent neurologic impairment from injury. In BPI, pseudomeningoceles are usually seen in the context of preganglionic nerve root avulsions, however, may also be seen without a complete root avulsion. Clinically, the degree of functional impairment does not always correlate with the presence of a pseudomeningocele. We hypothesize that fractional anisotropy (FA), as a marker of neuronal microstructural integrity, may serve as a better predictor of functional outcome in patients with BPI.

Materials and Methods

Between 8/23/2012 and 8/14/2017, 8 patients between the ages of 4-8 months born with BPI were imaged using brachial plexus MR Neurography, including DTI. FA values corresponding to the nerve roots at each brachial plexus level was measured bilaterally. Imaging was reviewed for structural evidence of injury, including pseudomeningocele. Clinical extent of injury was measured by neurologic examination and electromyography. Nerve roots were categorized as avulsed if associated with a pseudomeningocele, injured if at levels of clinical or imaging evidence of injury. Patients were followed between 6 months – 2 years and stratified into categories of poor, modest, and good recovery. The average FA for each nerve root category was calculated for all patients. Calculations were also stratified by patient recovery category.

Results

7 out of 8 patients had pseudomeningoceles, and 5 out of the 7 had pseudomeningoceles at two levels. In all patients, the mean FA of normal, injured, and avulsed nerve roots were 0.264, 0.242, and 0.196 respectively. In patients with good functional recovery at follow-up, the mean FA of normal, injured, and avulsed nerve roots were 0.221, 0.191, and 0.085. In patients with poor functional recovery at follow-up, the mean FA of normal, injured and avulsed nerve roots were 0.322, 0.306 and 0.235. In patients with modest functional recovery at follow-up, the mean FA of normal, injured, and avulsed nerve roots were 0.280, 0.212, and 0.217. Each group had 1 patient undergo surgical repair.

Conclusions

Nerve roots that are most severely injured, at the levels with pseudomeningoceles, have lower FA values relative to less severely injured and normal nerve roots. Patients with good functional recovery demonstrate lower FA values relative to patients with poor and modest functional recovery.
Cerebral “flip-flop” sign: Transition of diffusion restriction from grey matter to the white matter in acute hypoxic & delayed post-hypoxic injury due to hanging.

N Gupta\(^1\), N Abdeen\(^2\)

\(^1\)Children Hospital of Eastern Ontario, University of Ottawa, Ottawa, Ontario, \(^2\)CHEO, Ottawa, Ontario

Purpose
To illustrate the "flip flop" sign of delayed post hypoxic leukoencephalopathy (DPHL), which to our knowledge has not been well described in pediatric patients.

Materials and Methods
A 15 year old male, who had hanged himself, was found in cardiac arrest with return of spontaneous circulation after 40 mins of cardiopulmonary resuscitation. Patient was intubated with no corneal or gag reflex and no spontaneous movements. Initial head CT and CT angiogram was normal. Generalized seizures occurred on day of admission and again on day 3 with persisting myoclonic jerks and tremors. Patient remained unconscious despite weaning off sedation. A week later all supportive treatment was withdrawn following parental consultation.

Results
First MRI done on day 2 reveals bilateral symmetric T2 hyper intensity and corresponding restricted diffusion in the basal ganglia (including both putamina, caudate nuclei) and cerebral hemispheres (perilobaric gyri, parasagittal frontoparietal cortex and occipital cortex), consistent with severe hypoxic ischemic encephalopathy. MR performed on day 8 revealed resolution of restricted diffusion in the cortex and basal ganglia but new mild T2 hyper intensity and severe diffusion restriction bilaterally in the centrum semiovale, external capsules, internal capsules, corpus callosum, as well as the occipital, parietal and posterior frontal white matter. The anterior frontal lobes and temporal lobes were spared. Findings were suggestive of DPHL.
Conclusions
Hypoxic ischemic injury due to hanging or strangulation can have a biphasic presentation and initial MR may underestimate the extent of injury. The "flip-flop" sign of DPHL may be due to initial ischemic injury to metabolically active cortex and basal ganglia followed by early Wallerian degeneration of the white matter.

Day 2: Restricted diffusion in bilateral parieto-occipital cortex, basal ganglia and perirolandic gyri.
Day 8: Restricted diffusion in bilateral centrum semiovale, periventricular white matter and corpus callosum.

Scientific Abstract Session: AI 4
2547
5:05PM - 5:11PM

Are Radiomics Features from Deep Learning-based Segmentation Reproducible? Effects to Physiologic Low- and High-Dimensional Imaging Parameters and Diagnosis of Treatment Response versus Tumor Progression in Glioblastoma

H Kim¹, J Park², H Kim¹
¹Asan Medical Center, Seoul, Seoul, ²Asan medical center, Seoul, Seoul

Purpose
Deep learning-based automatic segmentation (DLAS) pursues reproducibility in radiomics features, but the effect to radiomics modeling is unknown. This study aimed to whether DLAS ensures robustness in MRI feature extraction and can provide an accurate assessment of treatment response in glioblastoma patients.

Materials and Methods
DLAS was trained on 238 glioblastomas and independently validated on 98 pre- and 86 post-treatment glioblastomas from two tertiary hospitals. A total of 1618 radiomics features from contrast-enhanced T1-weighted images, and histogram features from apparent diffusion coefficient (ADC) and cerebral blood volume (CBV), were extracted. DLAS accuracy was measured with dice similarity coefficient (DICE). The diagnostic performance of ADC and CBV parameters and radiomics for identifying treatment response was
tested using area under the curve (AUC) from receiver-operating-characteristics analysis. Feature reproducibility was tested using intraclass/concordance correlation coefficients (ICCs/CCC). Results DLAS was optimized with a DICE of 0.83 ± 0.06. DLAS-based radiomics features showed similar performance to the human segmentation-based in internal validation (AUC 0.81 [95%CI:0.64–0.99] vs. AUC 0.81 [0.60–1.00], P=.80), but slightly decreased in external validation (AUC 0.78 [0.61–0.95] vs. AUC 0.65 [0.46–0.84], P=.23). Reproducibility was excellent for ADC and CBV features (ICC 0.82–0.99) and first-order features (pre- and post-treatment, 100% and 94.1% remained after 0.8 CCC cut-off), but lower for texture (79.0% and 69.1% remained) and wavelet-transformed (81.8% and 74.9% remained) features. Conclusions Features extracted using the DLAS showed comparable diagnostic performance to those from human manual segmentations, but careful consideration is needed in texture and wavelet features.
Figure. Heatmap of radiomics features demonstrating reproducibility using concordance correlation coefficient (CCC) for the 1618 radiomics features between DLAS and reference human segmentation is shown. Note the feature reproducibility is decreased in texture and wavelet features and in patients of post-treatment glioblastomas in both internal and external data. Note- GLCM = grey-level co-occurrence matrix; GLRLM = grey-level run-length matrix; L = low-pass filter; H = high-pass filter. Wavelet features are arranged in the order of first-order feature and texture feature. D = distance

(Filename: TCT_2547_Figure ASN.jpg)
MRI Radiomic Features to Predict IDH1 Mutation Status in Gliomas: A Machine Learning Approach

Y Sakai¹, C Yang¹, S KIHIRA², N Tsankova¹, J Houldsworth¹, F Khan¹, A Hormigo¹, C Hadjipanayis¹, K Nael³
¹Icahn School of Medicine at Mount Sinai, New York, NY, ²MOUNT SINAI HOSPITAL, NEW YORK, NY, ³Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose

In patients with gliomas, those with IDH1 mutations, specifically IDH1 R132H, are associated with better prognosis compared to those with IDH1 wildtype. Recent advances in machine learning have demonstrated promise in utilizing radiomic features to study disease processes in the brain. We investigate whether machine learning analysis of multiparametric radiomic features from preoperative conventional FLAIR and DWI images of gliomas can reliably discriminate IDH1 mutation status.

Materials and Methods

Inclusion criteria for this retrospective study were patients with diagnosis of gliomas and known IDH1 status with preoperative FLAIR and DWI (b1000). Tumor segmentation was performed with volume-of-interest analysis. Radiomic features were extracted using Olea Sphere (Olea Medical). 92 radiomic features including first-order, co-occurrence matrix, and run length matrix were obtained. Two datasets, one with FLAIR and other with DWI radiomic features were analyzed. Stratified sampling was performed to split each dataset into training (60%), validation (20%), and testing (20%) sets. Synthetic Minority Oversampling Technique (SMOTE) was applied to create SMOTE-applied train sets. For each dataset, an eXtreme Gradient Boosting (XGBoost) classifier was trained, validated, and tested (Python 3.7; Packages: scipy 1.3.0; numpy 1.16.4; matplotlib 3.1.1; pandas 0.24.2; sklearn 0.21.2; xgboost 0.90.). Hyperparameters of the XGBoost classifier were optimized using exhaustive grid search with 5-fold cross validation. The receiver operating characteristic curve (ROC), accuracy, and f1-score of the FLAIR-trained and DWI-trained models were collected from the test set.

Results

100 patients (age: 55 ± 15, M/F 60/40, 22 IDH1 mutation, 78 wildtype) were included. The XGBoost model trained with FLAIR-derived radiomic features achieved ROC AUC of 0.95, accuracy of 0.90, f1-score of 0.67 on the test set. The DWI model achieved ROC AUC of 0.91, accuracy of 0.85, f1-score of 0.40. The FLAIR-SMOTE model achieved ROC AUC of 0.95, accuracy of 0.90, f1-score of 0.75. The DWI-SMOTE model achieved ROC AUC of 0.97, accuracy of 0.90, f1-score of 0.75.

Conclusions

Training a XGBoost classifier using multiparametric radiomic features derived from FLAIR and DWI images discriminated IDH1 mutation status with high accuracy, which concept may allow a noninvasive approach to predict prognosis in patients with gliomas. Additional machine learning training with larger MRI datasets are required to validate and improve upon these findings.
Distinguishing High and Low-Grade Meningiomas: Texture Analysis vs. Support Vector Machine

CALTINTAS TASLICAY1, E DERVISOGLU2, B ALPARSLAN3
1KOCAELI UNIVERSITY FACULTY OF MEDICINE, KOCAELI, Turkey, 2KOCAELI UNIVERSITY FACULTY OF MEDICINE, KOCAELI, Turkey, 3KOCAELI UNIVERSITY SCHOOL OF MEDICINE, Kocaeli, TURKEY

Purpose
Low-grade meningiomas have better prognosis than high grades. The aim of this study is to investigate the efficacy of radiomics features for differentiating high grade meningioma from low grade meningioma noninvasively.

Materials and Methods
Preoperative MR images of 47 patients with grade I, 34 patients with grade II and 2 patients with grade III meningiomas were evaluated retrospectively. Grade I meningiomas were classified as low grade meningioma (LGM), whereas Grade II and III meningioma were classified as high grade meningiomas (HGM). 3D Slicer software was used for segmentation and extraction features from postcontrast T1- weighted MR images and ADC maps. Fourteen shape-based features, and 93 textural features including first (histogram), second (Gray-Level Co-occurrence Matrix) and higher order statistical features were extracted. Mann Whitney U test was used to determine the features to classify groups (P < 0.01). And also a support vector machine (SVM) classifier was used for the tumor classification.

Results
Gray Level Cooccurrence Matrix including Cluster Shade which extracted from ADC and Gray Level Size Zone Matrix including Size Zone Non-uniformity which extracted from ADC were found the most useful features for classifying the groups, with the AUC of 0.725 (p<0.001) and 0.726 (p<0.001) respectively. Classification accuracy of SVM classifier was found 67.5% by using all the radiomics features.

Conclusions
Support vector machine classifiers using MRI textural features can be a useful tool for differential diagnosis of high grade meningioma from low grade meningioma. Second and higher order textural features were found more useful in this study.
Post-concussive mTBI Detected by MRI: An AI/Radiomics Driven Analysis

J Tamez-Peña1, P Gonzalez2, S Totterman2, P Rosella3, S Meyers4
1Tecnologico de Monterrey, Monterrey, Nuevo Leon, 2Qmetrics, Pittsford, NY, 3University of Rochester, Rochester, NY, 4University of Rochester Medical Center, Rochester, NY

Purpose
Mild traumatic brain injuries (mTBI) frequently result from sports or other trauma[1]. Unless acute symptoms present, imaging is typically utilized only for patients whose symptoms fail to resolve as expected[2]. MRI of post-concussive subjects are routinely negative, as mTBI is invisible to conventional radiological review[2,3]. Here, we used radiomics and AI to create an index able to identify mTBI by analyzing clinical MRI.

Materials and Methods
122 mTBI subjects (65M,57F) and 27 control subjects (15M,12F) with no prior injury were imaged on a single 3T Siemens Skyra using a standardized neuro MRI protocol including MPRAGE and DTI. FA and ADC were computed from the DTI acquisition. MRI images were transformed by 3-level wavelets decomposition and local fractals maps. Images were segmented using an atlas-based method to isolate white, gray and fluid tissues. All images were inspected; 24 were removed for acquisition artifacts, 6 for segmentation errors. Remaining images were quantified for gray-level co-occurrence matrix, signal shape and signal distributions yielding 420 features per subject. Measurements were adjusted for age, height and gender. Concussion index was created by analyzing subjects recently injured (<45 days, n=21) and control subjects (n=26). Filtered-Quadratic Discriminant Analysis (QDA) in a repeated cross validation framework used 90% of the data for training and 10% for test assessment to find the most relevant features for the QDA model. This train-test process was randomly repeated 300 times. The cross-validated model was used to predict the probability of concussion for each subject.

Results
Table 1 shows characteristics of the MRI set analyzed. Fig 1 shows the ROC plot of test results of the QDA analysis. The QDA driven index had a validation sensitivity of 71%, specificity of 77%, and AUC of 0.79. The magnitude of the AI findings was linearly associated with the number of past concussions. (p<0.001 for trend).

Conclusions
This work shows an objective imaging finding that detects post-concussive white matter alterations from routine MRI. This may also support studies of potential mTBI therapies. The study was limited by tight age distribution of the controls. Analysis of more healthy controls and mTBI subjects with longitudinal follow-up will be performed to refine the signal behavior during recovery. Further, the well-controlled imaging studies were obtained on one scanner; these results should be validated on imaging data from other sources.
Image Segmentation of Plexiform Neurofibromas from a Deep Neural Network Using Multiple b-value Diffusion Data.

J Kindler\textsuperscript{1}, C Ho\textsuperscript{1}, S Kralik\textsuperscript{2}, K Robertson\textsuperscript{1}, P Territo\textsuperscript{1}
\textsuperscript{1}Indiana University School of Medicine, Indianapolis, IN, \textsuperscript{2}Texas Children's Hospital, Houston, TX

Purpose

Plexiform neurofibromas (PN) commonly occur in NF1 patients and can be infiltrative, leading to tedious manual volumetric measurements for clinical trials. The purpose of this research was to develop a novel deep neural network model using diffusion data from PN and assess the accuracy of semi-automated tumor volume maps.

Materials and Methods

Patients were recruited from a phase II clinical trial for the treatment of PN in NF1 patients. Multiple b-value DWI (b=0, 50, 150, 200, 400, 600, TR=2137, TE=68.4, ST=5mm, gap=6.5mm, FA=90°) was performed to cover the largest PN. All DWI datasets were registered to the baseline, and intensity normalized prior to segmentation with a multi-spectral neural network classifier (MSNN). Intravoxel incoherent motion (IVIM) parameters were calculated based on MSNN tumor volumes. Manual volumes of PN were performed in consensus with a board-certified neuroradiologist and a neuroradiology fellow on 3D-T2 images registered to diffusion images. This was compared to MSNN volumes with the Sorensen-Dice coefficient.

Results

35 MRI scans were included from 14 subjects. Perfusion fraction (f) was significantly higher for tumor versus normal tissue (0.47±0.42 vs 0.30±0.22, p=0.02), similarly, true diffusion (D) was significantly higher for PN tumor versus normal tissue (0.0018±0.0003 vs 0.0012±0.0002, p<0.0001). By contrast, the pseudodiffusion coefficient (D*) was significantly lower for PN tumor versus normal tissue (0.024±0.01 vs 0.031±0.005, p<0.0001). Sorensen-Dice coefficient between the semi-automated tumor volume maps and manually drawn maps was 0.77 ± 0.016.
Conclusions
Volumes generated by a deep neural network from multiple diffusion data on PNs demonstrated good correlation with manual volumes. Furthermore, IVIM analysis of multiple b-value diffusion data demonstrates significant differences between PN and normal tissue.

Filling in the Gaps - Using Deep Learning Interpolation to Create 3D MRI Volumes from 2D Axial MRI Slices

J Seah¹, C Chow¹, J Tang², F Sepehrband³, B Sinclair¹, S Kolbe⁵, M LAW⁶
¹Alfred Health, Melbourne, VIC, ²Royal Melbourne Hospital, Melbourne, VIC, ³University of Southern California, Los Angeles, CA, ⁴Monash University, Melbourne, VIC, ⁵Monash University, Melbourne, VIC, ⁶ALFRED HEALTH, GLEN WAVERLEY, VIC

Purpose
Many post-processing algorithms such as brain morphometry, volume rendering or Enhanced PVS Contrast (EPC) can only be performed on 3D datasets. Whilst volumetric 3D imaging is widely available, many clinical MRI protocols still include 2D sequences due to time constraints. This demonstrates a novel technique using deep learning interpolation to synthesize 3D MRI volumes from 2D axial MRI slices and thus enabling us to utilize prior available imaging for clinical and research purposes.

Materials and Methods
Data was extracted from the clinical PACS system from January 2019 - December 2019. 835 3T MPRAGE volumes were used for training and 47 for testing. For each 3T volumetric scan, simulated 2D axial slices with 4mm slice thickness with a 1mm gap as per our institutions parameters. An invertible generative flow model was then trained on these slices, allowing the model to "fill in the gaps" and create 3D volumes from 2D axial slices. The VolBrain pipeline was used to compare the synthesized volumes to the original 3T volumetric acquisition. Total grey matter and white matter volumes were obtained and the median absolute error was calculated using the original volumetric acquisition as the ground truth. For each study, comparison 3D volumes were generated using bilinear interpolation and total grey and white matter volumes were calculated. The Wilcoxon signed rank test was used to calculate statistical significance with 0.05 being the significance level.

Results
White and grey matter volumes obtained from the VolBrain pipeline demonstrates that 3D volumes generated by deep learning interpolation better represented the original 3D volume than volumes generated by bilinear interpolation. When compared to bilinear interpolation, deep learning interpolation produced improved median absolute error for both white matter (27.2ml vs 39.8ml, p<0.05), and gray matter volumes (26.9ml vs 39.4ml, p<0.05).

Conclusions
Deep learning interpolation can synthesize isotropic 3D MRI volumes from 2D axial slices which demonstrate reduced volumetry error. While more research is required, this technique could enable other post-processing pipelines requiring isotropic 3D volumes such as EPC, multiple sclerosis lesion segmentation, or deep learning models to run on historical 2D data for clinical comparison as well as for research.
Impact of Slice Thickness and Reconstruction Algorithms on CAD assessed ASPECTS results in Acute Ischemic Stroke - Can AI Fix the Reproducibility Problems?

F AUSTEIN¹, O Jansen¹, J Juhasz¹, P Langguth¹
¹University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Schleswig-Holstein

Purpose
The purpose of our study was to investigate the effect of reconstruction kernels and slice thickness on AI computer assisted diagnosis (CAD) software and assess whether the AI software update of RAPID-ASPECTS could improve the reproducibility and robustness of ASPECTS score results acquired using different reconstruction kernels and slice thickness. Background: Reconstruction kernels and slice thickness may significantly affect automated ASPECT scoring in stroke CT. The reconstruction filter affects the distribution of pixel values or the noise pattern of a region of interest (ROI) while the mean pixel value remains relatively unchanged. Given that the interpixel relationship is affected by different reconstruction kernels, measures using an AI approach will also change. Although CT protocol can influence the results of AI software, there is no recommendation for a standardized non-contrast CT stroke protocol for evaluation of early ischemic changes either for the daily routine nor for clinical stroke studies.

Materials and Methods
Early ischemic changes in non-contrast CTs were assessed two times by RAPID ASPECTS (first software release and after software update) from different CT reconstruction algorithms (iterative model-based reconstruction [IMR] and iterative reconstruction [iDose]), with different slice thickness (1.0 mm, 3.0 mm and 5.0 mm) in 29 acute stroke patients with proximal middle cerebral artery occlusion. Ground truth was provided by an expert (PL) with unrestricted data access.

Results
The reproducibility of ASPECTS results using different reconstruction kernels and slice thickness showed significant improvement with the software update (Figure 1 a-d). In the pooled analysis using different kernels and slice thickness ICCs improved from 0.72 to 0.89 after applying the software update.

Conclusions
The implementation of automatically derived ASPECTS by fully automated software solutions has been shown to be a clinically useful tool. Our study shows that it may be possible to compare ASPECTS results from CT images with different reconstruction kernels using deep-learning approach. In conclusion, the software update based on a deep-learning algorithm dramatically improves the similarity of ASPECTS results obtained using different reconstruction kernels and slice thickness.
Automated prediction of arterial collateral status in stroke patients with anterior circulation large vessel occlusion: application of deep neural network and hand-crafted radiomics

S Payabvash1, T Zeevi2, B Sheikh3, S Haider1, C Filippi3, G Torres-flores4, K Al-Dasuqi2, C Matouk2, A Abou Karam2, L Sansing2, J Schindler2, K Sheth2, A Malhotra5, N Petersen2

1Yale University School of Medicine, NEW HAVEN, CT, 2Yale University School of Medicine, New Haven, CT, 3N/A, New York, NY, 4Yale School of Medicine, New Haven, CT, 5Yale University School of Medicine, New Canaan, CT

Purpose

In stroke patients with large vessel occlusion (LVO), CT angiographic collateral profile is a predictor of infarct core volume and clinical outcome in these patients (1); thus supporting the concept that "time is brain, but collaterals are time" (2). In this study, we devised and compared automated pipelines for prediction of vessel collateral status on CTA using imaging patterns extracted by deep neural network and preset hand-crafted radiomics features.

Materials and Methods

Stroke patients with anterior circulation LVO were included. Two neuroradiologists independently graded CTA collateral status as good, moderate, or poor according to Miteff et al. (3), and resolved discrepancies by consensus. Using FSL software, MCA territory masks were reverse-coregistered onto native head CTA source images from MNI-152 standard space, and 1133 preset radiomics features were extracted from each MCA territory. The VGG-16 deep neural network was applied to extract 4096 feature vectors from CTA slices at the level of MCA territory – from the circle of Willis to centrum semiovale (7 cm craniocaudal direction). XGBoost

Box plots demonstrate the distribution of ASPECTS assessed with the first software release and after an update in NCCT with different reconstruction algorithms and slice thickness from 1.0 mm to 5.0 mm and provides the intra-class-correlation coefficient (Interquartile range).

A) first software release and iterative reconstruction
B) after software update
C) first software release and iterative model-based reconstruction
D) after software update

(Filename: TCT_2063_Figure1A_D.jpg)
machine learning models were used for prediction of final score based on radiomics and deep neural network features. The averaged results of 30 seed repeats of 10-fold cross validation are reported.

Results
Of 221 patients included in our study, 94 (43%) had good, 81 (37%) had moderate, and 46 (21%) had poor CTA collateral status. The concordance rate between neuroradiologists and the final consensus collateral status were 74% and 75% for precise grading (e.g. categorizing poor as poor); and 97% and 97% allowing for 1-degree difference (e.g. categorizing mild instead of moderate). The concordance rate between deep neural network prediction and consensus collateral status were 63% for precise grading and 95% allowing for 1-degree difference (Table 1). The concordance rates for machine-learning models using radiomics features were 52%, and 87%, respectively.

Conclusions
Using a fully automated pipeline for MCA territory segmentation on CTA source images, and deep neural network feature extraction, we could predict the collateral status with an accuracy comparable to the concordance in collateral grading between two neuroradiologists - allowing for 1-degree difference. Such models can potentially replace subjective assessment of CTA collateral status or reduce the inter-rater discrepancies between interpreting neuroradiologists.

Visual Explanation of AI Sinus Disease Predictions on 3D Medical Scans

D Dunaway1, J Havelka2, K Hawk3
1Baylor College of Medicine, Houston, TX, 2InformAI, Houston, TX, 3Stanford University School of Medicine, CA, CA

Purpose
Artificial Intelligence (AI) will play a greater role in assisting radiologists in interpreting medical images for the presence of disease states. While AI models have shown an ability to make accurate medical imaging predictions, the capability to explain how the prediction was made has been lacking. The objective of this research was to demonstrate the ability to integrate recent advances in AI prediction visualization tools into a 3D AI sinus model (CNN-convolutional neural network) to enhance AI explainable predictions. Combining a 3D neural network with a novel 3D visualization tool provides expanded 3D explainable prediction functionality for medical practitioners.

Materials and Methods
The research team utilized a 3D AI sinus model to predict the presence of sinusitis in the maxillary and frontal sinus cavities. A 3D adaptation of the Gradient-weighted Class Activation Mapping (Grad-CAM) visualization tool (developed for 2D general images) was developed to provide a heat map overlay on 3D medical image locations where the AI model was being activated to make the sinus feature prediction. A sample of the image feature visualization which triggered left maxillary sinus opacification prediction is shown in Figure 1. Fifty (50) retrospective patient studies were tested with the AI sinus model and 3D Grad-CAM tool for accuracy. Each patient study was comprised of a 3D CT scan of the paranasal region (400x400x269 voxels, no contrast). Each patient study was labeled for the presence of opacification and/or mucosal thickening in the maxillary and frontal sinuses to determine prediction performance.

Results
Across the 50 patient studies, the AI sinus model and 3D Grad-CAM visualization tool (heat map) consistently and accurately identified the region within the 3D CT medical scan which contain the sinus feature(s) that activated the AI sinus model for a prediction of opacification or mucosal thickening in the maxillary and frontal sinus cavities.

Conclusions
The 3D Grad-CAM tool in conjunction with the 3D AI sinus model shows promise as a diagnostic-assist tool and productivity aid for
radiologists. The ability to highlight the 3D imaging scan locations which triggered the AI sinus model prediction will provide greater transparency and trust in using AI algorithms. Further AI sinus model and 3D Grad-CAM optimization is planned to increase heat map location accuracy especially for multi-location sinus features within a single sinus cavity.

Figure 1: Image feature visualization which triggered opacification prediction in left maxillary sinus (Filename: TCT_2364_Fig1.jpg)

Uveal versus Cutaneous Melanoma Brain Metastasis harbor distinct Radiomic Features

M Ayoub¹, T Habboub², A Kotrotsou³, S Ahmed⁴, L Haydu³, M Davies⁵, S Patel⁶, R Colen⁷
¹University of Pittsburgh, Pittsburgh, PA, ²College of Saint Elizabeth, Morrisontown, NJ, ³MD Anderson Cancer Center, Houston, TX, ⁴The University of Texas MD Anderson Cancer Center, Houston, TX, ⁵University of Texas MD Anderson Cancer Center, Houston, TX, ⁶University Of Texas MD Anderson Cancer Center, Houston, TX, ⁷Healthcare of Pittsburgh Medical Center, Pittsburgh, PA

Purpose
Unlike cutaneous melanoma, where metastasis to the CNS are common, CNS metastasis from uveal melanoma (the most common primary intraocular tumors in adults) is a rare occurrence (4-15%). This can be explained in part as uveal and cutaneous melanomas harbor distinct genomic abnormalities; cutaneous melanoma demonstrates mutations in BRAF (40-60%) and NRAS (~18%), while >80% of uveal melanoma demonstrate mutations in GNAQ or GNA11. Interestingly, 50% of patients with metastatic uveal melanoma have inactivating BAP1 mutations which promote metastasis. Herein, we seek to determine the radiomic landscape of uveal versus cutaneous melanoma brain metastasis.

Materials and Methods
80 patients with pathologically-proven brain metastasis (65 cutaneous melanoma;15 uveal melanoma) were included in the study. Treatment- naïve non-contrast T1-weighted images, post-contrast T1-weighted images and T2-FLAIR sequences were co-registered using the 3D slicer segmentation tool. The hemorrhagic component was excluded during segmentation of the whole tumor and edema yielding a total of 6100 radiomic features per patient. Features were then selected using LASSO (Least Absolute Shrinkage and Selection Operator) and the Mann-Whitney U test for further narrowing of the selected signatures. Receiver operating characteristic
(ROC) curves and leave one out cross-validation (LOOCV) were used to assess the performance of the prediction model built to distinguish cutaneous melanoma brain metastases from uveal melanoma brain metastases.

Results
Our results demonstrate that the radiomic signature between uveal versus cutaneous melanoma brain metastasis is distinct and robustly predicts whether the melanoma brain metastasis arose from a primary cutaneous versus uveal melanoma (sensitivity, specificity and accuracy of 100%, 93.33% and 99.85%, respectively).

Conclusions
Melanoma brain metastasis arising from uveal melanoma harbor distinct radiomic features compared to those arising from primary cutaneous melanoma. Furthermore, these radiomic features can robustly predict the primary melanoma location.

Scientific Abstract Session: Brain Stroke 4
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Incomplete and Failed Endovascular Recanalization in Patients with an ASPECTS of 0-5 – How Harmful is Trying?

G BROOCKS1, L Meyer2, G Thomalla2, J Fiehler3, U Hanning3, T Faizy4, M BECHSTEIN5, A Kemmling6
1UNIVERSITY MEDICAL CENTER HAMBURG-EPPENDORF, HAMBURG, 20359, Germany. 2University Medical Center Hamburg, Hamburg, AK. 3University Medical Center Hamburg-Eppendorf, Hamburg, AK. 4Stanford University, STANFORD, CA. 5UNIVERSITY MEDICAL CENTER HAMBURG - EPPENDORF UKE, HAMBURG, 20246, HAMBURG. 6University Hospital Kaiserslautern, Kaiserslautern, AK

Purpose
Potential clinical benefit or harm of endovascular treatment in patients with low initial Alberta Stroke Program Early Computed Tomography Score (ASPECTS) is a subject of current debate. The purpose of this study was to investigate the impact of incomplete or failed endovascular thrombectomy (EVT) on clinical outcome of ischemic stroke patients after presenting with an ASPECTS of 0-5 on admission. We hypothesized that incomplete and failed treatment is not associated with worse clinical outcome compared to low ASPECTS patients who did not underwent an endovascular procedure.

Materials and Methods
183 acute ischemic anterior circulation stroke patients with an ASPECTS of 0-5 were included, of which 169 patients had an available modified Rankin Scales (mRS) scores after 90 days. 71 patients did not receive EVT, 30 patients underwent EVT with a thrombolysis in cerebral infarction (TICI) score 0-2a, 31 patients underwent successful EVT (TICI 2b), and 37 patients had a TICI of 2c/3 as result of EVT. Clinical outcome was assessed using modified Rankin Scales (mRS) scores after 90 days. Poor clinical outcome was defined as mRS >4 and occurrence of death due to direct implications of stroke was retrieved from medical documentation.

Results
The mean mRS and mortality was 5.1 and 40% for patients without EVT, 5.0 and 32% for patients with TICI 0-2a, and 3.6 and 16% for patients with successful treatment. In multivariable logistic regression analysis, TICI 0-2a EVT was not associated with a worse outcome compared to no EVT. When comparing patients without EVT to patients with TICI 0-2b, patients with an incomplete EVT showed a significant lower mRS (median mRS 5, IQR: 4-6, p=0.006), and reduced likelihood for poor outcome, OR 0.39 (95%CI: 0.19-0.83), p=0.01).

Conclusions
Incomplete EVT in low ASPECTS treatment was not associated with worse clinical outcome compared to patients without EVT. When comparing patients with TICI 0-2b to patients without EVT, incomplete treatment was associated with reduced likelihood for very poor outcome.
A Retrospective Study of Carotid Web and its Association with Stroke

D Chen\(^1\), J Mei\(^1\), M Gold\(^2\), J Burns\(^1\), S Slasky\(^1\)

\(^1\)Montefiore Medical Center, Bronx, NY, \(^2\)Lincoln Medical Center, Bronx, NY

Purpose
A carotid web is a shelf-like filling defect protruding from the posterior wall of the carotid bulb. Recent studies have demonstrated significant associations between carotid webs and stroke; however, evaluation is limited due to its rarity. To date, the largest population based study in the US analyzed 622 neck CTAs and found an prevalence of 2.3% (Sajedi). This study aims to determine the prevalence of carotid webs in the largest US cohort to date, and to document the association between carotid webs and ischemic stroke.

Materials and Methods
A cohort was assembled consisting of patients aged greater or equal to 18 years who underwent neck computed tomography angiography (CTA) at our institution between January 1, 2011 to January 1, 2016. Exclusion criteria included occlusion of the internal or common carotid arteries and technical inadequacy. Direct imaging review was performed to evaluate for presence of carotid web. For patients with multiple studies, image analysis was performed on the earliest study. Chart review was performed in all patients with carotid webs.

Results
948 CTA neck studies underwent imaging review, which yielded 15 (1.6%) patients with carotid web (73.3% female, mean age at imaging 63 years). Seven (45.7%) patients self-identified as African-American, 5 (33.3%) as Hispanic, and 3 (20.0%) as Other. Fourteen patients had a unilateral web (8 left, 6 right). One patient had bilateral webs. Carotid web was only reported on one patient's imaging report. One report questioned a dissection, which per our analysis was truly a web. Seven (46.7%) patients with carotid web had history of stroke (6 female, 1 male), 5 (33.3%) of which were ipsilateral anterior. Five patients presented acutely at time of CTA neck imaging, 1 presented 3 months prior, and 1 patient presented with chronic infarcts. Among the acute stroke presentations, 3 (60.0%) involved the ipsilateral anterior circulation and 2 (40.0%) involved the contralateral anterior circulation. The average age was 59.2 years. One patient presented with ipsilateral anterior stroke 3-4 months prior to CTA neck imaging. Another patient was found to have chronic ipsilateral anterior infarct at time of CTA neck imaging.

Conclusions
We determined a 1.6% prevalence of carotid web in the largest US population analyzed to date. Our findings show a strong association with ipsilateral anterior stroke (33.3%), with female predilection. The majority of these carotid webs were unreported, highlighting the need for increased awareness of this entity.
Diagnostic Performance of One-Stop Cardiac-Stroke CT in Acute Stroke for Early Detection of Major Cardioembolic Stroke Sources

F AUSTEIN1, N Larsen2, O Jansen3, P Langguth4
1UNIVERSITY HOSPITAL KIEL, KIEL, SCHLESWIG-HOLSTEIN, 2University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Schleswig-Holstein, 3University Hospital Schleswig-Holstein, Campus Kiel, Ki, Kiel, Schleswig-Holstein, 4University Hospital Schleswig-Holstein, Campus Kiel, Kiel, Germany, Kiel, Schleswig-Holstein

Purpose
Currently, transesophageal (TEE) and transthoracic echocardiography (TTE) are considered as standard work-up for identifying sources of cardioembolic stroke (CES). This approach is time-consuming if performing TEE, semi-invasive, and not always feasible in patients with acute ischemic stroke (AIS), potentially delaying measures to prevent secondary stroke. We assessed the diagnostic performance of a one-stop cardiac-stroke CT (CS-CT) protocol to detect or exclude major CES compared to clinical reality work-up with TTE or TEE.

Materials and Methods
Patients with AIS verified by conventional stroke CT and subsequently examined by CS-CT were included in this study. The
diagnostic performance of CS-CT and echocardiography was compared with the final expert consensus as reference by using receiver-operating characteristic (ROC) curve analysis.

Results
Sixty AIS patients who received CS-CT and echocardiography were included in the final analysis. Median time interval between stroke and echocardiography was 3 (IQR 2-5) days. At ROC curve analysis, the diagnostic performance to detect or exclude major CES showed a significantly higher sensitivity of 1.00 and 95% confidence interval (95% CI) of 0.67 - 1.00 and specificity of 1.00 (95% CI 0.91 - 1.00) for CS-CT than for standard clinical work-up echocardiography [0.40 (95% CI 0.17 - 0.69) and 1.00 (95% CI 0.91 - 1.00)], respectively. Figure 1: In this patient a thrombus decreased over time, even without administering lysis therapy due to early cerebral infarct bleeding. In the initial examination, an oval contrast agent recess with a diameter of 24 mm in the sense of a thrombus can be seen (a, white arrow). At cardiac CT examination (b, c) 17 hours after initial imaging, in the arterial (b) and venous phase (c) a smaller thrombus (10 mm, white dotted arrows) could be detected. Note the LAA circulatory disorder with triangular contrast agent sparing in the arterial phase (b). The TEE on day 7 shows spontaneous echo contrast (SEC) or "smoke-like" echo (white stars) without solid thrombus detection (d).

Conclusions
With excellent accuracy in identifying major CES sources, CS-CT has the potential to improve early diagnosis and therefore could accelerate decision-making to prevent secondary stroke. Moreover, CS-CT might reduce preliminary assessment as cryptogenic stroke by ensuring early, definite diagnosis.

(Filename: TCT_2114_Abstract_CS-CT.jpg)
Conclusions
Texture analysis of MRI-R2* maps can accurately estimate the red blood cell count and iron content of AIS clot analogs, which may contribute to improved treatment algorithms for acute stroke patients.

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5:33PM - 5:39PM

Prediction of early hematoma expansion in cerebral hemorrhage based on non-contrast CT

L Song

1Xiangyang Central Hospital, Affiliated Hospital of Hubei University of Arts and Science, Xiangyang, Hubei

Purpose

Patients with intracerebral hemorrhage (ICH) were divided into hematoma expansion group and non-hematoma expansion group. The clinical features of the two groups of patients and the imaging features of non-contrast CT were analyzed to explore the relationship between the two groups and the early hematoma expansion.

Materials and Methods

Consecutive adult patients (>18 years) with spontaneous ICH who had undergone baseline CT within 6 hours after ICH symptom onset in Xiangyang Central Hospital between June 2017 and June 2019 were screened for inclusion into this study. A follow-up CT scan was performed within 24 hours after the initial CT scan. The time to baseline and follow-up CT scan and baseline clinical and radiological variables were recorded for each participant. Baseline clinical data, including age, sex, diabetes mellitus, coronary heart disease, past stroke history, onset to CT scan time, and CT features (hematoma volume, hematoma morphology, hematoma site, delayed intraventricular hemorrhage and island sign), were prospectively collected and recorded in our ICH research database. We also prospectively recorded admission blood pressure, admission Glasgow Coma Scale (GCS) score. We defined hematoma growth as a 33% increase in hematoma volume or >6 mL at the time of the follow-up CT scan, and the hematoma expansion group and non-hematoma expansion group were respectively evaluated. Detailed records of clinical and radiographic baseline characteristics and comparing the differences of data in two groups, univariate logistic regression was used to analyze the relationship between baseline variables and early hematoma expansion. Multivariate logistic regression was used to analyze the independent predictive effect of early hematoma expansion, and to calculate the sensitivity and specificity of predicting hematoma expansion.

Results

A total of 370 patients with cerebral hemorrhage were enrolled, including 140 patients with hematoma expansion group (37.8%) and 230 patients with non-hematoma expansion group (62.2%). There was no significant difference between the two groups in sex, age, blood pressure at admission, diabetes mellitus and coronary heart disease (P > 0.05). Compared with the non-hematoma expansion group, the initial GCS score was relatively low in the hematoma expansion group (P = 0.033), and the time from onset to the first CT scan was shorter (P = 0.043). In terms of CT features, there was no significant difference between the two groups in the hematoma site and the delayed intraventricular hemorrhage (P>0.05). The initial hematoma volume, irregular hematoma shape, island sign and delayed intraventricular hemorrhage in both groups (P<0.05). Multivariate logistic regression analysis showed irregular hematoma shape (OR=2.289, 95% CI=1.131-4.631, P=0.021), island sign (OR=2.327, 95% CI=1.139-4.751, P=0.020) and delayed intraventricular hemorrhage (OR=4.979, 95% CI=1.423-17.429, P=0.012) are the independent predictor of early hematoma expansion. The predicted sensitivity and specificity were 71.45% and 54.78%, 51.4% and 81.7%, 23.07% and 71.3%, respectively.

Conclusions

Irregular hematoma shape, island sign and delayed intraventricular hemorrhage expansion based on non-contrast CT are the independent predictors of early hematoma expansion. Irregular hematoma shape has the higher sensitivity and island sign has the highest specificity.

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5:40PM - 5:46PM

Prediction of Language Outcome after Chronic Infarct Associated Aphasia Using Multiple Compartment Lesion Analysis

S OSBORN1, J Higgins2, V Hill1, T Parish3, S Kiran4, B Rapp4, D Caplan5

1Northwestern University Feinberg School of Medicine, Chicago, IL, 2Northwestern Medicine, Chicago, IL, 3Boston University, Boston, MA, 4Johns Hopkins University, Baltimore, MD, 5Harvard Medical School, Boston, MA

Purpose

Infarct extent and location predict symptoms and prognosis.1 Prior studies on voxel-based lesion-symptom mapping (VLSM) in stroke have analyzed overt necrosis on T1W images; evidence suggests white matter (WM) disease on FLAIR may also help predict outcomes.2-3 Our aim was to determine which lesions contribute to disease severity and treatment outcome.

Materials and Methods

37 participants (mean age 60 y, 12 female) with chronic stroke-induced aphasia were enrolled from 3 sites. 29 received language therapy over 3 months. The western-aphasia battery aphasia quotient (WABAO) was used as a metric of global aphasia severity. Treatment effects were assessed using treatment-specific tests per site. 2 neuroradiologists used Freesurfer to manually segment co-registered T1 MPRAGE and FLAIR images into core infarct, gliosis, periventricular hyperintensities, right and left sided lacunes and
WM hyperintensities (Figure 1), building on prior work in which only the infarct was segmented.4 Spearman rank correlations were determined between WABAQ and volumetric estimates of each lesion class as well as the number of lacunae and WM lesions. VLSM was used to analyze the relationship between each lesion class and WABAQ. For VLSM, lesion masks were normalized into a standard (MNI) space. At each voxel a t-test compared WABAQ between individuals with and without lesions in that location, and maps were FDR corrected to p=0.01 using permutation testing (1000 permutations).5

Results
In the correlational analysis of WABAQ, only core infarct (ρ=−0.44, p=0.007) and peri-infarct volumes (ρ=−0.47, p=0.0004) were significant, and peri-infarct volume lost significance in a partial correlation including core infarct volume (ρ=−0.26, p=0.13). Only periventricular hyperintensity volume showed an association with treatment outcomes (ρ=−0.26, p=0.02), which survived correction for core infarct volume (ρ=−0.51, p=0.004) but not age (ρ=−0.34, p=0.07). Only core infarct and peri-infarct volumes were sufficiently powered for VLSM analysis. VLSM maps showed core infarct effects in the superior temporal gyrus (STG), insula, and inferior frontal gyrus (IFG) and peri-infarct gliosis along the arcuate fasciculus (AF) resulted in the worst language outcome.

Conclusions
Preliminary results show that, no matter the underlying burden of WM disease and lacunae, only core infarct predicts language outcome after an ischemic stroke, with the worst language outcomes having lesions in the STG, insula, IFG, ILF and AF.
Cerebral venous thrombosis in a postpartum patient with idiopathic thrombocytopenia

A Sakata
1Japanese Red Cross Wakayama Medical Center, Wakayama, Japan

Purpose
To describe a case of cerebral venous sinus thrombosis in a postpartum patient with refractory idiopathic thrombocytopenia.

Materials and Methods
A 38-year-old lady was admitted to this hospital because of seizure. Seventeen days before this admission, she delivered her 2nd baby. Her past medical history was remarkable with cavernous angioma of the brain and idiopathic thrombocytopenia, which was treated with immunotherapy and eltrombopag, a thrombopoietin receptor agonist. Head CT on admission revealed subcortical hemorrhage in the right frontal lobe. Her platelet count was 55000 per microliter on admission. CT angiography showed neither abnormal vessels nor arteriovenous shunts. She was loaded with antiepileptics to control the seizure. On 12th day of her admission, she complained headache which gradually worsened in intensity. Head CT demonstrated new foci of hematoma in the right frontal lobe, which were attributed to her low platelet count although her platelet count remained more than 50,000 per microliter. Her level of consciousness deteriorated 7 hours later, and surgical drainage of hematoma was planned. Prior to the surgery, CT angiography was performed, which revealed extensive thrombus formation of the superior sagittal sinus. Diagnosis of cerebral venous thrombosis was made. Thrombectomy and removal of intracerebral hematoma were performed. Postoperative hypercoagulate work up was unremarkable. There was improvement in her consciousness, and she was transferred to a rehabilitation facility.

Results
Head CT on admission showed subcortical hemorrhage in the right frontal lobe. First CTA detected neither abnormal vessels nor thrombus in the superior sagittal sinus. CTA obtained on the 12th admission day demonstrated obstruction of the superior sagittal sinus as well as extensive intracerebral hemorrhage in right frontal lobe.

Conclusions
ITP is a disorder characterized by autoimmune destruction of platelets and its common presentation is bleeding diathesis. However, thrombotic complication can also occur in ITP. The clinical scenario of intracerebral hemorrhage in ITP patient can be challenging, especially in the background of severe ITP and low platelet count. In addition to ITP itself, treatments for ITP including IVIG, steroid and eltrombopag can also be predisposing factors of hypercoagulable state. The knowledge of thrombotic complication of ITP and its treatment would be important in the early detection of this complication warrants appropriate management.

Rapid Evaluation of Collateral Development by Axial Time-Sequential CT Angiogram Covering Only 4-cm Width With A Focus On The Middle Cerebral Artery To Identify Candidates Of Thrombectomy

T Mori1, T Shimizu2
1Shonan Kamakura General Hospital Stroke Center, Kamakura, Kanagawa, 2Shonan Kamakura general Hospital, Kamakura, Kanagawa

Purpose
Four-dimensional computed tomography (CT) angiography (4D-CTA) can visualize time sequential changes of bilateral internal carotid (ICA) and middle cerebral arteries (MCA). Therefore, 4D-CTA is promising but reconstruction time is too long and not applicable before acute ischemic stroke (AIS) thrombectomy. The purpose was to investigate whether axial time-sequential CT Angiogram (aTS-CTA) covering only 4-cm width with a focus on the MCA rapidly visualized ICA or MCA occlusion because of small volumetric data and appropriately evaluated collateral development status to identify candidates of thrombectomy.

Materials and Methods
We included AIS patients who 1) were admitted from August 2018 to October 2019 due to ICA or MCA occlusion, 2) underwent aTS-CTA covering only 4-cm width on admission and 3) underwent endovascular thrombectomy. We classified collateral status into good, moderate and poor collateral according to opacification of M2 and M3 branches distal to occlusion and evaluated successful recanalization of thrombolysis in cerebral infarction (TICI) grade 2b or 3 and improvement of NIHSS score 7 days after thrombectomy.

Results
During the study period, 29 patients met our inclusive criteria. Median age was 81 years and median ASPECTS was 9. Image reconstruction time of 1,000 images was only 69 seconds and aTS-CTA with only 4-cm width demonstrated MCA occlusion in 19 patients, IC occlusion in 10 patients and collateral status as good in 4 patients, moderate in 15 patients and poor in 10 patients. Median onset-to-recanalization time was 5.48 hours, successful recanalization was achieved in 27 patients (93.1%), median NIHSS score on admission was 19, median 7-day NIHSS score decreased to 4 (p<0.0001) and median decrease of NIHSS score was 13. Two patients without successful recanalization had no early improvement of NIHSS score, whereas 26 of 27 patients with successful recanalization obtained early neurological improvement.
Conclusions
Axial TS-CTA with only 4-cm width rapidly visualized ICA or MCA occlusion and appropriately evaluated collateral status to identify candidates of thrombectomy for ICA or MCA occlusion and achieved early neurological improvement following successful recanalization.

Favorable Venous Microperfusion Profile correlates with pial arterial collateral status and clinical outcome in acute stroke patients with large vessel occlusion
Purpose
Robust pial arterial collaterals (PAC) preserve blood flow to critically hypoperfused brain tissue in patients with acute ischemic stroke due to large vessel occlusion (AIS-LVO). CT angiography (CTA) based methods of pial collateral assessment do not provide tissue level perfusion information, and prior studies have shown that PAC assessment on CT perfusion imaging strongly predicts outcome in AIS-LVO patients treated by thrombectomy. Patients with favorable pial collaterals and brain tissue perfusion also likely have robust cortical venous drainage relative to patients with more impaired cerebral perfusion. We determined the venous microperfusion profile (VMP) in AIS-LVO patients. We hypothesized that robust PAC on CT perfusion predict robust cortical venous contrast opacification on pre-treatment CTA and that a favorable VMP is associated with good clinical outcomes in AIS-LVO patients.

Materials and Methods
We performed a multicenter retrospective study of consecutive AIS-LVO patients who underwent thrombectomy. Patient details were obtained from prospectively maintained stroke databases and the electronic medical record. Pre-thrombectomy CTA and CTP studies were reviewed and scored for tissue-level collaterals using the Hypoperfusion Intensity Ratio (HIR). HIR was defined as the volume ratio of brain tissue with [Tmax>10 sec/ Tmax>6 sec] such that a lower HIR correlates with favorable collaterals. HIR was automatically calculated by RAPID (iSchemaView). VMP was determined with the cortical vein opacification score (COVES). Primary outcome measure was VMP. Secondary outcome measure was ordinal modified Rankin Scale (mRS). Ordinal linear regression models were performed to predict the effect of HIR on VMP, as well as the effect of VMP on mRS.

Results
186 patients met inclusion criteria. HIR was dichotomized into lower (≤0.4, favorable collaterals) and higher (≥0.5, poor collaterals) ratios. Mann-Whitney-U test indicated that subjects with higher HIR (median COVES = 1) had lower VMP than patients with lower HIR (median COVES = 3) (p<0.001). An ordinal logistic regression model tested the effects of VMP on mRS at 90 days after discharge while controlling for HIR (non-dichotomized), age, and TICI score. High (favorable) VMP predicted lower (favorable) mRS (OR=0.544, [95% CI 0.4-0.7]; p=0.032). A robust cerebral venous microperfusion profile reflects greater tissue microperfusion, good arterial collateralization status and is associated with improved clinical outcome in patients with AIS.

Characterization of Geometry of Intra-Cranial Atherosclerotic Lesions Using Computed Tomography Angiography and their Clinico- Imaging Correlates

L Sebastian1, J Nadarajah2, M GUPTA3, P Balasundaram4, A Garg5
1All India Institute of Medical Sciences, NEW DELHI, Delhi, 2All India Institute of Medical Sciences, New Delhi, NH, 3ALL INDIA INSTITUTE OF MEDICAL SCIENCES, new delhi, delhi, 4MGM Healthcare, Thanjavur, Tamil Nadu, 5AIIMS New Delhi, New Delhi, Delhi

Purpose
• To study the role of CTA in diagnosing ICAD and other intracranial vasculopathies in adults. • To correlate geometric distribution & morphology of intracranial atherosclerotic lesions with infract patterns and clinical characteristics of different subgroups.

Materials and Methods
Ours is an ambispective study. We enrolled adults with history of TIA or ischemic strokes who has undergone CT angiography (CTA) in our department during January 2016 to December 2018. CTA images were analyzed independently by 2 neuroradiologists for the presence and geometry of intracranial and/or extra-cranial large vessel atherosclerotic lesions (ICAD and ECAD respectively). The same were correlated with clinical risk factors and infract pattern.

Results
Of the 184 patients included 148 were male (80%) and 36 females (20%) with mean age of 56.05 years. Out of 111 patients with LVD (Combining stroke and TIA) Intracranial atherosclerotic disease (ICAD) was noted in 58 patients (52%), extracranial atherosclerotic disease (ECAD) was noted in 22 patients (20%) and both ECAD and ICAD in 31 patients (28%). Hypertension was the most common risk in all the groups. Statistically significant association (P<0.04) was noted between ICAD and tobacco users (table1). Statistically significant association was noted in patient with ICAD +ECAD subgroup with intracranial large vessel calcification(P<0.02). Middle Cerebral Artery (MCA) was the most commonly involved vessel in our study. Out of 65 infarcts in ICAD group, territorial, watershed and perforator infract pattern were noted in 35.38%, 32.32% and 32.30% respectively. Out of 24 infarcts in ECAD group, territorial, watershed and perforator infract pattern were noted in 50%, 37.5% and 12.5% respectively(table 2). Although statistically not significant (P<0.06), compared to patients with ECAD, infarcts in perforator territory is noted in high proportion in ICAD group (32.30% Vs 12.5%). Further in ICAD involving MCA degree of stenosis correlated with infract pattern - mild, moderate and severe stenoses were predominantly associated with perforator, watershed and territorial infract patterns respectively (table 3).
Conclusions
ICAD was noted in relatively younger age and contributed to stroke in more than 50% of study population with large vessel disease. Tobacco use was significantly associated with ICAD. Severity of MCA stenosis is also seen to be associated with infarct pattern and volume.

<table>
<thead>
<tr>
<th>Baseline Characteristic</th>
<th>ICAD (No-58 Pts)</th>
<th>ECAD (No-22 Pts)</th>
<th>ICAD+ ECAD (No-31 Pts)</th>
<th>P-value (Between ECAD &amp; ICAD)</th>
<th>P-value (Between ICAD &amp; ICAD+ECAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age± SD</td>
<td>55.1±11.327</td>
<td>56.8±11.48</td>
<td>60.4±11.52</td>
<td>0.55</td>
<td>0.03</td>
</tr>
<tr>
<td>Male (%)</td>
<td>54.78</td>
<td>57.4</td>
<td>59.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>56.5</td>
<td>44.0</td>
<td>66.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>22 (37.9%)</td>
<td>9 (40.90%)</td>
<td>17 (54.83%)</td>
<td>0.8</td>
<td>0.12</td>
</tr>
<tr>
<td>Tobacco</td>
<td>7 (12.06%)</td>
<td>0 (0%)</td>
<td>1 (0.03%)</td>
<td>0.09</td>
<td>0.04</td>
</tr>
<tr>
<td>Alcohol</td>
<td>12 (20.68%)</td>
<td>7 (31.8%)</td>
<td>5 (16.12%)</td>
<td>0.29</td>
<td>0.6</td>
</tr>
<tr>
<td>Hypertension</td>
<td>43 (74.13%)</td>
<td>17 (77.27%)</td>
<td>27 (87.09%)</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Diabetes</td>
<td>6 (10.34%)</td>
<td>2 (0.90%)</td>
<td>4 (12.90%)</td>
<td>0.1</td>
<td>0.7</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>12 (20.68%)</td>
<td>4 (18.18%)</td>
<td>7 (22.58%)</td>
<td>0.8</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Table 2: shows relationship between infarct pattern with ECAD and ICAD

<table>
<thead>
<tr>
<th>Infarct pattern</th>
<th>ICAD (No-65)</th>
<th>ECAD (No-24)</th>
<th>ECAD+ICAD (No-35)</th>
<th>P value ICAD ECAD</th>
<th>P value ICAD+ECAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Territorial</td>
<td>23 (35.38%)</td>
<td>12 (50%)</td>
<td>15 (42.86%)</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>Watershed</td>
<td>21 (32.32%)</td>
<td>9 (37.5%)</td>
<td>12 (34.29%)</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Perforator</td>
<td>21 (32.30%)</td>
<td>3 (12.5%)</td>
<td>3 (22.85%)</td>
<td>0.06</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 3: Infarct pattern in different grades of stenosis

<table>
<thead>
<tr>
<th>MCA disease with Anterior circulation involvement</th>
<th>Perforator</th>
<th>watershed</th>
<th>Territorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (&lt;50%) (No-33)</td>
<td>16(48.48%)</td>
<td>9(27.27%)</td>
<td>8(24.24%)</td>
</tr>
<tr>
<td>Moderate (50-69%) (No-40)</td>
<td>14(35%)</td>
<td>16(40%)</td>
<td>10(25%)</td>
</tr>
<tr>
<td>Severe (70-99%) (No-17)</td>
<td>6(35.29%)</td>
<td>3(17.64%)</td>
<td>8(47%)</td>
</tr>
</tbody>
</table>

(Filename: TCT_2329_TablesICAD.JPG)
Iatrogenic EBV-Positive Immunodeficiency-Associated CNS Lymphoma Mimicking Lupus Vasculitis

D Helmy¹, A Ozturk², O Raslan³, J Chang³, R Assadsangabi¹, V Ivanovic³, M Bobinski³, N Pham¹
¹UC Davis Medical Center, Sacramento, CA, ²University of California, Davis Medical Center, Sacramento, CA, ³UC Davis, Sacramento, CA

Purpose
To illustrate an important differential in a patient with lupus

Materials and Methods
A 36-year-old woman presented with acute left-sided facial droop and hand numbness. She had a longstanding history of systemic lupus erythematosus (SLE) on chronic immunosuppression. MRI showed multiple, bilateral cortical and subcortical lesions that were hyperintense on FLAIR without hemorrhage or restricted diffusion. These lesions showed patchy enhancement after ferumoxytol administration, given for this study because of the patient's CKD. With suspicion for lupus vasculitis, neurosurgery was consulted for biopsy. Pathology showed robust infiltration of the cortex and subcortical white matter by atypical lymphocytes with positive in situ hybridization for Epstein-Barr virus (EBV), consistent with immunodeficiency-associated primary CNS lymphoma (PCNSL). She was started on rituximab and her immunosuppression was decreased. 4 months later, her neurological symptoms had resolved. Follow-up MRI showed small residual nonenhancing foci of increased signal on FLAIR, consistent with treatment response.

Results
FLAIR sequences at the level of the centrum semiovale (A) and insula (B) show multiple bilateral cortical and subcortical lesions. Post-ferumoxytol contrast images demonstrate patchy enhancement (C and D).

Conclusions
Immunodeficiency-associated PCNSL usually manifests as multiple ring-enhancing lesions, whereas in an immunocompetent patient PCNSL is more likely to be a solid, homogeneously enhancing mass that restricts diffusion. EBV is often associated with PCNSL in both immunocompetent and immunodeficient patients, with EBV-positive PCNSL more likely demonstrating hemorrhage or necrosis. CNS lupus vasculitis can have a variable appearance but most commonly appears as multiple bilateral hyperintense foci in the subcortical and periventricular white matter that may restrict diffusion or demonstrate patchy enhancement. The imaging appearance in a given SLE patient can be further confounded by underlying antiphospholipid syndrome, aseptic cerebritis, or opportunistic infection. This case is unique in that it occurred in a young patient with SLE on chronic immunosuppressant medications with imaging and clinical presentation compatible with lupus vasculitis. However, biopsy showed EBV-positive immunodeficiency-associated PCNSL instead. Thus, in a SLE patient on immunosuppressant therapy with suspected lupus vasculitis an important differential consideration is PCNSL, as imaging characteristics may overlap.
“Neither the place nor the condition!”: Periventricular neurocytoma in Neurofibromatosis Type 1 – Diagnostic dilemma and therapeutic implications

S Hiremath1, U ERDENEBOLD2, S Chakraborty3
1The Ottawa Hospital, Ottawa, Ontario, 2THE OTTAWA HOSPITAL, OTTAWA, ON, 3University of Ottawa, Ottawa, Ontario

Purpose
To describe and highlight the rare occurrence of a periventricular neurocytoma in neurofibromatosis type 1

Materials and Methods
A 29-year-old gentleman, known neurofibromatosis type 1 (NF 1), presented with slight right foot drag. Magnetic resonance imaging revealed a periventricular lesion involving splenium of the corpus callosum on the left. On routine surveillance, it demonstrated an interval increase in the size compared to the initial scan in 2013. Because of a mild interval increase in size over six years with a likelihood of low-grade glioma, he underwent left parietal craniotomy and excision of the lesion in September 2019

Results
A small lobulated T2 and FLAIR hyperintense lesion with mild peripheral enhancement is seen involving splenium of the corpus callosum on the left side with intraventricular extension (Fig 1 A, B). The lesion shows no restricted diffusion and focal areas of blooming on gradient images (Fig 1C). Perfusion imaging showed low rCBV (Fig 1D). On spectroscopy, the lesion demonstrated decreased NAA, an increase in choline to creatinine ratio, and lactate peak. Due to the mild interval in size, imaging characters of peripheral enhancement, low perfusion, and spectroscopy findings in a known NF 1, the lesion was likened to be low-grade glioma. Histopathology and immunohistochemistry revealed a periventricular neurocytoma WHO Gr II.

Conclusions
Neurocytomas in an extra and periventricular location are rare than intraventricular neurocytomas involving foramen of Munro and septum pellucidum. They have been described in cerebral hemispheres, deep grey nuclei, brain stem, spinal cord, and cauda equina. Molecular analysis and immunohistochemistry aids in differentiating atypical neurocytomas from pathologic mimics such as oligodendroglioma and ependymoma. NF 1 is a common autosomal dominant condition associated with low-grade gliomas and malignant peripheral nerve sheath tumors. Since optic pathway tumors are commonly low-grade pilocytic astrocytomas, they do not need biopsy for confirmation of the diagnosis. Extending this approach to lesions in atypical locations could lead to a potential risk of missing a tumor amenable to alternative therapeutic regimes. Chemotherapy is the standard treatment for unresectable low-grade gliomas compared to total resection or adjuvant radiotherapy in residual neurocytomas.
Multiparametric MRI Texture Analysis in Prediction of Glioma Biomarker Status

S. Kihira¹, N. Tsankova², A. Bauer³, Y. Sakai², J. Houldsworth², F. Khan², A. Hormigo², C. Hadjipanayis², K. Nael⁴
¹Mount Sinai Hospital, New York, NY, ²Icahn School of Medicine at Mount Sinai, New York, NY, ³Kaiser Permanente, Fontana, CA, ⁴Icahn School of Medicine at Mount Sinai Hospital, New York, NY

Purpose
Early identification of glioma molecular phenotypes can lead to understanding of patient prognosis and guide treatment planning. MR texture analysis has shown promising results in discriminating molecular subtypes (1–4). We aimed to develop a multiparametric MRI texture analysis model to predict several important prognostic biomarkers: isocitrate dehydrogenase-1 (IDH-1) mutation, O6-methylguanine–DNA methyltransferase (MGMT) methylation, epidermal growth factor receptor (EGFR) overexpression, alpha thalassemia/mental retardation syndrome X linked (ATRX) mutation, tumor protein p53 (TP53) mutation, and phosphatase and tensin homolog (PTEN) mutation statuses.

Materials and Methods
In this retrospective IRB approved study, patients were included if 1) had diagnosis of gliomas with known IDH-1, EGFR, MGMT, ATRX, TP53, and PTEN statuses from surgical pathology and 2) had preoperative MRI including FLAIR and T1c+. Tumor segmentation was performed using volume-of-interest (VOI) analysis. VOIs were transferred for radiomic texture analysis using Olea Sphere software (Olea Medical). A total of 92 texture features including first-order, co-occurrence matrix, and run length matrix were calculated. As there were more texture features than patients, correlation between the biomarker statuses and texture features were assessed using Least Absolute Shrinkage and Selection Operator (LASSO) regression algorithm to prevent overfitting and increased interpretation. Receiver-operating characteristic (ROC) curve analysis was performed to determine the optimal parameters and threshold for predicting glioma prognostic biomarker statuses.

Results
A total of 111 patients (age: 56 ± 15, M/F 66/45) were included. Using logistic regression, a combination of texture features on FLAIR and T1c+ resulted in overall AUC (sensitivity and specificity) of 0.96 (95.5%, and 87.5%) for IDH-1, 0.65 (67.2% and 57.5%) for MGMT, 0.81 (72.3% and 72.7%) for EGFR, 0.95 (92.8% and 83.3%) for ATRX, 0.75 (75.0% and 69.9%) for TP53, and 0.72 (75.6% and 65.9%) for PTEN.

Conclusions
Results show that our multiparametric MR texture analysis can predict glioma biomarker mutation statuses in preoperative gliomas with good to excellent accuracy. Multiparametric MR texture analysis may be a promising noninvasive tool to predict biomarker mutation status with important prognostic and treatment implications in patients with glioma.
Metabolic phenotyping of glioblastoma with magnetic resonance imaging of hyperpolarized [1-13C]pyruvate.

F Zaccagna1, J Grist1, M McLean1, F Riemer2, J Kaggie1, S Deen1, R Woitek1, K Allinson1, A Chhabra1, M Laurent1, A Frary1, T MATYS1, S Urpsrung1, B Basu1, C Watts1, S Price1, S Jefferies1, J Gillard1, M Graves1, K Brindle1, F Gallagher1

1University of Cambridge, Cambridge, United Kingdom, 2University of Bergen, Bergen, Norway, 3University of Birmingham, Birmingham, United Kingdom

Purpose

Metabolic reprogramming is one of the main determinants of morphological and biological heterogeneity in glioblastomas (GBM). The characterization of metabolic heterogeneity in vivo could improve diagnosis, prognostication and treatment. Hyperpolarized [1-13C]pyruvate Magnetic Resonance Spectroscopic Imaging (HP 13C MRSI) is a novel technique that allows for non-invasive in vivo assessment of metabolism. The purpose of this study was to explore metabolic reprogramming in GBM using HP 13C MRSI.

Materials and Methods

Eight treatment-naïve patients (6 males; 60±11 years) with GBM were imaged on a 3T scanner (GE Healthcare, WI, USA) using a dual-tuned 13C/1H quadrature transmit/receive head coil (Rapid Biomedical, Rimpar, Germany). [1-13C]pyruvate was hyperpolarized using a clinical hyperpolarizer (Research Circle Technology, NY, USA). 13C-MRSI acquisition was performed using a dynamic IDEAL spiral sequence. A reference 3D T1W FSPGR was acquired with the dual-tuned 13C/1H head coil and repeated using a 1H coil following the injection of a gadolinium-based contrast agent. Paired and unpaired t-tests, Wilcoxon rank tests and Spearman's rho were used to compare imaging and biological biomarkers from image-guided biopsies. Significance for multiple comparisons was assessed using the Benjamini-Hochberg procedure.

Results

Kinetic analysis showed a high degree of variability in pyruvate, lactate and bicarbonate. The lactate-to-pyruvate ratio in the GBM was similar to that in contralateral brain tissue (p = 0.38) but the average bicarbonate-to-pyruvate ratio was lower (p < 0.01). The GBM lactate-to-pyruvate ratio exhibited a linear positive correlation with LDHA (r = 0.43, p = 0.04) and negative with MIB-1 (r = -0.46, p = 0.01) and the bicarbonate-to-pyruvate ratio was positively correlated with CA IX (r = 0.51, p < 0.01), CD8 (r = 0.61, p < 0.01) and CD68 (r = 0.55, p < 0.01).
Conclusions
HP 13C MRSI can probe in vivo metabolic activity of GBM and investigate both intra- and intertumoral heterogeneity. The exchange of the hyperpolarized 13C label between pyruvate and lactate was similar in GBM and normal brain tissue, as has been observed in PDX models, while the unidirectional formation of bicarbonate was also consistently and significantly reduced within GBM. Moreover, we detected intralesional heterogeneity in labelling highlighting the presence of different metabolic habitats that may represent targets for image-guided biopsies, which could improve diagnostic accuracy.

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2275

SWI Changes in the Dentate Nucleus in High and Low-grade Brain Stem Neoplasms

K Jobanputra1, B Roy2, K Raj3, A Agarwal3, F Yu1
1University of Texas Southwestern Medical Center, Dallas, TX, 2University of California, Los Angeles, Los Angeles, CA, 3UT Southwestern Medical Center, Dallas, TX

Purpose
Given their proximity to vital nuclei, brainstem neoplasms present challenges in terms of therapy. Furthermore, management differs between low grade and high-grade neoplasms. While reviewing a case of pontine hemangioblastoma it was observed that the ipsilateral dentate nucleus was atrophic, which was best appreciated on SWI images. In this study, we evaluated the difference in susceptibility weighted imaging (SWI) signal within the dentate nucleus as a marker of iron content in high grade and low grade brain stem tumors.

Materials and Methods
This was an IRB approved, single institution, retrospective study. Primordial search for patients with pathologic biopsy proven primary or secondary brainstem neoplasm in adult patients who underwent MR imaging with an SWI sequence from July 2018-June 2019. There were 11 patients (6 females) ranging from 25 to 69-years-old. There were 5 HG (WHO III-IV) and LG tumors (WHO I-II). The dentate nuclei manually demarcated on SWI images. In order to facilitate comparison of subjects across different scanners, weighted SWI signal intensities were calculated. These were then divided by the values obtained from ROI placed within the centrum semiovale normal appearing white matter (NAWM) for normalization. This strategy of weighting and normalization allowed us to compare subjects across scanners/ vendors/ field strengths.
Results
Statistical analysis was performed on SPSS v25. No statistically significant difference was found between the dentate nucleus signal intensity between left and right side for the LG tumor group. For the HG tumor group, a significant difference was found in the dentate nucleus SWI signal ($p=0.024$), which was increased to the side of the tumor. A similar nonsignificant trend was observed in the LG tumor group ($p=0.15$). Evaluation of volumes showed no significant difference in the HG group ($p=0.451$), although there was a trend toward lower volumes of the dentate nucleus ipsilateral to the side of the LG tumor ($p=0.10$).

Conclusions
We found significantly increased SWI values within the dentate nucleus ipsilateral to HG tumors that may reflect reduced iron. A trend of reduced volume and increased SWI values within the dentate nucleus ipsilateral to LG tumors was also observed. Future work with larger prospective studies, as well as correlation with histology including iron quantification, may help to validate these findings.
Table 1. Average weighted SWI signal intensity values of high grade tumors at dentate nuclei.

<table>
<thead>
<tr>
<th></th>
<th>Left Dentate (mean=SD)</th>
<th>Right Dentate (mean=SD)</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right sided High Grade tumors (n=3)</td>
<td>0.957±0.087</td>
<td>1.006±0.097</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Table 2. Volumes of dentate nuclei of low grade tumors.

<table>
<thead>
<tr>
<th></th>
<th>Left Dentate (mean=SD. mm³)</th>
<th>Right Dentate (mean=SD. mm³)</th>
<th>P values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right sided Low Grade tumors (n=3)</td>
<td>5.14±3.31</td>
<td>3.23±4.00</td>
<td>0.10</td>
</tr>
<tr>
<td>Midline Low Grade tumors (n=2)</td>
<td>5.43±2.08</td>
<td>5.69±2.80</td>
<td>0.698</td>
</tr>
</tbody>
</table>

Figure 1: Right midbrain high grade glioma showing increased signal intensity at the right dentate nucleus A) Flair B) SWI. Right brain stem ependymoma showing reduced volume of the right dentate nucleus C) Flair and D) SWI.

(Filename: TCT_2275_Figure1_new_new.jpg)
Bilateral Internal Carotid Arteries Blood Flow Restriction Secondary to Compression by a Suddenly Enlarged Pituitary Adenoma.

B Chen¹, A Aein¹, A Kamali¹, S Khanpara¹, R Patel¹, C Sitton¹
¹Department of Diagnostic and Interventional Imaging, McGovern Medical School, UTHealth, Houston, TX

Purpose
To present a rare case of anterior circulation territories stroke due to bilateral ICA compression by enlarged pituitary adenoma.

Materials and Methods
A 60-year-old female who presented with sudden onset nausea, vomiting and vision loss. She had no speech problem or focal weakness on presentation but became more obtunded and altered during her hospital course leading to a comatose state. The patient had intermittent nausea, vomiting and progressive headache without further workup in the past year.

Results
The non-contrast head CT showed a large homogenous non-hemorrhagic sellar mass lesion (35 x 31 x 37 mm) with suprasellar extension causing significant mass effect. The brain CTA revealed luminal narrowing and poor opacification of the bilateral cavernous ICA (more on the right side) and bilateral A1 segments. The CT perfusion demonstrated significant perfusion abnormality within bilateral anterior circulation territories. Therefore, emergent transsphenoidal hypophysectomy surgery was performed to decompress the ICAs. The brain DWI sequence showed a large area of restricted diffusion in anterior circulation with left basal ganglia hemorrhage; However, cerebral angiography showed the normalization of ICAs blood flow after decompression. The histopathologic examination was consistent with non-functional pituitary adenoma.

Conclusions
Pituitary apoplexy (PA) is a rare life-threatening endocrine emergency and it's characterized by a sudden increase in pituitary gland volume due to hemorrhages and/or infarcts. The acute presentation of PA could be the first manifestation of an underlying pituitary tumor especially in non-functional adenomas and can occur in 0.2% to 0.6% of patients. Clinical manifestations are highly variable (sudden onset headache, visual disturbance, altered mental status, and hormonal dysfunction) and unclear precipitating factors. The CT attenuation differs depending on the duration of apoplexy. The contrast CT rim enhancement is suggestive but not diagnostic for PA. CT might be more efficient than MRI in the acute stage and better for visualizing the hemorrhagic PA in the first few days but MRI can be more sensitive in detecting and following the PA findings in the subacute stage. To our knowledge, the bilateral ICA compression by enlarged pituitary adenoma secondary to PA is uncommon and deserved to be recognized.
Hemangiopericytomas, and How to Distinguish From More Benign Extra-Axial Tumors

K Seifert¹, N Das², V Zohrabian³, I Ikuta⁴
¹Yale New Haven Hospital, Milford, CT, ²UT Health San Antonio, San Antonio, TX, ³Yale School of Medicine, New Haven, CT, ⁴Yale University School of Medicine, Milford, CT

Purpose
Hemangiopericytomas are rare tumors of the meninges, which often present similarly to the more common meningioma, with symptoms due to mass effect to the adjacent structures. These tumors are often diagnosed on pathology after resection or debulking. As these tumors tend to be aggressive, often reoccur, and have been shown to metastasize in up to 20% of patients, it is important to identify imaging characteristics of this diagnosis.
Materials and Methods
81 years old female was brought to the emergency department after obtaining the results of her outpatient CTA. She reported complaints of feeling unbalanced, dizzy, with subjective generalized weakness for the past 6 weeks, with intermittent nausea, and left parietal headache. The CTA images revealed a large extra-axial left cerebellar pontine angle mass, with mass effect on the left cerebellar hemisphere and brainstem. An MRI was performed and confirmed the CTA findings. Imaging findings were felt to be consistent with a meningioma.

Results
The CTA demonstrated a 4.0 cm avidly enhancing mass with regions of non enhancement centered in the left cerebral pontine angle exerting mass effect on the left cerebellum and brainstem. In addition, there was crowding of the cerebellar tonsils at the foramen magnum and partial effacement of the fourth ventricle. It appeared that the predominant blood supply the mass is from the left tentorium cerebellum. MRI findings confirmed a large 5.3 cm enhancing solid extra-axial mass adjacent to the left cerebellar hemisphere, with evidence of a dural tail. There was mass effect on the cerebellum, fourth ventricle and cerebral aqueduct with displacement of the left cerebellar tonsil and brainstem. Vasogenic edema was noted predominantly in the left cerebellar peduncles. There was no evidence of intralesional hemorrhage, restricted diffusion or cystic changes. Imaging findings were determined to be consistent with a meningioma. A few imaging characteristics can help distinguish a hemangiopericytoma from a meningioma. On CT, a hemangiopericytoma may have bony erosion, however does not elicit hyperostosis. There are no calcifications in hemangiopericytomas. These lesions will demonstrate vivid enhancement, that tend to be heterogenous. DWI sequences will demonstrate intermediate restricted diffusion, whereas spectroscopy will be notable for high myoinocitol and absent alanine.

Conclusions
As disease progression and treatment vary, it is important to identify imaging characteristics of hemangiopericytomas.

Impact of the Novel Contrast Agent Gadopiclenol on Decision Making in Patients with Brain Metastases

M Essig1, F Giordano2, J Fleckenstein2, M Eckl2, L Hoppen2, M Bendszus3
1University of Manitoba, Winnipeg, Manitoba, 2University of Heidelberg, Mannheim, Germany, 3University of Heidelberg, Heidelberg, Germany

Purpose
Limited numbers of brain metastases are rather treated with stereotactic radiosurgery (SRS) than with whole-brain radiotherapy (WBRT) due to much lower toxicity. However, the identification of even smallest lesions is key for determining the extent of brain involvement and thus the choice of the adequate therapeutic modality. We here evaluate the impact on decision making and treatment planning of brain metastases using the gadopiclenol, a new high relaxivity macrocyclic gadolinium-based contrast agent.

Materials and Methods
This is a post-hoc analysis of data from a phase IIb study, where patients underwent two separate MRI examinations, one with gadopiclenol (at either 0.025, 0.05, 0.1 or 0.2 mmol/kg) and one with gadobenate dimeglumine (0.1 mmol/kg). Only patients who have received gadopiclenol at 0.1 mmol/kg and had one or more brain metastases detected in any of both scans were subjected to a blinded reader analysis. For each patient, treatment plans (SRS or WBRT) were calculated for both MRIs, with the gross tumor volume (GTV) indicating the contrast-enhancing aspects of the tumor and a planning target volume (PTV) after adding an additional 1 mm margin to the GTV. For each lesion, the volume receiving ≥12 Gy or more (V12Gy), was calculated.

Results
A total of 13 adult patients (31% females) presenting with at least one brain metastasis were analyzed. Among these patients, gadopiclenol depicted additional brain metastases as compared with gadobenate dimeglumine in 7 patients (54%) and the treatment plan was modified in 2 patients (15%). In one of those patients, a single metastasis was seen only with gadopiclenol, changing the decision from no treatment to SRS. In the second patient, gadopiclenol detected 5 additional metastases, changing the decision from SRS to WBRT. In addition, the mean GTV was consistently higher in therapy plans calculated on gadopiclenol-based scans than on
Gadobenate dimeglumine-based scans (mean GTV of 4.74 vs. 4.32 cm³), indicating a different appearance of brain metastases sizes. Logically, the mean V12Gy was also higher with gadopiclenol than with gadobenate dimeglumine-based scans (mean V12Gy of 14 vs. 11 cm³).

Conclusions
Gadopiclenol improved detection of brain metastases, which led to a change in treatment decisions in 2 out of 13 of patients (from no therapy to SRS and from SRS to WBRT) and to treatment plans with larger GTVs.
The combination models incorporating radiomics signature and clinical-radiological characteristics were superior to the clinical-radiological models in two classification strategies (AUC: 0.928 for differentiation of GBM and MET and 0.827 for differentiation of MET-lung and MET-other). The nomograms showed satisfactory performance and calibration, and decision curve analysis revealed the nomograms were clinically useful.

Conclusions
Radiomics analysis has superior classification ability in differentiation of GBM, MET-lung and MET-other. Combination of the radiomic and non-radiomic features is helpful for the differentiation of tumor types.

EBM Programming: Extended Window for Thrombolysis After Stroke: Implications on Advanced Imaging and Post-Processing Software

CT Angiography for Triage of Acute, Minor Stroke Patients: A Cost-Effectiveness Analysis

A Malhotra, X Wu, C Matouk, D Gandhi, P Sanelli

Yale University School of Medicine, New Canaan, CT, Yale University School of Medicine, New Haven, CT, University of Maryland School of Medicine, Baltimore, MD, Northwell Health NSUH, Manhasset, NY

Purpose
Minor stroke is common, and may represent up to two-thirds of patients with acute ischemic stroke. The cost-effectiveness of computed tomography angiography (CTA) for patients with minor stroke (National Institute of Health Stroke Scale ≤6) is not well-established. This study aims to evaluate cost-effectiveness of CTA for detection of large vessel occlusion (LVO) in patients with acute, minor stroke (NIHSS<6).

Materials and Methods
A Markov decision-analytic model was constructed accounting from a societal perspective. Three different management strategies were evaluated: 1) No vascular imaging, and best medical management; 2) CTA for all patients, and immediate thrombectomy (IMT) for large-vessel occlusion (LVO) after intravenous thrombolysis (IVT); and 3) CTA for all, and best medical management (BMM) including IVT, with rescue thrombectomy for LVO patients with neurologic deterioration. One-way, two-way and probabilistic sensitivity analyses were performed.

Results
Base-case calculation showed CTA followed by IMT had the lowest cost ($346,007) and highest health benefits (9.26 QALYs). CTA followed by BMM with possible rescue thrombectomy for LVO patients had a slightly higher cost ($346,500) and lower health benefits (9.09 QALY). No vascular imaging had the highest cost and lowest health benefits. The difference in health benefit compared to the CTA and IMT strategy was 0.39 QALY which corresponds to 142 days in perfect health per patient. The conclusion is robust in probabilistic sensitivity analysis. CTA was cost-effective when the probability of LVO was >0.16% in patients with acute, minor stroke. The net monetary benefit of doing CTA was higher in younger patients ($68,950 difference between CTA followed by IMT and no vascular imaging in 55-year-old patients, compared to $20,931 in 85-year-old patients). In the two-way sensitivity analysis varying the cost of CTA and proportion of LVO patients, the result showed that the threshold of LVO proportion at which vascular imaging became superior increased as the cost of CTA increased. When the cost of CTA was $5,000, the LVO threshold proportion was 1.32%.

Conclusions
Screening for LVO with CTA in patients with acute, minor stroke is cost-effective with improved health outcomes. Undetected LVO in absence of vascular imaging results in lower health outcomes and higher costs.
Health Policy Programming: The Numbers Game: Updates on CMS Payment Policies Affecting Your Bottom Line

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Towards Patient-Specific Imaging Strategies in Acute Ischemic Stroke: A Cost-Effectiveness Analysis

G Martinez1, A Pandya2, J Katz3, J Wang4, A Boltyenkov5, P Sanelli6
1Siemens Healthineers, Manhasset, NY, 2Harvard T.H Chan School of Public Health, Boston, MA, 3Northwell Health, Manhasset, NY, 4Northwell Health, Mnhasset, NY, 5Siemens Healthineers, Manhasset, NY, 6Northwell Health NSUH, MANHASSET, NY

Purpose

One of the American Stroke Association's recommendations for acute ischemic stroke (AIS) management focuses on the prompt identification of candidates for treatment, which requires timely completion of neuroimaging with CT or MRI. CT is often preferred in clinical practice because of its availability, but CT radiation exposure could increase lifetime cancer risk. Despite the superior ability of MRI to detect AIS, it commonly involves complex workflow that could potentially cause delays to treatment, and thus has not been widely adopted in practice. Furthermore, there is still uncertainty about the appropriate utilization of angiography and perfusion (CTAP, MRAP) in clinical practice. Our study objective was to evaluate cost-effectiveness of CTAP versus MRAP in AIS based on age, sex, outcomes and health care cost.

Materials and Methods

We developed a decision model representing different levels of imaging and modality (CT and/or MRI) utilization in AIS. The modeled cohort represented 50 and 70-year-old patients presenting with AIS with known symptom onset time (SOT). We used National Cancer Institute methodology to calculate lifetime cancer risks based on radiation dose, age at imaging and sex. Health outcomes were penalized to reflect the decline in functional states associated with treatment delays. We conducted cost-effective analyses from the societal perspective, using conventional willingness-to-pay (WTP) thresholds ($100,000 and $50,000) to determine appropriate imaging strategies for AIS based on age and sex. Model parameters were based on data from meta-analyses and clinical trials.

Results

Our analyses determined that performing CTAP at presentation improved outcomes for patients at SOT 0-4.5 hours and 70-year-old at SOT 0-6 hours using both WTP. For 50-year-old at SOT >4.5-6 hours, CTAP at presentation was cost-effective at WTP $50,000; MRAP was cost-effective at WTP $100,000 if its workflow was within 7 and 4 minutes for females and males, respectively. For SOT >6-24 hours, NCCT at presentation and utilization of CTAP or MRAP only for assessment of thrombectomy eligibility was cost-effective if imaging of thrombectomy candidates occurs within 12 and 15 minutes for 50- and 70-year-old, respectively. Radiation risk could affect outcomes only for 50-year-old females.

Conclusions

Our results indicated that optimal utilization of advanced imaging was a function of WTP and time delay. Cost-effective modality choices depended on patient-specific factors such as age, sex, and SOT.
Role of Multiparametric PET/MRI in Differentiating Between Radiation Necrosis and Tumor Recurrence: A Single Institute 10-Year Experience

A Sauer\(^1\), S Pahwa\(^2\), C Badve\(^2\)

\(^1\)Case Western Reserve University School of Medicine, Cleveland, OH, \(^2\)University Hospitals, Cleveland, OH
Purpose
Advanced MRI techniques including FDG PET, permeability and perfusion imaging are commonly used in clinical setting to differentiate between radiation necrosis (RN) and tumor recurrence (TR). However, there is very limited data in the literature comparing the utility of these techniques against each other. In this 10-year retrospective review, we evaluate the effectiveness of quantitative parameters derived from dynamic susceptibility contrast (DSC) and dynamic contrast enhanced (DCE) perfusion MRI (pMRI) and 18F-FDG PET imaging in distinguishing between RN and TR.

Materials and Methods
In this IRB approved retrospective study, all patients from our institute in the last 10 years with glioblastoma who presented with imaging progression after undergoing standard of care Stupp protocol and who underwent 18F-FDG PET, pMRI or hybrid PET/MRI were included. The diagnosis was confirmed by histopathology or by clinical consensus and was reached within 1 month of the advanced imaging study. For PET ROI analysis, the SUV(max) of the lesion was measured and a ratio of lesion to contralateral normal white matter (CNWM) was calculated, relative SUV(max). For pMRI (data partially analyzed), lesion to CNWM ratios for multiple parameters were documented (including Ktrans, ADC, rCBV). The sensitivities and specificities of these parameters were calculated.

Results
Between the years 2010 to 2019, 372 patients underwent advanced imaging for brain tumors at our institute. A total of 87 patients met the study inclusion criteria. Total n=87, n(pMRI only)=38, n(hybrid PET/MRI)= 49. The final diagnosis is available by histology in n=15 and by clinical consensus in n=72. Since this is an ongoing study, 49 PET and 16 pMRI patients have been analyzed with ROI analysis so far. Only the PET data is being presented here, perfusion data is expected to be available in the next 2 weeks after the submission deadline. Relative SUV(max) was able to detect a statistically significant difference between RN and TR with p<0.05 using the single-tailed independent t-test. This parameter had a sensitivity of 83% and specificity of 83% with cutoff at 1.5.

Conclusions
Our preliminary results demonstrate the diagnostic utility of FDG-PET with sensitivity and specificity of 83% using a relative SUVmax cutoff value of 1.5. This is a work in progress and we anticipate completing the analysis on the entire dataset very soon (in next 2 weeks after the deadline). The authors are willing to submit the updated abstract if the reviewers will allow it.

Prediction of BRAFV600E-Mutation Status Using Preoperative MR Imaging Phenotypes in Glioblastoma

O Arevalo1, L De Alba1, A Dono1, T Takayasu1, Y Esquenazi1, L Ballester1, X Zhang1, C Soto2, S Khanpara1, J Zhu1, R Riascos1

1The University of Texas Health Science Center at Houston, Houston, TX, 2National University of Colombia, Bogota, TX
Purpose
Glioblastomas (GBM) are classified based on the presence of a mutation in the isocitrate dehydrogenase genes in wildtype (IDH1/2-WT) and mutant (IDH1/2-Mut), which have prominent differences in prognosis. Molecular subclassification of GBMs has been reported to predict treatment response and prognosis. Clinical trials of targeted therapy in an uncommon subset of GBM IDH1/2-WT harboring BRAF mutation have reported promising treatment response rates. We sought to evaluate the predictive value of imaging phenotypes assessed with the Visually AcceSAble Rembrandt Images (VASARI) lexicon, in addition to semiautomated segmentation, to discriminate BRAF mutation in GBM IDH1/2-WT.

Materials and Methods
MR imaging scans of 153 patients with GBM IDH1/2-WT with known BRAF-status were included (142 IDH1/2-WT BRAF-WT, 11 IDH1/2-WT BRAF-Mut). MR imaging features were reviewed using VASARI, and semiautomatic segmentation (volumetric measurement of the enhancement, FLAIR hyperintensity, and necrosis). Association between genotype and MR features was evaluated by Fisher's exact test for categorical variables and the Wilcoxon rank-sum test for continuous variables.

Results
A lower frequency of deep white matter structures (DWMS) invasion was seen in tumors harboring the BRAF mutation. A smaller proportion of enhancing tumor (p=0.07) and the absence of cortical involvement (p=0.07) trends to predict BRAF mutation. There was no significant difference in the volumes or ratios of the different tumor compartments after analysis of the segmentation data. The areas under the curve for each of the volumes and volume ratios ranged between 0.470-0.667.

Conclusions
New diagnostic challenges arise with the newer genotypic classifications, and identifying imaging biomarkers for the early recognition of specific genotypes becomes crucial as new highly-effective targeted, effective therapies become more available. Most of the examined preoperative MR imaging features did not reach statistical significance to predict the BRAF mutation status. However, some of the features such as frequency of DWMS invasion, the presence of cortical involvement, the proportion of enhancing tumor, among others, showed a tendency for potential imaging biomarkers. It is hypothesized that further multicenter studies with a larger sample size could find discriminatory imaging features.
Table 1. Association between imaging features and BRAF mutation status in patients with GBM IDH wild type (N=153)

<table>
<thead>
<tr>
<th>Feature</th>
<th>BRAF mutant (N=11)</th>
<th>BRAF wildtype (N=142)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAIR volume cm3, median (IQR)</td>
<td>95 (67, 129)</td>
<td>109 (58, 150)</td>
<td>0.76</td>
</tr>
<tr>
<td>Enhancement volume cm3, median (IQR)</td>
<td>11.4 (79, 18.0)</td>
<td>19.2 (10.2, 32.8)</td>
<td>0.15</td>
</tr>
<tr>
<td>Necrosis volume cm3, median (IQR)</td>
<td>4.2 (2.1, 12.4)</td>
<td>6.2 (1.9, 11.2)</td>
<td>0.66</td>
</tr>
<tr>
<td>Total tumor volume FLAIR+Enh+Nec, median (IQR)</td>
<td>125 (82, 154)</td>
<td>139 (76, 194)</td>
<td>0.56</td>
</tr>
<tr>
<td><strong>F1 - Tumor location</strong></td>
<td></td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>Frontal</td>
<td>3 (27%)</td>
<td>46 (32%)</td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>6 (54%)</td>
<td>58 (41%)</td>
<td></td>
</tr>
<tr>
<td>Insular</td>
<td>0 (0%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
<tr>
<td>Parietal</td>
<td>1 (9%)</td>
<td>26 (18%)</td>
<td></td>
</tr>
<tr>
<td>Occipital</td>
<td>1 (9%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>0 (0%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
<tr>
<td><strong>F2 - Side</strong></td>
<td></td>
<td></td>
<td>0.47</td>
</tr>
<tr>
<td>Right</td>
<td>4 (36%)</td>
<td>77 (54%)</td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td>0 (0%)</td>
<td>5 (4%)</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>7 (64%)</td>
<td>60 (42%)</td>
<td></td>
</tr>
<tr>
<td><strong>F3 - eloquent brain involvement (Yes)</strong></td>
<td></td>
<td></td>
<td>0.54</td>
</tr>
<tr>
<td>Marked/avid</td>
<td>10 (91%)</td>
<td>127 (89%)</td>
<td></td>
</tr>
<tr>
<td>Minimal/mild</td>
<td>0 (0%)</td>
<td>11 (8%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (9%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
<tr>
<td><strong>F5 - Proportion enhancing, median (IQR)</strong></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td><strong>F6 - Proportion nCET, median (IQR)</strong></td>
<td></td>
<td></td>
<td>0.16</td>
</tr>
<tr>
<td><strong>F7 - Proportion of Necrosis, median (IQR)</strong></td>
<td></td>
<td></td>
<td>0.74</td>
</tr>
<tr>
<td><strong>F8 - Cysta (Yes)</strong></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td><strong>F9 - Multifocal/Multicentric (Yes)</strong></td>
<td></td>
<td></td>
<td>0.32</td>
</tr>
<tr>
<td>Expansive</td>
<td>5 (45%)</td>
<td>80 (56%)</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>1 (9%)</td>
<td>20 (14%)</td>
<td></td>
</tr>
<tr>
<td>Infiltrative</td>
<td>5 (45%)</td>
<td>42 (30%)</td>
<td></td>
</tr>
<tr>
<td><strong>F10 - Quality of enhancement</strong></td>
<td></td>
<td></td>
<td>0.44</td>
</tr>
<tr>
<td>Solid</td>
<td>1 (9%)</td>
<td>8 (6%)</td>
<td></td>
</tr>
<tr>
<td>Thick</td>
<td>7 (64%)</td>
<td>105 (74%)</td>
<td></td>
</tr>
<tr>
<td>Thin</td>
<td>2 (18%)</td>
<td>24 (17%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (9%)</td>
<td>5 (3%)</td>
<td></td>
</tr>
<tr>
<td><strong>F12 - Definition of enhancing margin</strong></td>
<td></td>
<td></td>
<td>0.26</td>
</tr>
<tr>
<td>Well defined</td>
<td>7 (64%)</td>
<td>100 (70%)</td>
<td></td>
</tr>
<tr>
<td>Poorly defined</td>
<td>3 (27%)</td>
<td>40 (28%)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>1 (9%)</td>
<td>2 (15%)</td>
<td></td>
</tr>
<tr>
<td><strong>F13 - Definition of the non-enhancing margin</strong></td>
<td></td>
<td></td>
<td>0.21</td>
</tr>
<tr>
<td>Well defined</td>
<td>0 (0%)</td>
<td>24 (17%)</td>
<td></td>
</tr>
<tr>
<td>Poorly defined</td>
<td>11 (100%)</td>
<td>18 (83%)</td>
<td></td>
</tr>
<tr>
<td><strong>F16 - Hemorrhage (Yes)</strong></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td><strong>F17 - Diffusion characteristics</strong></td>
<td></td>
<td></td>
<td>0.72</td>
</tr>
<tr>
<td>Facilitated</td>
<td>5 (46%)</td>
<td>46 (32%)</td>
<td></td>
</tr>
<tr>
<td>Restricted</td>
<td>4 (36%)</td>
<td>66 (47%)</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>2 (18%)</td>
<td>30 (21%)</td>
<td></td>
</tr>
<tr>
<td><strong>F18 - Pial invasion (Yes)</strong></td>
<td></td>
<td></td>
<td>0.13</td>
</tr>
<tr>
<td><strong>F19 - Ependymal extension (Yes)</strong></td>
<td></td>
<td></td>
<td>0.49</td>
</tr>
<tr>
<td><strong>F20 - Cortical involvement (Yes)</strong></td>
<td></td>
<td></td>
<td>0.07</td>
</tr>
<tr>
<td><strong>F21 - Deep WM structures invasion</strong></td>
<td></td>
<td></td>
<td>0.029</td>
</tr>
<tr>
<td>Brainstem</td>
<td>2 (18%)</td>
<td>3 (2%)</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>0 (0%)</td>
<td>32 (23%)</td>
<td></td>
</tr>
<tr>
<td>Internal capsule</td>
<td>2 (18%)</td>
<td>31 (22%)</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>7 (64%)</td>
<td>76 (53%)</td>
<td></td>
</tr>
<tr>
<td><strong>F22 - nCET crosses midline (Yes)</strong></td>
<td>1 (9%)</td>
<td>23 (16%)</td>
<td></td>
</tr>
<tr>
<td><strong>F23 - CET crosses midline (Yes)</strong></td>
<td>1 (9%)</td>
<td>8 (6%)</td>
<td></td>
</tr>
<tr>
<td><strong>F24 - Satellites (Yes)</strong></td>
<td>4 (36%)</td>
<td>48 (34%)</td>
<td></td>
</tr>
<tr>
<td><strong>F25 - Calvarial remodeling (Yes)</strong></td>
<td>0 (0%)</td>
<td>4 (3%)</td>
<td></td>
</tr>
</tbody>
</table>

Association was evaluated by Fisher’s exact test for categorical variables and Wilcoxon rank sum test for continuous variables.

Table 2. AUC for continuous variables in differentiating BRAF mutant from BRAF wildtype

<table>
<thead>
<tr>
<th>Feature</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAIR cm3</td>
<td>0.528</td>
</tr>
<tr>
<td>Enhancement cm3</td>
<td>0.632</td>
</tr>
<tr>
<td>Necrosis cm3</td>
<td>0.540</td>
</tr>
<tr>
<td>Tum volume FLAIR+Enh+Nec</td>
<td>0.553</td>
</tr>
<tr>
<td>F5 - Proportion enhancing</td>
<td>0.667</td>
</tr>
<tr>
<td>F6 - Proportion nCET</td>
<td>0.628</td>
</tr>
<tr>
<td>F7 - Proportion of Necrosis</td>
<td>0.470</td>
</tr>
</tbody>
</table>

(Filename: TCT_1715_Tables.jpg)
A Rare Case of Brainstem Infarction due to Basilar Compression from Intradural Notochordal Remnant Lesion.

P Rathousky¹, M Chakko¹, R Bashiti¹
¹Ascension Providence Hospital / MSUCHM, Southfield, MI

Purpose
To highlight an unusual symptomatic presentation of an intradural notochordal remnant lesion resulting in stroke caused by basilar compression, treated by stenting.

Materials and Methods
70-year-old female presented to the emergency department with right sided weakness and dysarthria. Initial NECT head revealed an indeterminate left pontine hypodensity and prepontine mass. Subsequent CTA and MRI were performed which demonstrated subacute left pontine infarct, presumed to be related to basilar compression by the mass. The patient underwent emergent conventional angiography and stenting of the basilar artery. Routine imaging follow-up was performed which demonstrated stability of the lesion over a period of 5 years.

Results
Axial DWI demonstrates restricted diffusion compatible with subacute infarct of the left pons (A). Postcontrast sagittal T1 reveals a heterogeneously enhancing prepontine lesion (arrow) (B). Axial thin section bone window CTA demonstrates a bony stalk extending from the clivus to the intradural component of the lesion (arrow) and displacement of the basilar artery (curved arrow) (C). Axial T2 shows a hyperintense prepontine mass (arrow), encasing and compressing the basilar artery (curved arrow) (D).

Conclusions
The case highlights the diagnostic dilemma posed by midline clival lesions. The chief differential diagnosis ranges from the benign ecchordosis physaliphora (EP), to the potentially aggressive intradural chordoma. Both lesions arise from notochord remnants and as such may be found in the midline retroclival region. Pathologic analysis alone is often insufficient as both EP and intradural chordoma contain physaliphorous cells. As a result, there is controversy as to whether these lesions represent a spectrum of the same pathology. Thus, a combination of imaging and clinical features must be used to aide in diagnosis. Classic imaging features of EP include an osseous stalk connecting the intradural component to the clivus. On MRI, the lesion is uniformly T2 hypertense. Typically, EP does not demonstrate contrast enhancement. In contrast, intradural chordoma would be expected to avidly enhance. In our case the osseous stalk, stability over multiple years, lack of tumor blush on angiogram and overall non-aggressive appearance favors the diagnosis of EP despite minimal contrast enhancement.

(Filename: TCT_1658_Figure.jpg)
Enlarging Perivascular Spaces Following Radiation Therapy

I MARK1, C Carr2, D Johnson3

1MAYO CLINIC-ROCHESTER, ROCHESTER, MN, 2Mayo Clinic, Rochester, MN, 3Mayo Clinic, ROCHESTER, MN

Purpose
To present a case of enlarging perivascular spaces in the setting of radiation therapy.

Materials and Methods
A 62-year-old male underwent proton beam therapy for adult onset left cerebellar medulloblastoma in 2007. Multiple MR studies were acquired for tumor follow-up, with a progressive non-neoplastic imaging abnormality developing approximately 10 years following treatment. A companion case with similar history and imaging will also be presented.

Results
Serial T2-weighted axial images over five years demonstrate enlarging well-demarcated clustered cysts of variable sizes centered on the left basal ganglia. The cysts are isointense to CSF and do not enhance. There is a small amount of adjacent T2 hyperintense signal of the surrounding white matter laterally that concurrently increases as the cysts enlarge. Findings are most consistent with tumefactive dilated perivascular spaces. There is no evidence for tumor recurrence/progression at any timepoint.

Conclusions
Virchow-Robin or perivascular spaces are comprised of interstitial fluid around penetrating arteries that do not connect to the CSF. They are thought to be incidental and stable over time, though slow growth is occasionally seen. Tumefactive perivascular spaces are a rare subtype of enlarged perivascular spaces. At least one prior case of new dilated perivascular spaces following radiation has been reported. The recognition of benign perivascular spaces is important so as not to mistakenly suggest sinister pathology.

(filename: TCT_1788_enlargingPVS.jpg)

Atypical Teratoid Rhabdoid Tumors Can Occur in the Adult Population

K SEIFERT1, R Messina2

1YALE NEW HAVEN HOSPITAL, MILFORD, CT, 2Yale University School of Medicine, Woodbridge, CT

Purpose
Atypical Teratoid Rhabdoid Tumors are rare WHO IV tumors, generally seen in the posterior fossa in the pediatric patient population, with a median age less than 2 years. Rarely, these tumors can occur in adults, where the majority of these tumors will be supratentorial. Given the low number of adult patients diagnosed, this tumor is often not considered, which results in a delay in diagnosis and treatment.

Materials and Methods
A 53 year old female initially presented for evaluation of an known posterior fossa mass, that was found at an outside facility for evaluation of gait instability and dizziness. A CT was performed, which demonstrated a hyperdense extra-axial mass at the right cerebellopontine angle, resulting in mass effect to the cerebellum. The patient was taken to the OR for tumor resection/debulking. The intraoperative MRI was noted to have a heterogeneous enhancing mass. She was routinely followed for about 2 years, however, lost to follow up due to insurance issues, and later presented with numbness, ataxia, and back pain, and was found to have recurrent disease in the posterior fossa, with leptomeningeal carcinomatosis, as well as a large intramedullary thoracic mass.

Results
The initial CT demonstrated a hyperdense extra-axial mass in the right cerebellopontine angle with mass effect to the cerebellum, originally thought to represent a meningioma. The intraoperative MRI was notable for a heterogeneously enhancing mass. Thoracic MRI at the time of her presentation with numbness and ataxia revealed an avidly enhancing intramedullary mass resulting in cord compression.

(Filename: TCT_1788_ATRT.jpg)
signal abnormalities. A repeat brain MRI was notable for recurrent disease in the posterior fossa and new leptomeningeal carcinomatosis. The typical CT appearance of these tumors is an isodense mass, which commonly contains calcifications and will heterogeneously enhance. MRI characteristics show a T1 iso- to hyperintense, T2 hyperintense lesion, which will heterogeneously enhance and restrict diffusion. As these tumors tend to internally hemorrhage, imaging characteristics may altered. MR spectroscopy will show elevated choline and decreased N-acetylaspartic acid. Leptomeningeal seeding has been seen in a significant proportion of patients, and therefore, entire neuroaxis imaging has been recommended in these patients.

Conclusions
Although rare in the adult population, Atypical Teratoid Rhabdoid Tumor should be considered with a heterogeneously enhancing mass as it is a highly malignant tumor that requires prompt diagnosis.

(Filename: TCT_2327_ATRT.jpg)

2478

An intraventricular hemorrhagic lesion - an unusual presentation of a subependymoma.

S Hiremath1, M Kingstone1, V Tsehmaister-Abitbul2
1The Ottawa Hospital, Ottawa, Ontario, 2University of Ottawa, Ottawa, Ontario

Purpose
To present an unusual radiological appearance of subependymoma as bilateral ventricular heterogeneous enhancing hemorrhagic lesions.

Materials and Methods
A 43-year-old woman with a few month's history of headache underwent an MRI, which revealed bilateral ventricular lesions.

Results
The magnetic resonance images showed a large heterogeneously enhancing ventricular lesion in the atrium of the right ventricle (Fig 1A, B). It was associated with blooming artifact on gradient images, suggestive of hemorrhagic areas (Fig 1C). There was no diffusion restriction. Perfusion maps demonstrated relative high CBV in the periphery of the lesion (Fig 1D). Additional smaller lesions were seen in the left lateral ventricle. The initial differential considerations included choroid plexus neoplasm, choroid plexus papilloma, or choroid plexus carcinoma, as well as ependymoma or central neurocytoma. However, surgical pathology revealed it to be a hemorrhagic subependymoma WHO Grade 1.

Conclusions
We describe a rare imaging presentation of subependymoma as an enhancing, multifocal biventricular hemorrhagic lesion. Multiplicity, hemorrhage, and enhancement in subependymoma are uncommon. Only a few case reports have been published in the
Although rare, awareness of this unusual imaging manifestation of a subependymoma is essential, as it may broaden the differential diagnosis and influence the management and clinical outcome.
Differentiating Primary Central Nervous System Lymphoma from Glioblastoma using Mono-, Bi-, and Stretched Exponential Diffusion-Weighted Magnetic Resonance Imaging: A histogram analysis

D Momsakak, O Togao, K Kikuchi, Y Kikuchi, A Hiwashi
1Kyushu university, Fukuoka, Fukuoka, 2Kyushu University, Fukuoka, Fukuoka, 3Kyushu university, Fukuoka, Fukuokashi

Purpose
To compare the diagnostic performance of mono-, bi, and stretched-exponential DWIs in differentiating primary central nervous system lymphomas (PCNSLs) from glioblastomas (GBs).

Materials and Methods
Sixty-six patients including 18 patients with PCNSL (10 males and 8 females, age 67.2 ± 14.9 y.o.) and 48 patients with GB (28 males and 20 females, age 64.0 ± 17.8 y.o.), were retrospectively studied. All patients were histopathologically diagnosed and had received no treatment before MRI. DWI was performed using a 3T unit with 13 b-values (0, 10, 20, 30, 50, 80, 100, 200, 300, 400, 600, 800, 1000 s/mm2). The apparent diffusion coefficient (ADC) was obtained with two b-values (0 and 1000 s/mm2). The true diffusion coefficient (D), pseudo-diffusion coefficient (D*) and perfusion fraction (f) were calculated by fitting the bi-exponential model. The distributed diffusion coefficient (DDC) and heterogeneity index (α) were obtained by fitting the stretched-exponential model. We measured histogram values including 10, 25, 50, 90 percentiles in regions-of-interest which were placed within the area that corresponded to the enhancing area on postcontrast T1-weighted images. Histogram values were compared between PCNSL and GB using Mann-Whitney U-test. Receiver-operating characteristics analysis was performed and then the histogram values showing the largest area under the curve (AUC) were evaluated.

Results
The ADC50th, D50th and DDC50th values were significantly lower in PCNSL (0.87 ± 0.18, 0.82 ± 0.18, and 0.85 ± 0.21 x10−3 mm2/s, respectively) than those in GB (1.13 ±0.22, 1.08 ± 0.22, and 1.15 ± 0.27 x10−3 mm2/s; all for p < 0.0001). The f90th value was significantly lower in PCNSL (10.4 ± 2.8 %) than that in GB (13.3 ± 4.1 %, p = 0.0026). There were no significant differences in α and D* values (P > 0.05). The AUC values for ADC50th, D50th, DDC50th and f90th were 0.84, 0.82, 0.82, and 0.74, respectively. The combination of the D50th and f90th showed the best diagnostic performance (AUC = 0.85).

Conclusions
The combination of D50th and f90th derived from the bi-exponential model showed the best diagnostic performance in differentiating PCNSLs from GBs.

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Prediction of IDH1/2-Mutation Status of Glioblastoma in Preoperative MR Imaging using the VASARI feature set

O Arevalo, L De Alba, A Dono, T Takayasu, Y Esquenazi, L Ballester, X Zhang, C Soto, S Khanpara, J Zhu, R Riascos
1The University of Texas Health Science Center at Houston, Houston, TX, 2National University of Colombia, Bogota, TX

Purpose
Glioblastomas (GBM) are classified by the presence of a mutation in the isocitrate dehydrogenase genes in wildtype (IDH1/2-WT) and mutant (IDH1/2-Mut), which have prominent differences in prognosis. We aimed to evaluate the predictive value of imaging phenotypes to discriminate these subtypes by the assessment of the Visually AcceSAble Rembrandt Images lexicon (VASARI), in addition to semiautomated segmentation.

Materials and Methods
MR imaging scans of 167 patients with pathological diagnosis of GBM with known IDH1/2 statuses were included (153 IDH1/2-WT, 14 IDH1/2-Mut ). MR imaging features were reviewed using VASARI, moreover semiautomated segmentation was performed (volumetric measurement of the enhancement, FLAIR hyperintensity, and necrosis). The association between genotype and MR features was evaluated by Fisher's exact test for categorical variables. For continuous variables, the Wilcoxon rank-sum test and AUC were used.

Results
Ten of the twenty-five imaging features of the VASARI set were significantly different according to IDH1/2-mutation. IDH1/2-WT GBMs showed higher enhancing and necrosis volumes (p<0.001), enhancement/FLAIR (p<0.001), and necrosis/enhancement (p<0.001) volume ratios. Conversely, the IDH1/2-Mut GBMs demonstrated a predilection for the frontal and parietal lobes (p=0.03), a higher prevalence of cysts (p=0.028), and higher rates for ill-defined enhancing margin (p<0.001). Interestingly, ependymal invasion was seen at diagnosis only in IDH1/2-WT GBMs (p=0.023). The AUC on the ROC curve was significant for the volume of enhancement (0.784) and necrosis (0.794), and the different ratios between enhancing, non-enhancing, and necrotic tumor (0.765-0.810).

Conclusions
Imaging features predict IDH1/2 mutations in GBM on standard-of-care (SOC) MR scans. Our results are in concordance and validate
other published studies on isolated imaging biomarkers. A combination of the discriminating depicted features on SOC MR scans, including volumetric measurements, demonstrated value in distinguishing between GBMs harboring IDH1/2-mutation from their wildtype counterpart.
Table 1. Association between imaging features and IDH1 mutation status (N=167)

<table>
<thead>
<tr>
<th>Feature</th>
<th>IDH1 mutant (N=14)</th>
<th>IDH1 wildtype (N=153)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAIR volume cm³, median (IQR)</td>
<td>104 (32, 204)</td>
<td>109 (59, 148)</td>
<td>0.86</td>
</tr>
<tr>
<td>Enhancement volume cm³, median (IQR)</td>
<td>3.11 (0.50, 7.80)</td>
<td>18.79 (9.80, 32.20)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Necrosis volume cm³, median (IQR)</td>
<td>0.25 (0, 1.80)</td>
<td>3.80 (1.90, 11.20)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Tumor volume FLAIR+Enh+Nec, median (IQR)</td>
<td>112 (32, 204)</td>
<td>138 (79, 191)</td>
<td>0.40</td>
</tr>
</tbody>
</table>

**F1. Tumor location**
- Frontal: 11 (79%) vs 49 (32%), P = 0.029
- Temporal: 1 (7%) vs 64 (42%), P = ~0.001
- Insular: 0 (0%) vs 5 (3%), P = 0.32
- Parietal: 2 (14%) vs 27 (17%), P = 0.63
- Occipital: 0 (0%) vs 5 (3%), P = 0.028
- Corpus callosum: 0 (0%) vs 4 (3%), P = 0.28

**F2. Side**
- Right: 6 (43%) vs 81 (53%), P = 0.65
- Center: 0 (0%) vs 5 (3%), P = 0.028
- Left: 8 (57%) vs 67 (44%), P = 0.028

**F3. Eloquent brain (Yes)**
- Yes: 5 (36%) vs 79 (52%), P = <0.001

**F4. Enhancement quality**
- Marked/avid: 5 (36%) vs 137 (90%), P = ~0.001
- Minimal/mild: 6 (43%) vs 11 (7%), P = 0.028
- None: 3 (21%) vs 5 (3%), P = 0.028

**F5. Proportion enhancing, median (IQR)**
- 3.19 (0.50, 11.03) vs 15.75 (10.74, 21.33), P = 0.001

**F6. Proportion nCET, median (IQR)**
- 95.5 (88.6, 99.5) vs 77.6 (70.4, 85.2), P = <0.001

**F7. Proportion of Necrosis, median (IQR)**
- 0.24 (0, 2.0) vs 4.29 (2.0, 7.88), P = <0.001

**F8. Cysta (Yes)**
- Yes: 5 (36%) vs 18 (12%), P = 0.028

**F9. Multifocal/Multicentric (Yes)**
- Yes: 2 (14%) vs 16 (10%), P = 0.65

**F10. T1/FLAIR ratio**
- Expand: 8 (57%) vs 85 (56%), P = 0.32
- Mixed: 0 (0%) vs 21 (14%), P = 0.028
- Infiltrative: 6 (43%) vs 47 (31%), P = 0.028

**F11. Thickness of enhancing margin**
- Solid: 5 (36%) vs 9 (6%), P = <0.001
- Thick: 5 (26%) vs 112 (73%), P = <0.001
- Thin: 1 (7%) vs 26 (17%), P = <0.001
- None: 3 (21%) vs 6 (6%), P = <0.001

**F12. Definition of enhancing margin**
- Well defined: 2 (14%) vs 107 (70%), P = 0.028
- Poorly defined: 9 (64%) vs 43 (28%), P = 0.028
- None: 3 (21%) vs 3 (2%), P = 0.028

**F13. Definition of the non-enhancing margin**
- Well defined: 3 (21%) vs 24 (16%), P = 0.70
- Poorly defined: 11 (79%) vs 129 (84%), P = 0.028

**F16. Hemorrhage (Yes)**
- Yes: 4 (29%) vs 98 (64%), P = 0.019

**F17. Diffusion characteristics**
- Facilitated: 8 (57%) vs 51 (33%), P = 0.23
- Restricted: 4 (29%) vs 70 (46%), P = 0.23
- Mixed: 2 (14%) vs 32 (21%), P = 0.23

**F18. Pal invasion (Yes)**
- Yes: 3 (21%) vs 77 (50%), P = 0.05

**F19. Ependymal extension (Yes)**
- Yes: 0 (0%) vs 41 (27%), P = 0.023

**F20. Cortical involvement (Yes)**
- Yes: 14 (100%) vs 129 (84%), P = 0.22

**F21. Deep WM structures involvement**
- Brainstem: 0 (0%) vs 5 (3%), P = 0.26
- Corpus callosum: 6 (43%) vs 32 (21%), P = 0.26
- Internal capsule: 1 (7%) vs 33 (22%), P = 0.023
- No: 7 (50%) vs 83 (54%), P = 0.26

**F22. nCET crosses midline (Yes)**
- Yes: 4 (29%) vs 24 (16%), P = 0.26

**F23. nCET crosses midline (Yes)**
- Yes: 0 (0%) vs 9 (6%), P = 0.26

**F24. Satellites (Yes)**
- Yes: 2 (14%) vs 52 (34%), P = 0.23

**F25. Calvarial remodeling (Yes)**
- Yes: 0 (0%) vs 4 (3%), P = 1.00

Association was evaluated by Fisher’s exact test for categorical variables and Wilcoxon rank sum test for continuous variables.

Table 2. AUC for continuous variables in differentiating IDH mutant from IDH wildtype

<table>
<thead>
<tr>
<th>Feature</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>FLAIR volume cm³</td>
<td>0.486</td>
</tr>
<tr>
<td>Enhancement volume cm³</td>
<td>0.784</td>
</tr>
<tr>
<td>Necrosis volume cm³</td>
<td>0.794</td>
</tr>
<tr>
<td>Tumor volume FLAIR+Enh+Nec</td>
<td>0.432</td>
</tr>
<tr>
<td>F5 - Proportion enhancing tumor</td>
<td>0.765</td>
</tr>
<tr>
<td>F6 - Proportion non-enhancing tumor</td>
<td>0.791</td>
</tr>
<tr>
<td>F7 - Proportion of Necrosis</td>
<td>0.810</td>
</tr>
</tbody>
</table>

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Microglial Density Alters Measures of Axonal Integrity and Structural Connectivity

S Yi1, N Stowe2, B Barnett2, K Dodd2, J Yu1
1University of Wisconsin School of Medicine and Public Health, Madison, WI, 2University of Wisconsin-Madison, Madison, WI

Purpose
This purpose of this study was to examine how changes in microglial density influence quantitative measures of neuronal microstructure. Little is known regarding how alterations in the glial composition of the brain can affect measures of axonal integrity and structural connectivity despite increasing evidence that suggests a highly dynamic neuroglial environment is present in both health and disease.

Materials and Methods
Microglia were depleted via treatment with CSF1R inhibitor, PLX5622. Ex vivo diffusion weighted imaging of age- and sex-matched control and CSF1R-inhibitor-treated brains was performed. A DTI-based mouse brain atlas was used to generate a study-specific template and regions of interest (ROI) including left and right hippocampus, prefrontal cortex, globus pallidus, amygdala, nucleus accumbens, corpus callosum, and internal capsule. ROI analyses of FA, and AxCaliber (res), NODDI (NDI), and ActiveAx (ic) representing MC-DWI indices of axonal diffusion were calculated in each ROI and compared between control and microglia-depleted animals. Deterministic fiber tractography of the right hippocampus was also generated in control and microglia-depleted animals. The mean number of tracts, tract length, and tract density were calculated, and paired-sample t-tests were used to compare these measures between controls and microglia-depleted animals.

Results
Following microglial depletion with PLX5622, we observed a significant reduction in microglial density (Fig. A and B). Diffusion weighted imaging of age- and sex-matched control and microglial depleted brains revealed statistically significant changes of decreased axonal integrity in both DTI and MC-DWI models across several ROIs in the bilateral gray and white matter including the hippocampus, corpus callosum, amygdala, and globus pallidus. Deterministic fiber tractography of the right hippocampus demonstrated a significant decrease in the number of fiber tracts, tract length, and tract volume (p < 0.05) in brains of animals treated with CSF1R inhibitor with markedly different tractography streamlines and clear visual differences in fiber orientation and organization in microglia-depleted animals (Fig. C and D).

Conclusions
With accumulating evidence of the role of microglia in neurologic, neurocognitive, and neuropsychiatric illness, our findings support a reconsideration of interpretations of axonal integrity and structural connectivity in DWI and the role of neuroglia in neuroimaging assessments of axonal integrity in the brain.
Improvement of Glymphatic System Activity Following Lumbar Drain Placement in Idiopathic Normal Pressure Hydrocephalus

A Zhang¹, H Tatekawa², N Salamon³
¹UCLA, Los Angeles, CA, ²University of California, Los Angeles, Los Angeles, CA, ³UCL, Los Angeles, CA
To investigate change in glymphatic system activity in a patient with idiopathic normal pressure hydrocephalus (iNPH) before and after therapeutic lumbar drain placement through diffusion tensor imaging (DTI) analysis.

Materials and Methods
A 76 year-old right-handed female was diagnosed by a board-certified neurologist with 5 years experience in adult neurology as having iNPH based on neurological assessment, and subsequently treated with therapeutic lumbar-drain placement. Before and after lumbar drain placement, the patient received MRI examinations with diffusion tensor imaging. In order to approximate glymphatic system activity, diffusivity maps in the direction of the x-axis (right-to-left) (Dx), y-axis (anterior-to-posterior) (Dy), and z-axis (inferior-to-superior) (Dz) were generated and coregistered to the International Consortium for Brain Mapping (ICBM) DTI-81 atlas. These maps were used to calculate an analysis along the perivascular space (ALPS) index, an index used to approximate glymphatic system activity defined as mean (Dxpro, Dypro)/mean (Dypro, Dzasc), where Dxpro and Dxasc are Dx values in the projection and association fiber areas, respectively.

Results
MR brain images before and after lumbar drain placement demonstrate diffuse brain volume loss with increased ventricular size out of proportion to sulcal volume loss, with no significant change between exams. Previously published data on the use of ALPS index for the diagnosis of iNPH showed patients clinically diagnosed with iNPH to have a mean ALPS index of 0.94+/-0.06, while control patients had a mean ALPS index of 1.18+/-0.08. In our patient, initial ALPS index prior to lumbar drain placement was 0.85, while ALPS index after lumbar drain placement increased to 1.08, suggestive of improvement in glymphatic system activity.

Conclusions
iNPH is often challenging to diagnosis, as both clinical and imaging findings are frequently nonspecific. Evaluation of glymphatic system activity by using DTI analysis to calculate an Atlas-based ALPS index is a recently proposed method to aid in diagnosis. This initial excerpt suggests that after therapeutic drain placement, glymphatic system activity in iNPH patients may improve toward normal. This finding further supports the role of glymphatic system dysfunction in the pathogenesis of iNPH, and suggests that the use of atlas-based ALPS index to help diagnose iNPH may be a promising direction for future study.
Purpose
Our aim was to longitudinally evaluate with diffusion tensor imaging (DTI) the integrity of cerebral white matter in patients with moderate and severe DAI at three moments after trauma. In addition, correlations between DTI quantitative parameters and neuropsychological data were also investigated.

Materials and Methods
Twenty victims of moderate and severe TBI were scanned at a 3 Tesla MRI at three different times: 2 months (timepoint 1), six months (timepoint 2), and 12 months (timepoint 3) after trauma. ExploreDTI software was used to perform deterministic tractography of the corpus callosum (CC) and bilateral superior longitudinal fascicles (SLF). Different cognitive domains were evaluated, such as attention, verbal fluency, working memory, and estimation of the intelligence coefficient (IQ). A generalized linear function test with robust standard error and unstructured correlation matrix was performed to evaluate changes over time of DTI parameters and neuropsychological tests. The Benjamin - Hochberg procedure for repeated measures was performed. Pearson and Spearman's tests assessed correlation coefficients. Results were considered significant with p <0.05.

Results
The CC and both SLF demonstrated extensive microstructural abnormalities, with more noticeable changes in the body and the splenium. All DTI parameters demonstrated changes across time in the body of the cc, while only FA (fractional anisotropy) changes were seen on both SLF. In the splenium of the corpus callosum, changes in the mean diffusivity (MD) and axial diffusivity (AD) were observed across time. There was an improvement in attention domain test performance between 6 and 12 months. The FA values in all segments of the CC demonstrated a positive correlation with attention, verbal fluency, and IQ estimation. Throughout time, different cognitive domains findings demonstrated different correlations with DTI parameters on the different brain regions studied.

Conclusions
We observed quantitative changes in DTI values in various segments of white matter tracts. The diversity of correlation findings of the evaluated cognitive indices and the respective studied areas demonstrate how heterogeneous and extensive are the microstructural changes present in DAI. The results of this study demonstrate that even after 12 months of the traumatic event, there are microstructural changes in the white matter, and these are detectable by DTI.
Fully Automated Segmentation of the Corticospinal Tract Using TractSeg Algorithm in Patients with Brain Tumors.

T Richards¹, K Anderson², J Anderson²

¹University of Utah School of Medicine, Salt Lake City, UT, ²University of Utah, Salt Lake City, UT
Purpose
Tractography has been used to define the presurgical location of corticospinal tracts in patients with lesions displacing the tract, but this is subjective and time-intensive, making incorporation to radiology workflow at scale problematic. We are validating a fully automated procedure using the TractSeg algorithm (Wasserthal et al. NeuroImage 2018 183:239-253) that can segment the entire corticospinal tract from raw diffusion weighted images in under 30 minutes from acquisition.

Materials and Methods
We automated using Matlab the import from PACS of a structural MPRAGE image and raw diffusion-weighted images, execution of the TractSeg algorithm, overlay of the resulting bilateral corticospinal tracts, fornix, and optic radiations on the MPRAGE image as a binary mask, and export of this composite image back to PACS. This procedure was used to segment the corticospinal tract in 10 patients with brain lesions including low and high grade astrocytomas, oligodendrogliomas, tumefactive demyelination, and cavernous malformations adjacent to or involving the corticospinal tract. Manual segmentation of the corticospinal tract was performed using DSI Studio using seeds placed in the pons. The manual segmentations were overlaid on the automated segmentations for visual comparison.

Results
In all 10 patients evaluated, the centerlines of the manually segmented corticospinal tracts were within 5 mm of the centerlines of the automated corticospinal tracts. In nearly all of the cases, the automated segmentation included more extensive contributions from the lateral radiations of the corticospinal tracts. In two cases, there was a brain tumor that was centered in the periorolical cortex and only the automated segmentation was able to identify tracts up to the mass through the internal capsule and corona radiata.

Conclusions
Initial results show that automated segmentation of the corticospinal tracts using TractSeg in patients with brain lesions near the corticospinal tracts generates results overlapping with manual segmentation, even when displaced by space-occupying lesions, despite being trained on healthy control data. Evaluation on a larger scale of patients is necessary to determine if this method of automated segmentation can inform surgical planning in patients with these challenging lesions while conforming to modern radiology workflows.

Tractography of the Arcuate Fasciculus in Healthy Right-Handed and Left Handed Trilingual Subjects and Its Relation to Language Lateralization on Functional MRI.
Purpose
fMRI enables evaluation of language lateralization and plays a central role in surgical planning. Diffusion Tensor Imaging (DTI) allows evaluation of the white matter fibers involved in language. Unlike fMRI, Tractography is a technique that does not rely on the patient's cooperation. In monolingual subjects, there is a good correlation between the lateralization of language on fMRI and the DTI Laterality Index (DTI-LI). Our objective is to delineate the arcuate fasciculus (AF) in right and left-handed trilingual subjects and to determine if the AF laterality is correlated to the language lateralization on fMRI.

Materials and Methods
15 right and 15 left-handed trilingual volunteers underwent fMRI and DTI on a 3T GE magnet. Language fMRI was performed with a visual responsive naming paradigm that was repeated for each of the 3 languages. 33 directions DTI was also obtained. Analysis was done using SPM12 for fMRI and TrackVis for DTI. fMRI Laterality Index (LI) was determined on fMRI. Mean Diffusivity, Fractional Anisotropy (FA), Fiber Volume and DTI-LI of the AF were calculated on tractography. Their correlation was assessed with Pearson Index.

Results
28 subjects presented a bilateral AF. Most subjects (52%) were found to have a bilateral language lateralization of the AF. Only 4 subjects had bilateral lateralization of language on fMRI. The diffusivity was significantly different between the right AF and the left AF in the global population (p<0.001) and in the right-handed (p=0.017) and the left-handed subjects (p=0.002), with a higher diffusivity of the left AF. The FA, the Volume and the Length of the AF were not significantly different between the right and the left AF. There was no correlation between the DTI-LI of the AF and the LI on fMRI. In the right hemisphere of the right-handed subjects, there was positive correlation between the FA (p=0.044), and a negative correlation between the Fiber Volume (p=0.02), the number of fibers (p=0.035) and the LI. No correlation was found in the left-handed subjects.

Conclusions
While in monolingual subjects, the leftward asymmetry of the volume of the AF is correlated to the left lateralization of language on fMRI, this is not applicable in trilingual subjects. Trilingualism leads to a more bilateral structural organization of the arcuate fasciculus. In right-handed subjects, the volume and number of fibers of the AF in the right hemisphere decrease and the FA increases when the left lateralization of language (LI) increases on fMRI.
Correlation between Cranial Nerve Microstructural Characteristics and Vestibular Schwannoma Tumor Volume

A Halawani1, S Tohyama2, P Hung3, B Behan4, M Bernstein4, S Kalia4, G Zadeh4, M Cusimano6, M Schwartz7, F Gentili8, D Mikulis9, N Laperriere9, M Hodaie10

1University of Toronto, Toronto, Ontario, 2Krembil Research Institute, Toronto Western Hospital, Toronto, Ontario, 3Ontario Brain Institute, Toronto, ON, 4Krembil Research Institute, Toronto, ON, 5The Arthur and Sonia Labatt Brain Tumour Research Centre, Toronto, ON, 6Li Ka Shing Knowledge Institute, Toronto, ON, 7Sunnybrook Health Sciences Centre, Toronto, ON, 8Cancer Clinical Research Unit (CCRU), Princess Margaret Cancer Centre, Toronto, ON, 9Toronto Western Hospital, Toronto, ON, 10Toronto Western Hospital, Toronto, Ontario

Purpose

Vestibular Schwannoma (VS) are common cerebellopontine angle tumors arising from the vestibulocochlear nerve which can result in cranial nerve dysfunction. Conventional imaging doesn't provide sufficient detail to determine the level of CNs compression and correlate this CNs symptoms. In this study, we use multi-tensor diffusion tensor imaging (MT-DTI) to evaluate the relationship between the white matter microstructural properties of CNs and tumor volume in a cohort of VS treated with Gamma Knife radiosurgery (GKRS), as a first step to correlate DTI changes with function.

Materials and Methods

Retrospective chart review of 258 patients with VS treated at the GK clinic at Toronto Western Hospital (2014 to 2018). 3T-MRI images were analyzed in 162 surgically naïve patients after excluding bilateral VSs, prior surgical resection or GKRS. We assessed diffusion metrics (fractional anisotropy (FA), radial, axial, and mean diffusivities (RD, AD, MD)) of bilateral CN VII/VIII. The ROIs placed on the intracanalicular segment (IC). We also defined CN vulnerable zone (VZ) as the transition between the cisternal and IC segments, an anatomical area with increased mechanical compression by the tumor. For the unaffected side we define the VZ where the CNs travel in close proximity and become difficult to be differentiate anatomically. Criteria for tract assessment include anatomical accuracy of the tracts with CNs gross anatomy on T1 and T2 images and delineation of the tumor mass effect on the CNs. Image analysis was done using eXtended Streamline Tractography (XST) reconstruction method, previously demonstrated for its efficacy on producing detailed projections of CN VII/VIII compared to ST-DTI. Following this, the respective diffusion metrics were correlated with the calculated three-dimensional tumor volume that derived from GK clinic.

Results

DTI analyses revealed significantly higher FA values and reduction in AD, RD and MD (all p<0.00001) within the vulnerable zone of the affected VII/VIII CNs compared to unaffected side. All specific diffusivities demonstrated an inverse correlation with tumor volume (AD, RD, MD (p < 0.05)).

Conclusions

Our results suggest that MT-DTI allows for the quantification of microstructural alterations of the affected VII/VIII CNs. Moreover, our findings support the hypothesis that tumor volume may cause microstructural alterations of the affected VII/VIII CNs. This type of advanced imaging may represent a possible avenue to correlate diffusivities with cranial nerve function.

Role of Whole Brain Diffusion Kurtosis Imaging (DKI) in Differentiating Bipolar Depression from Unipolar Depression

M Maralakunte1, V Gupta2, S Grover1, C Ahuja1

1PGIMER, Chandigarh, Chandigarh, Chandigarh, 2Paras Hospitals, Panchkula, Haryana

Purpose

Depression is the most common morbidity affecting people worldwide. Bipolar depression (BD) is frequently misdiagnosed as Unipolar depression (UD), due to the lack of objective diagnostic criteria. Diffusion kurtosis imaging (DKI), an emerging technique utilized to assess tissue in-homogeneity and thereby the micro-structural changes causing the organic diseases of the brain. The purpose of the study was to identify the whole brain micro-structural changes (imaging markers) in differentiating Bipolar depression (BD) from Unipolar depression (UD) in the context of depressive episode by employing Diffusion Kurtosis (DKI) magnetic resonance imaging technique.
Materials and Methods
A prospective, cross-sectional, comparative study done in PGIMER (Institute of National Importance), Chandigarh, India (Jan 2017 to Jul 2018). Depressed (current episode) subjects with clinical diagnosis of Bipolar depression (BD) (n=21) or Unipolar depression (UD) (n=18), and Healthy individuals (HI) (n=20) were subjected for whole brain (parcellated into 189 regions of interest) Diffusion Kurtosis Imaging (DKI) evaluation. The diffusivity and kurtosis metrics, such as Mean diffusivity (MD), Axial diffusivity (AD), Radial diffusivity (RD) & Fractional anisotropy (FA) measured at b1000, and Mean kurtosis (MK), Axial kurtosis (AK), Radial kurtosis (RK) & Kurtosis Fractional anisotropy (KF) measured at b2000 value. Principle component analysis (PCA) and ANOVA with post hoc tests were used for statistical analysis.

Results
Increased Radial Diffusivity (RD) & Mean Diffusivity (MD) at left amygdala and decreased Mean Kurtosis (MK) & Radial Kurtosis (RK) at right hemicerebellum observed in Bipolar depression as compared Unipolar depression. Increased Axial Kurtosis (AK), Radial Kurtosis (RK), Mean Kurtosis (MK) at right amygdala and increased Mean Kurtosis (MK) at right external capsule found in Unipolar subjects (UD) as compared to bipolar (BD) and Healthy individuals.

Conclusions
It's a unique study which explored whole brain Diffusion Kurtosis Imaging technique to evaluate the micro-structural changes in Bipolar depression (BD) and Unipolar depression (UD) as compared to Healthy individuals (HI) as well as among the depressed groups (UD versus BD). It has provided additional insights into the brain areas which might play central role in etiopathogenesis of depression. This study able to find specific imaging markers which can potentially differentiate Bipolar depression (BD) from Unipolar depression (UD).

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REGION OF INTEREST</th>
<th>UNIPOLAR DEPRESSION (MEAN)</th>
<th>BIPOLAR DEPRESSION (MEAN)</th>
<th>CONTROL (MEAN)</th>
<th>P- VALUE (ANOVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean diffusivity</td>
<td>Left amygdala</td>
<td>1.07</td>
<td>1.16</td>
<td>1.07</td>
<td>0.024</td>
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<tr>
<td>Radial diffusivity</td>
<td>Left amygdala</td>
<td>0.99</td>
<td>1.08</td>
<td>1.002</td>
<td>0.019</td>
</tr>
<tr>
<td>Mean kurtosis</td>
<td>Right External capsule</td>
<td>0.89</td>
<td>0.85</td>
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<td>0.0000098</td>
</tr>
<tr>
<td>Radial kurtosis</td>
<td>Right amygdala</td>
<td>0.76</td>
<td>0.73</td>
<td>0.68</td>
<td>0.002</td>
</tr>
<tr>
<td>Mean kurtosis</td>
<td>Right amygdala</td>
<td>0.75</td>
<td>0.71</td>
<td>0.68</td>
<td>0.001</td>
</tr>
<tr>
<td>Axial kurtosis</td>
<td>Right amygdala</td>
<td>0.71</td>
<td>0.66</td>
<td>0.68</td>
<td>0.003</td>
</tr>
<tr>
<td>Mean kurtosis</td>
<td>Right cerebellum</td>
<td>0.95</td>
<td>0.90</td>
<td>0.94</td>
<td>0.05</td>
</tr>
<tr>
<td>Radial kurtosis</td>
<td>Right cerebellum</td>
<td>1.01</td>
<td>0.96</td>
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(Filename: TCT_1630_subbarao-final.gif)

Upper Limbs Forced Exercise in Parkinson Disease: Arterial Spin Labeling Brain, DTI and Resting State f-MRI assessment.

L Monti1, D Momi2, L Messa3, F Ginanneschi1, M Senesi4, C Battisti3, D Cioncoloni5, B Pucci3, A Rossi6
1University Hospital of Siena, Siena, Italia, 2Imaging and Clinical Sciences, University “G. d’Annunzio”, Chieti, Chieti, 3Neurology and Clinical Neurophysiology Unit, Siena, Tuscany, 4Unit of Diagnostic and Functional Neuroimaging, 53100, Tuscany, 5Rehabilitation and Physiotherapy Unit, Siena, Tuscany, 6Neurology Unit, Siena, Tuscany

Purpose
Recent data in rodent model of Parkinson disease (PD) suggest that motor forced exercise (FE) triggers an endogenous release of neurotrophic factors within areas of the basal ganglia, which is likely to increase the level of dopamine within the dorsolateral striatum and facilitate compensatory changes in dopamine handling and neurotransmission. Forced cycling (lower limbs) exercise experiments in PD patients induced a significant higher global motor improvement than patients who completed the same
voluntary, not forced-cycling exercise. The aim of the present study was to determine 1) if there are reliable microstructural differences in specific white matter tracts between pre-treatment phase and post-treatment phase; 2) CBF and brain connectivity changes and 3) if there is a related improvement of quality life.

Materials and Methods

A specially designed device AngelWings device®, has been used for upper limb FE. UPDRS scores, functional magnetic resonance imaging (rs-fMRI, ASL, DTI) and ad-hoc cognitive assessment will be used before and after 2-months of upper limb exercise paradigm in 10 right handed PD patients.

Results

Neuroimaging analyses after 2 months' exercise training showed, with respect to pretraining condition, many changes: 1) increased functional connectivity between right and left hemispheres and 2) increased cerebral blood flow in the left primary motor cortex (M1), left supplementary motor cortical area, and left cerebellar cortex. 3) No significant changes of FA and MD have been demonstrated among FA pre-treatment (0.5900 ± 0.01158, n=14); MD pre-treatment (0.9887 ± 0.01851) and FA post-treatment (0.5940 ± 0.009749, n=15);MD post-treatment (0.9685 ± 0.02227). 4) After 2 months' upper-limb training, a significant improvement in the UPDRS-III and the neurocognitive tests have been demonstrated UPDRS-III score improved by 68% when compared with baseline.

Conclusions

Improvement of global motor function after FE provides a strong evidence that functional MRI findings (CBF and rs-fMRI) reflect adaptive CNS changes without statistical significant difference of pyramidal tract microstructure. Our results could likely be related to compensatory mechanisms and could suggest a new complementary therapeutic strategy.
sensorineural hearing loss and possible conductive deafness with stapes footplate fixation. It is a rare genetic disease due to POU3F4 gene mutation located on chromosome Xq21. X-linked deafness is characterized by symmetrical cochlear incomplete partition type 3 (IP-III) and has pathognomonic imaging findings including absence of bony modiolus and of the bony plate separating the base of the cochlea and internal auditory canal (IAC) and dilated IAC, wide tympanic and labyrinthine segments of the facial nerve canal and malformed vestibules and semisircular canals. Vestibular diverticula have been recently reported with X-linked deafness.

Malformations in the hypothalamus in the patients with this genetic anomaly have been recently reported and it was pointed that POU3F4 had a critical role in the development of inner ear and hypothalamus both. In this study we aimed to examine CT and MRI findings of patients with X-linked deafness with bilateral IP-III to evaluate inner ear and hypothalamus retrospectively.

Materials and Methods
Among all patients with bilateral typical inner ear findings with diagnosis of X-linked deafness cases that had their baseline temporal bone CT available in PACS database of Hacettepe University were included in the study (n=12). Patients who didn't meet these criteria, whose imaging had artifact were excluded from study. Nine patients had MRI examinations. CT and MRI examinations of patients in this study were retrospectively evaluated.

Results
Study group consisted of 12 patients. All subjects but one was male (M/F: 11/1). Mean age was 10.18 years (min: 7/12, max: 53 years). All cases had bilateral typical IP-III with large IAC, absent bony modiolus and lamina spiralis and preserved interscalar septa and cochlea size. Five patients (41%) had bilateral vestibular diverticula. All patients had bilateral cochlear vestibular and facial nerves. Characteristic dysmorphism of the hypothalamus appeared thickened and irregular bulky on axial images. Among in patients who had MRI, eight patients (88%) had mammillary body hyperplasia with asymmetry in four and hamartoma-like lesion in five.

Conclusions
Hypothalamic malformations including mammillary body hyperplasia and associated hamartoma-like lesion and vestibular diverticula may be seen in X-linked deafness with high rates according to our study. Radiologist should be aware of this situations.

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The Natural History of Tiny Vestibular Schwannomas

S. Akkan1, S Finucane1, M Bashir1, D Moore1, M Kircher1, C Britt1
1Loyola University Medical Center, Maywood, IL

Purpose
Contrast enhanced MRI is considered the "gold standard" test for the diagnosis of vestibular schwannoma and is often performed in the work up for sensorineural hearing loss. However, the incidence of discovering a vestibular schwannoma is low and there are drawbacks associated with contrast enhanced MRI including contrast reactions, high cost, and patient anxiety/claustrophobia. Several protocols have been developed for a screening non contrast MRI to minimize these factors. Multiple prior studies have shown high accuracy of screening MRI protocols with false negatives primarily occurring when tumors measure ≤ 4mm. This study aims to examine the growth pattern of tiny vestibular schwannomas measuring ≤ 4mm and predict the likelihood of a tiny vestibular schwannoma needing treatment.

Materials and Methods
After IRB approval, a retrospective review was performed. Illuminate Insight software was used to conduct a search of all MRI brain and internal auditory canal studies from 1995-2019. The search resulted in 372 cases which were then evaluated for the presence of a vestibular schwannoma measuring ≤ 4mm and a follow up MRI. Images were reviewed by a neuroradiologist and any cases with imaging features not characteristic of a vestibular schwannoma were excluded.

Results
A total of 8 patients were identified with tiny vestibular schwannomas meeting all search criteria. The maximum growth demonstrated by these lesions was 2 mm. The observation times ranged from 1-13 years.

Conclusions
None of the tiny vestibular schwannomas identified in this study grew more than 2 mm over the observation times of 1-13 years. Kirchmann et al showed that vestibular schwannomas are most likely to grow in the first few years after diagnosis, with few growing after 4.6 years of observation. In this study, 2 cases had observation times significantly less than 4.6 years (1 and 2 years, with the next lowest being 4 years), suggesting that most observation times were adequate to assess potential growth. Even excluding the cases with an observation time of 1-2 years there was no significant growth. Furthermore, none of the 8 patients required or underwent surgical resection for their tiny vestibular schwannoma according to available medical records. Overall, the findings in this study further support the use of screening MRI protocols for vestibular schwannoma by demonstrating the lesions that are most likely to cause false negatives do not grow significantly and have low likelihood of needing treatment.

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Diagnostic Performance of Cone Beam CT Pixel Values in Otospongiosis

F. Deng1, P Touska2, K Reinshagen3, H Curtin3, A Juliano3

ASNR20 Virtual Proceedings Page 1020
Purpose
Imaging diagnosis of the spongiotic/lucent phase of otosclerosis (otospongiosis) relies on detection of abnormal hypodensity involving the otic capsule on multidetector CT (MDCT). The preferential site of involvement for fenestral otospongiosis is the region anterior to the oval window. Prior studies support quantitative bone densitometry on MDCT as a diagnostic aid for fenestral otospongiosis.[1] Cone-beam CT (CBCT) has gained interest in temporal bone imaging for its ability to produce high spatial resolution images potentially using less radiation than MDCT, but a major barrier to assessing bone density on CBCT is the technical variability of CBCT pixel values. A method to calibrate CBCT pixel values using internal references has been suggested.[2] The purpose of this study is to evaluate the performance of internally calibrated CBCT pixel value measurements/ratios for the diagnosis of fenestral otospongiosis.

Materials and Methods
CBCT images were evaluated in 37 ears with otospongiosis and 35 control ears (22 age-matched patients per group). Regions of interest 0.5 square millimeters in size were drawn by two blinded head and neck radiologists in regions anterior to the oval window (AOW), in the lateral semicircular canal (LSCC) bone island, and in an aerated space within the temporal bone nearest the lateral otic capsule (air). A relative attenuation ratio (RAR) was calculated from mean CBCT pixel values within each region of interest: (AOW – air) / (LSCC bone island – air). Receiver operating characteristic (ROC) analysis was performed using different RAR thresholds for predicting otospongiosis. An optimal operating point was identified by pooling both readers' results and maximizing Youden's J statistic (sensitivity + specificity – 1). Sensitivity and specificity were then calculated for the mean RAR for the two readers.

Results
The area under the ROC curve for reader 1 was 0.982 (95% confidence interval [CI]: 0.961-1.000) and for reader 2 was 0.987 (95% CI: 0.987-0.987). The optimal RAR cutoff was 0.844. Below this cutoff, otospongiosis was correctly predicted with a mean sensitivity of 94.6% (95% CI: 81.2-99.3%) and specificity of 97.1% (95% CI: 83.9-100%).

Conclusions
Internally calibrated pixel value ratios in temporal bone CBCT can feasibly help diagnose fenestral otospongiosis.
Identifying Imaging Predictors of Vestibular Schwannoma Resectability

J Huang, N Deep, M Scheck, J Connors, G Fatterpek, J Roland, J Golfinos, D Jethanamest, M Hagiwara

NYU School of Medicine, New York, NY, N/A, N/A

Purpose
We performed a comprehensive evaluation of magnetic resonance imaging features for correlation with features of vestibular schwannoma (VS) resectability including extent of resection and outcome.

Materials and Methods
This retrospective study examined patients with VS resected from 1/2016 to 4/2019. Exclusion criteria included size of the extracanalicular portion smaller than 1.5 cm and multiple VS. Clinical measures included extent of resection, facial nerve stimulation, House-Brackmann score at 1 year after operation or last follow-up, status of arachnoid planes around the VS, and need for additional treatment. Two blinded readers assessed imaging measures including total and extracanalicular sizes, extension anterior to the porus acusticus (PA), anterior and posterior angles between the petrous ridge (PR) and VS, difference between ipsilateral and contralateral angles of the anterior and posterior PA margins, T2 and ADC values, and presence of susceptibility, cysts, cleft between the VS and brainstem, midline shift, adjacent edema, and extension to the foramen of Luschka. Quantitative measures were averaged and qualitative measures were reviewed for consensus. We analyzed preliminary data in 50 subjects using the Fisher and Mann-Whitney tests and Pearson and Spearman correlations.

Results
Preserved arachnoid planes correlated with presence of cysts (95.2% of VS with cysts vs 64.3% without, p<0.05) (Table 1) and larger contralateral than ipsilateral angles of the anterior margin of the PA (4.92 vs 5.83°, p<0.05) (Table 2). Need for additional treatment correlated with smaller anterior angle between the VS and the PR (27.66 vs 42.77°, p<0.05), larger size including longest dimension (4.05 vs 2.73 cm, p<0.001), greater extension anterior to the PA (0.50 vs 0.22 cm, p=0.005), and larger difference in pontine angle (43.13 vs 16.72°, p<0.005) (Table 2). Lesser extent of resection correlated with a smaller angle between the VS and the PR anteriorly (r= -0.33, p<0.05) and posteriorly (r= -0.32, p<0.05), larger size including longest dimension (r= 0.63, p<0.001), greater extension anterior to the PA (r= 0.41, p<0.005), larger difference in pontine angle (r= 0.45, p=0.001), and larger ipsilateral than contralateral angles of the anterior margin of the PA (r= -0.39, p=0.005) (Table 3).

Conclusions
Our study demonstrated that larger size of a VS, greater extension anterior to the PA, and smaller angle between the VS and PR can help predict a lower chance of complete resection and need for additional treatment.
<table>
<thead>
<tr>
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<th>Feature</th>
<th>Feature Absent</th>
<th>Feature Present</th>
<th>P</th>
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<tr>
<td></td>
<td></td>
<td>%</td>
<td>#</td>
<td>N</td>
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<td>ArachPlane</td>
<td>Cysts</td>
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Table 1. The statistically significant percentage (%) and number (#) of patients with each binary outcome among patients with and without each binary imaging feature. N is the total number of patients providing data. Each p value is from the Fisher exact test to compare the patients with and without the indicated feature in terms of the percentage with the indicated outcome. Non-significant pairs were not included for concision.

<table>
<thead>
<tr>
<th>Outcome</th>
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<th>Outcome Absent</th>
<th>Outcome Present</th>
<th>P</th>
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<td>PontAngPetLes</td>
<td>-5.83</td>
<td>8.85</td>
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</table>

Table 2. The statistically significant mean, standard deviation (SD), median and inter-quartile range (IQR) of each ordinal and numeric imaging feature among patients with and without each binary outcome. Each p value is the exact significance level from a Mann-Whitney test to compare patients with and without the indicated outcome in terms of the indicated feature. Non-significant pairs were not included for concision.

<table>
<thead>
<tr>
<th>Outcome</th>
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<td>&lt;0.001</td>
</tr>
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<td>LongOrth</td>
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<td>&lt;0.001</td>
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</tr>
<tr>
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<tr>
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<td>PontAngDiff</td>
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<td>0.01</td>
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<td>PorAntAngPetLes</td>
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<tr>
<td>Extent</td>
<td>PontAngPetLes</td>
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Table 3. The statistically significant Pearson and Spearman correlation (r) and p value for the association of ordinal and numeric outcomes with ordinal and numeric imaging features. Non-significant pairs were not included for concision.
Anatomical Factors Impacting Attic Cholesteatoma Removal Through Endoscopic and Limited Mastoidectomy Approaches Through The Zygomatic Root

J Thiessen\(^1\), S Gupta\(^2\), B Hamilton\(^3\)
\(^1\)Oregon Health and Science University, Portland, OR, \(^2\)OHSU, Portland, OR, \(^3\)Oregon Health and Sciences University, Portland, OR

Purpose
There is a trend towards minimally invasive approaches for cholesteatoma resection. Endoscopy often allows complete removal without requiring mastoidectomy, but access to the epitympanum can be limited for angled endoscopes if the tegmen height is too great. Canal wall-up mastoidectomy can be limited to the zygomatic root (ZR) in patients with mastoid disease confined to the attic and anterior mastoids, however access may be impossible if the ZR is too thin. We evaluated temporal bone CT exams and surgical reports in a series of consecutive patients undergoing cholesteatoma resection at our institution to assess clinical and temporal bone findings impacting surgical approach.

Materials and Methods
All patients who underwent cholesteatoma removal by a single experienced neurotologist between 6/27/17 to 9/17/2019 were retrospectively reviewed. Patients without pre-operative temporal bone CT or having surgical changes precluding measurement of tegmen height were excluded. Electronic medical records were used to classify surgical approach(es): endoscopic (ETC), canal wall up along the ZR vs conventional mastoidectomy (CM), and posterior disease extent. The ZR was considered that portion of the mastoid temporal bone anterior and superior to the external auditory canal that gives direct access to the epitympanum. ZR height at the scutum and at its thinnest point were measured on pre-operative temporal bone CT.

Results
After exclusions, 53 of 63 patients met inclusion criteria. Isolated ETC was successful in 30/53. Highest tegmen height at the scutum in this group was 10.3 mm (range 3.3-10.3, mean 6.1 mm). For patients requiring mastoidectomy (23/53), 7 were done through the ZR. The thinnest zygomatic root height in this group was 3.0 mm (range 3.0-8.3, mean 6.2 mm). CM was required if disease extended into the posterior antrum/mastoids.

Conclusions
Endoscopy is often sufficient to remove cholesteatoma without mastoid extension by an experienced surgeon. Tegmen height may impact feasibility of resection through angled endoscopes. The upper limit of endoscopic-only resection was 10.3 mm in our series. ZR mastoidectomy is feasible in patients without posterior antrum disease if the ZR is sufficiently developed. A lower limit of 3.0 mm height allowed ZR mastoidectomy in our series.

Psuedoaneurysms in the Paranasal Sinus: Do Not Biopsy and Do Not Miss!

J MATHIEU\(^1\), M BARKOVICH\(^2\)
\(^1\)UCSF, SAN FRANCISCO, CA, \(^2\)UNIVERSITY OF CALIFORNIA-SAN FRANCISCO, SAN FRANCISCO, CA

Purpose
Distinguishing pseudoaneurysms from solid masses in the paranasal sinuses can be diagnostically challenging. Pseudoaneurysms typically develop after trauma, surgical intervention, radiation therapy, or direct invasion by a neoplasm. Many other masses may arise in the paranasal sinuses, such as mucocele, encephalocele, inverted papilloma, malignant tumors, and fibro-osseous lesions. The radiologist must be able to identify what is worrisome enough for pseudoaneurysm to warrant vascular imaging. We aim to highlight imaging features that should raise suspicion for pseudoaneurysm with a review of several instructive cases.

Materials and Methods
Three patients are included in this case series. The first presented with a homogeneously enhancing right posterior ethmoid lesion (Image A). Given proximity to the cavernous carotid artery and patient's past history of head trauma, MRA was recommended, which showed a large pseudoaneurysm extending through a bony dehiscence in the carotid canal, confirmed on catheter angiography (Image B). The second patient presented with a right nasopharyngeal mass that had eroded the anterior wall of the right petrous carotid canal (Image C). Although suspicion for pseudoaneurysm was raised, vascular imaging wasn't obtained and the patient returned months later with right holohemispheric subdural hemorrhage due to pseudoaneurysm rupture. Time of flight images demonstrated a large pseudoaneurysm (Image D). The third patient presented with an expansile, irregularly enhancing right sphenoid sinus mass after radiation and chemotherapy to treat nasopharyngeal carcinoma. Suspected to be a partially thrombosed pseudoaneurysm, the patient underwent a negative catheter angiography. Biopsy ultimately yielded chronic organizing hematoma with bacterial superinfection.

Results
These three patients presented with paranasal sinus masses and given the location of the lesions—in close proximity to a large vessel—as well as other factors including lamellated appearance, enhancement, and associated bony expansion/dehiscence, these lesions were identified as suspicious for pseudoaneurysm.
Conclusions
When confronted with an isolated paranasal sinus mass, identifying a potential pseudoaneurysm is of paramount importance, as their management is decidedly different from solid masses. Biopsy or watchful waiting may be catastrophic, and neurointerventional embolization is often the appropriate treatment. This presentation will review pearls and pitfalls to consider when diagnosing these lesions.

An Interesting Pathway to Occlude the Vertebral Artery - Retropharyngeal Abscess

D Cohen-Addad¹, Z Farooq²
¹Sunny Downstate Medical Center, Brooklyn, NY, ²SUNY Downstate Health Sciences University, Brooklyn, NY

Purpose
Retropharyngeal abscess a common entity with potential fatal complications. Knowledge of the potential anatomical spaces assisting in the dissemination of the infection and clinical risk factors are essential to predict complications. Further some imaging feature such as "vacuum disc phenomenon" is often attributed to benign etiology, but not in our case. The purpose of this case report is to illustrate the potential anatomical space of infection spread and potential imaging pitfalls.

Materials and Methods
64 years old female with a past medical history of diabetes, hypertension and recent history of throat pain treated two weeks prior to presentation, which was treated with antibiotics. The patient presented to the emergency department, complaining of bilateral hand and arm tremors, tingling and burning sensation. The patient had no hand/arm weakness or any more throat pain. She appeared diaphoretic. Her finger stick glucose was above 600. A CT cervical spine was order. The result lead to an MRI request and subsequently to the department of neurosurgery.

Results
CT cervical spine without contrast showed, air foci within the spinal canal, a questionable epidural collection, air within the intervertebral disc space of C6-7 and retropharyngeal soft-tissue edema. MRI with contrast and a CT neck and chest with contrast showed the following: Retropharyngeal abscesses extending from C4-5 down to T2-3. There was no involvement of the mediastinum or the danger space. Discitis osteomyelitis of C6-7 with extensive epidural abscess extending from C2-T4. The thickest component measured 8mm resulting in severe stenosis of the spinal cord with abnormal cord signal. The epidural abscess extended along the neural foramina of C5-7 resulting in inflammatory changes of the scalene muscle, the brachial plexus, and abscesses in the paravertebral muscles. The inflammation burden along the neural foramina/transverse process resulted in occlusion of the left vertebral artery flow.
Conclusions
Retropharyngeal infection can lead to severe complication especially with uncontrolled diabetic or in immunocompromised patients. The presence of air in the vertebral disc is mostly attributed to benign etiology however this should be taken in context with adjacent findings. Lastly, this case illustrates well the potential anatomical pathways of infection spread and their complications.
Craniofacial Bone Changes Associated with Uremic Secondary Hyperparathyroidism

S Fazeli¹, N Farid¹
¹University of California San Diego, San Diego, CA

Purpose
Craniofacial bone changes associated with secondary hyperparathyroidism are relatively uncommon and can present with three different radiologic patterns: osteitis fibrosa cystica (a.k.a Brown tumor), fibrous dysplasia, and leontiasis ossea. We describe a case of uremic secondary hyperparathyroidism with CT images illustrating a spectrum of all three patterns of involvement.

Materials and Methods
A 47-year-old woman presented to the emergency department with a palpable lump on her hard palate for a month. Her past medical history was notable for end stage renal disease secondary to systemic lupus erythematosus nephritis, on hemodialysis since renal transplant failure in 2016. Furthermore, she had secondary hyperparathyroidism with PTH level of 4447 pg/mL. Facial CT was ordered for further characterization of the mass.

Results
CT of the facial bones showed a 2 x 2 cm circumscribed, expansile, osteolytic mass arising from the right anterior aspect of the hard palate (A), consistent with pathology proven osteitis fibrosa cystica on subsequent biopsy. Additionally, CT showed diffuse bony expansion of the skull base and facial bones and replacement of the normal medullary space by ground glass attenuation, mimicking fibrous dysplasia, with associated loss of corticomedullary distinction, a unique feature of hyperparathyroidism (B). Lastly, disproportionate expansion of the mandible and maxilla was seen with a few areas of serpentine tunneling, compatible with leontiasis ossea (C). Retrospective review of a Tc-99 bone scan performed a few months earlier showed markedly increased bone uptake in the skull and facial bones (D).

Conclusions
Here we present a case of uremic secondary hyperparathyroidism with CT images illustrating uncommon but characteristic radiologic patterns of skull and facial bone involvement including osteitis fibrosa cystica, fibrous dysplasia, and leontiasis ossea.
Association between Head Computerized Tomography Findings and Long Term Outcomes in an Adult Indian Cohort with Severe Traumatic Brain Injury

B Sannananja, M Mossa-Basha, S Moorthy, N Kannan, K Agyem, A Lele, C Mock, R Pandey, H Dash, M Vavilala
1University of Washington, Seattle, WA, 2Harborview Injury Prevention and Research Center, Seattle, WA, 3Harborview Injury Prevention & Research Center, Seattle, WA, 4Department of Radiology, University of Washington, Seattle, WA, 5Harborview Injury Prevention and Research Center and Departments of Anesthesiology & Pain Medicine, Seattle, WA, 6Departments of Surgery and Epidemiology, University of Washington, Seattle, WA, 7Department of Epidemiology, All India Institute of Medical Sciences, New Delhi, Delhi, 8Departments of Anesthesiology & Pain Medicine, University of Washington, Seattle, WA

Purpose
The study evaluates the association between head CT findings and outcomes in a prospective cohort of severe traumatic brain injury (TBI) patients treated at a level 1 trauma center in India.

Materials and Methods
The study was approved by local ethics committee with informed consent. The study population included 200 adult patients with severe TBI treated between 2012-2014. The exclusion criteria were subjects with no head CT prior to neurosurgical intervention or within 125 hours of admission. For each patient, all head CT performed prior to any neurosurgical intervention within first 5 days after admission were analyzed. The raters were trained with data abstraction training modules followed by data abstraction from five test cases. Kappa>0.8 was considered adequate reliability, and supplementary trainings were conducted for kappa<0.8 until the goal was achieved. The outcomes were assessed at the time of discharge and at 3, 6 and 12 months after injury. Primary outcomes were mortality and Glasgow Outcome Scale (GOS) among survivors. Bivariate and multivariable analyses of patient characteristics including head CT findings on outcomes at each time point were performed using Poisson regression model. The results of subgroup analysis of the significant factors to patient outcome was also performed according to patients who did and did not receive neurosurgical intervention.

Results
A total of 242 head CT scans from 179 patients were included. The most common findings on head CT were non-hemorrhagic contusions, both in patients with and without neurosurgical intervention. Diffuse axonal injury was more common in patients without neurosurgical intervention. Of the 114 patients who were alive at 12 months, 3 had poor GOS. Brain herniation, subarachnoid hemorrhage (SAH), intraventricular hemorrhage (IVH), contusion, cerebral edema, and intraparenchymal infarct were all associated with increased mortality at some point during follow-up (reference 1). Ischemic infarct and SAH were associated with poor GOS at 3 and 6 months respectively. Epidural hematoma was the only finding associated with improved survival at 6 and 12 months.

Conclusions
Early head CT findings of IVH, tonsillar herniation, SAH and infarct were associated with poor short and long-term outcomes for patients with severe traumatic brain injury treated at level 1 trauma center in India.

Impact of cortical volume on clinical symptom presentation and longevity in mTBI

T Knoblauch, S Parikh, A Rodriguez, C Vanier, A Hertzler, L Ma, T Snyder
1University of Nevada, Las Vegas, Las Vegas, NV, 2UPMC Pinnacle, Harrisburg, PA, 3IMGEN LLC., Las Vegas, NV, 4Touro University Nevada, Henderson, NV, 5SimonMed, Las Vegas, NV

Purpose
Cortical volume loss and cortical thinning have been described following traumatic brain injury and are known to correlate with symptoms such as post traumatic headaches. Military studies have described increased age associated cortical thinning in mTBI patients versus controls. This study examines the association between cortical volumes and asymmetry and symptom presentation and longevity within a diverse civilian mTBI population.

Materials and Methods
Cortical volume and asymmetry in the 5 major lobes of the brain of 268 mTBI patients were compared to age and gender matched controls in the Neuroquant normative database. Differences in normalized percentiles related to feature size and asymmetry relative to the presence or absence of symptoms using a Mann-Whitney test. Correlations between symptom longevity and cortical volume (1st-10th percentiles vs 11th-99th percentiles), lateral asymmetry (left/right-biased (1st-10th percentiles), and overall asymmetry (left/right-biased 1st-10th percentiles) of five different brain regions were tested using a semi-parametric interval-censored survival analysis, with p-values determined by bootstrapping. Analyses were done in Rv3.6.1 and package 'icenReg'. Clinical data on symptom presentation and longevity was acquired retrospectively from a de-identified patient dataset.
Results
Asymmetry and size of different brain regions did not vary with symptom presentation (asymmetry: Wmax=9682, unadjusted Pmin=0.037; Size: Wmax=8696, unadjusted Pmin=0.097). Patients in the bottom tenth percentile occipital or parietal volumes exhibited cognitive deficits (Estimate (SE) p-value: -0.76 (0.28) 0.008) and anxiety (-11.03 (0.47) <0.001) lasting longer than patients in higher percentiles. We observed no statistically significant association between lateral asymmetry and symptom longevity (unadjusted p-values > 0.071), or between overall asymmetry and symptom longevity (without regard to direction; unadjusted p-values > 0.061). Left biased asymmetry in the occipital lobe was associated with prolonged symptoms of anxiety (-11.61 (0.64) p<0.001).

Conclusions
Regional cortical volumes (specifically of the occipital and parietal lobes) appears to associate with longevity of anxiety and cognitive deficits in mTBI subjects.

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Radiomic Texture Analysis Discriminates between the Solitary Malignant Brain Tumors (Glioblastoma versus Lymphoma versus Solitary Metastasis)

R Colen¹, M Ayoub², M Pease³, P Zinn³, F Moron⁴
¹Hillman Cancer Center, University of Pittsburgh Medical Center, Pittsburgh, PA, ²University of Pittsburgh, Pittsburgh, PA, ³UPMC, Pittsburgh, PA, ⁴BAYLOR COLLEGE OF MEDICINE, HOUSTON, TX

Purpose
To discriminate between solitary intra-axial malignant brain tumors (glioblastoma (GBM), primary brain lymphoma and solitary brain metastasis) using MR radiomic texture analysis (TA).

Materials and Methods
450 patients were retrospectively included in this IRB-approved HIPAA compliant study as follows: treatment- naïve, pathologically-proven glioblastoma (N=150), metastasis (lung/breast) (N=150), and primary brain lymphoma (N=100). T2-FLAIR, post contrast T1-weighted images and Apparent Diffusion Coefficient images were co-registered using 3D slicer 4.10.1 segmentation module (http://www.slicer.org). Volume of interests (VOIs) were obtained from the segmented whole tumor and edema components to extract a total of 310 features per phenotype yielding 2480 texture feature per patient. We used Maximum Relevance Minimum Redundancy (mRMR) for feature selection. Leave-one-out cross-validation (LOOCV) and receiver operating characteristic (ROC) analysis were used to assess the radiomic signature derived from solitary malignant brain tumors that discriminated between solitary enhancing GBM vs Lymphoma vs Solitary Metastasis.

Results
We were able to robustly differentiate between the various enhancing solitary malignant brain tumors with a high sensitivity, specificity and accuracy.

Conclusions
This study shows that radiomics can help differentiate between different solitary malignant brain tumors, namely GBM, lymphoma and metastasis.
Primary CNS Lymphoma Presenting with Multiple Hemorrhagic Subependymal Masses

K Tran¹, A Krishnan¹
¹Beaumont Health (Royal Oak), Royal Oak, MI
Purpose
Various typical and atypical imaging findings for primary CNS lymphoma in immunocompetent patients have been described in the literature. Presence of intratumoral hemorrhage is a rare manifestation. We report the unusual imaging presentation of a case of diffuse large B cell lymphoma of the CNS presenting as multiple hemorrhagic subependymal masses.

Materials and Methods
A 53 year old woman with past medical history notable for non-Hodgkin's lymphoma of right breast treated with chemotherapy 12 years previously, presented to the emergency department for mechanical fall at home. An unenhanced head CT revealed multiple bilateral hyperdense periventricular masses, which were new from head CT performed 7 years earlier. Contrast-enhanced brain MR confirmed multiple homogenously enhancing subependymal masses with extensive intratumoral microhemorrhages. There was no evidence of dural or leptomeningeal disease within the brain or spine on MR imaging with unremarkable CSF analysis. Further work-up with whole-body PET and CT examinations failed to demonstrate a primary tumor of origin outside of the central nervous system. Subsequent stereotactic biopsy revealed diffuse large B-cell lymphoma.

Results
Noncontrast head CT (Fig A) demonstrates multiple bilateral hyperattenuating periventricular masses. T1 post-contrast imaging (Fig B) revealed marked homogenous enhancement of these periventricular masses, as well as prominent areas of internal blooming artifact on T2* sequence (Fig C) within all lesions, compatible with intratumoral microhemorrhages. T2 hypointensity (Fig D) as well as restricted diffusion (not shown) were also demonstrated within these lesions. There was no evidence of dural or leptomeningeal enhancement.

Conclusions
Primary CNS lymphoma is a rare form of extranodal NHL, accounting for 3-6% of all primary brain neoplasms. Classic imaging findings for this entity include solitary or multiple focal parenchymal masses with a predilection for periventricular white matter and basal ganglia, with 95% of lesions contacting a CSF surface. Our patient exhibited these typical findings, however also demonstrated the presence of extensive intratumoral microhemorrhages, a rare manifestation which is seen in only 5-8% of reported cases unless the patient is immunocompromised. This finding highlights an unusual presentation of a rare disease that made the initial diagnosis particularly challenging. We hope with this case to make neuroradiologists more aware of an unusual presentation of primary CNS lymphoma.
First-Order Histogram Based Texture Features in Glioblastoma Correlate with Survival Only for Whole Tumor But Not for Solid Tumor

G Bathla¹, S Priya², N Soni³, T Locke³, A Saad Aldine², V Monga³
¹Univ. Of Iowa Hospitals & Clinics, Iowa City, IA, ²University of Iowa hospitals and Clinics, IOWA CITY, IA, ³University of Iowa, Iowa City, IA

Purpose
To evaluate whether the first-order histogram statistical parameters derived from T1W contrast-enhanced (CE) images correlate with overall survival in glioblastoma (GBM), using features derived from (a) whole tumor texture analysis (enhancing plus non-enhancing necrotic segment) and (b) using the enhancing tumor component only.

Materials and Methods
Retrospective evaluation of 97 patients with GBM was performed. The analysis was performed using a proprietary research software and involved manual segmentation of (a) whole tumor and (b) enhancing tumor component in separate sessions. Six first-order texture parameters at different spatial scale filters were extracted on the T1-CE axial images, both for whole tumor as well as enhancing tumor only. A Cox proportional hazards regression model was used to identify the marginal associations of patient survival times with the six texture features for every level of spatial smoothing for both groups. Multivariate cox regression model was performed that included age, sex and significant texture feature seen on univariate analysis. All statistical analysis was performed in 'R'.

Results
Mean and Mean of positive pixels (MPP) was significantly associated with survival for texture features derived from enhanced tumor only, while mean, MPP and skewness were significant for whole tumor at SSF 0 (P <0.05). Skewness was significantly associated with overall survival at SSF 0, 3, 4 and 5. Multivariate analysis showed that effect of age (p <0.0001) and skewness (p < 0.007) was significant on survival times for whole tumor whereas only age was significant for enhancing tumor analysis (p < 0.05).

Conclusions
Both age and first-order histogram derived skewness show significant association with survival times for whole tumor analysis while only age was significant in predicting survival time for enhancing tumor analysis.
Assessing axon loss in perilesional normal appearing white matter in multiple sclerosis

D Lakhani¹, S Wen¹, S Gao¹, K Ciccone², S Smith², J Xu², R Dortch², F Bagnato²
¹West Virginia University, Morgantown, WV, ²Vanderbilt University, Nashville, TN

Purpose
Following focal lesional axonal transection, axons undergo transection followed by anterograde and retrograde degeneration. Studies on experimental autoimmune encephalomyelitis animal model showed that these changes are largely preventable and axonal morphology can be restored with early intervention. Hence, quantifying and monitoring these changes will offer a tool to monitor disability progression before it becomes clinically overt and will allow personalizing treatments to prevent progression of multiple sclerosis (MS). We implemented the Neurite Orientation Dispersion and Density Imaging (NODDI) derived intracellular volume fraction (ficvf), isotropic volume fraction (fiso) and orientation dispersion index (ODI) metrics to measure differences in axonal quantity among chronic black hole (cBHs), peri-lesional normal appearing white matter (NAWM) adjacent-to and contralateral-to cBHs in persons with MS (pwMS). Our ultimate goal is assessing anterograde and retrograde WM-degeneration and its impact on disability of pwMS.

Materials and Methods
In this prospective case-control study nineteen pwMS underwent a 3T-MRI with clinical scans, and NODDI protocol. Region-of-
interests in cBHs, NAWM adjacent-to-cBHs (referred as perilesional-NAWM) and contralateral-NAWM were manually delineated and ficvf/fiso/ODI values were extracted. Mixed-effects regression model and bootstrapping 95% confidence interval (CI) were used to examine differences and correlations respectively.

Results
Ficvf (p<0.001) and fiso (p<0.001) were lower in cBHs compared to perilesional NAWM; whilst ficvf (p<0.001) and ODI (p<0.05) were lower in perilesional NAWM compared to contralateral NAWM. (Figure 1) No difference was noted in ODI between BH and perilesional NAWM. We did not find any correlation between ficvf-fiso-ODI metrics within different tissue-subtype.

Conclusions
Our results indicate that perilesional-NAWM is characterized by decrease in axonal axon density (lower intraxonal volume fraction-ficvf), and increased disruption in normal neuronal structural organization at microscopic level (lower ODI) as compared to contralateral-NAWM. No difference in ODI was noted between BH and perilesional-NAWM which could relate to similar degree of disruption in the neuron structure at microscopic level. These findings are suggestive of degenerative changes extending outside of the lesions. We are further working on assessing the impact of lesional disease on distant degeneration and its effect on clinical outcome.

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Structural Brain Patterns in Bilingual Versus Monolingual Persons with Alzheimer’s Disease

C Raji¹, S Meysami², M Mendez²
¹Mallinckrodt Institute of Radiology, St. Louis, MO, ²David Geffen School of Medicine at UCLA, Los Angeles, CA

Purpose
This work applied automated quantitative volumetric MR neuroimaging to characterizing specific patterns of brain volume loss in bilingual versus monolingual persons with Alzheimer's dementia (AD). With increased interest in determining factors that can modify risk of AD by increasing cognitive reserve, bilingualism is one such factor. However, brain biomarkers of bilingualism in AD are limited.

Materials and Methods
A total of 46 persons with AD from UCLA and either bilingual or monolingual status were evaluated by a Behavioral Neurologist with 20 years of experience. All subjects received a sagittal T1 weighted volumetric acquisition on a Siemens 3T MR scanner. All volumetric scans were analyzed by an FDA cleared volumetric algorithm, Neuroreader (1), that segmented and calculated brain volumes.

Results
Of the 46 persons, 17 were bilingual and 21 were monolingual. The average age for the entire sample is 72.4 ± 11.6 years (Range: 53-95). 46% of the sample are women. There were no statistically significant differences between age and gender between bilingual and monolingual individuals. The following statistically significant or trending partial correlations were noted between bilingual status and the following brain volumes, when accounting for age, gender, and total head size: i) Ventral Diencephalon (r = .46, p = .002) ii) Pallidum (r = .31, p = .04) iii) Brainstem (r = .29, p = .05) and iv) Total Gray Matter (r = .29, p = .05). The hippocampus was larger in bilingual persons (r = .07, p = .6) but the relationship was not statistically significant.
Conclusions
Quantitative volumetric MR neuroimaging shows specific volumetric differences across persons with AD as a function of bilingual versus monolingual status. Several regions, such as the ventral diencephalon are novel compared to prior studies. Additional multimodal imaging is needed to understand the relationship between bilingualism and cognitive reserve.

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Microhemorrhages and White Matters Changes in Fighters on 7T versus 3T MRI

A Mangat1, J Joyce2, S Jones3, C Bernick1, J Lee4
1Cleveland Clinic Foundation, Cleveland, OH, 2UC Health, Cincinnati, OH, 3Cleveland Clinic, Cleveland, OH, 4N/A, Brecksville, OH

Purpose
Prior study with a large cohort of fighters in the Professional Fighters Brain Health Study (PFBHS) showed no statistical difference in the number of nonspecific WM changes (NSWMC) and cerebral microhemorrhages (CMH) at 3T MRI compared to controls. This study utilizes 7T MRI in order to evaluate whether more NSWMC changes and CMH can be seen in fighters at 7T, which may be a reason for the lack of statistical significance on the prior study.

Materials and Methods
7T MRI was used to assess 15 professional fighters (boxers, mixed martial artists, and martial artists) for nonspecific WM changes (NSWMC) and cerebral microhemorrhages (CMH) and compared to concurrently performed conventional 3T MRI by a Neuroradiology fellow. Paired t-test was used to compare the two samples.

Results
The number of NSWMC observed was significantly higher on 7T scans (52 lesions) as compared to the concurrently performed 3T scans (39 lesions) with a p value of 0.0069. No CMH were identified on either 7T or 3T images from the small cohort of fighters studied.

Conclusions
There is increased prevalence of NSWMC on 7T as compared to 3T MRI, which may indicate that many NSWMC are missed by conventional 3T imaging. This may be one reason that NSWMC were not significantly different in fighters versus controls on a prior study. No cerebral microhemorrhages were found on either 3T or 7T images, which supports the earlier study that demonstrated relatively low prevalence of cerebral microhemorrhages.

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Diagnostic yield of body CT or PET/CT for evaluation of extent of disease in patients with primary central nervous system lymphoma: Multicenter cohort study

C Suh1, H Kim1
1Asan Medical Center, Seoul, Seoul

Purpose
There are still debates over the clinical utility of contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT for evaluation of the extent of disease in patients with a positive diagnosis of primary central nervous system lymphoma (PCNSL) and multicenter cohort data are lacking. Therefore, we aimed to validate the diagnostic yield and false-referral rate of contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT for evaluation of extent of disease in patients with a positive diagnosis of PCNSL.

Materials and Methods
A single-arm multicenter cohort study of patients with PCNSL who underwent contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT between 1998 and 2019 for evaluation of extent of disease. This multicenter cohort study was conducted at Asan Medical Center, Samsung Medical Center, Yonsei University Severance Hospital, and Seoul National University Hospital.

Consecutive patients with a positive diagnosis of PCNSL on brain biopsy were included. All patients underwent contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT for evaluation of extent of disease, and these were interpreted as part of daily clinical practice. Lesion validation was performed by the consensus of two neuroradiologists blinded to all clinical information. The primary outcome was the diagnostic yield of contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT for evaluation of extent of disease and the secondary outcome was false-referral rate.

Results
A total of 878 patients (482 males, 54.9%) with a mean age of 59 years (SD 13) were included. The diagnostic yield of contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT was 2.6% (23 of 878; 95% CI, 1.7–3.9%). The false-referral rate was 5.0% (44 of 878; 95% CI, 3.7–6.7%), with the false-positive findings resulting in unnecessary biopsy (n=16), follow-up imaging (n=16), endoscopy (n=8), additional imaging (n=2), and surgery (n=2). In patients <65-years-of-age with diffuse B-cell lymphoma, the diagnostic yield was 0.9% (5 of 537; 95% CI, 0.3–2.2%).

Conclusions
Our multicenter cohort study of patients with a positive diagnosis of PCNSL, contrast-enhanced chest/abdominal/pelvic CT or whole-body PET/CT for evaluation of extent of disease showed the diagnostic yield was 2.6% and the false-referral rate was 5.0%.
body PET/CT had a low diagnostic yield for evaluating extent of disease and should not be performed in patients <65-years-of-age with primary CNS diffuse large B-cell lymphoma.