NEURORADIOLOGY

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COURSE DESCRIPTION
This course introduces the fundamental neuro- and vascular imaging technologies used in eye care. Plain film x-ray, computed tomography (CT), computed tomography angiography (CTA), computed tomography venography (CTV), magnetic resonance imaging (MRI), magnetic resonance angiography (MRA), magnetic resonance venography (MRV), conventional catheter angiography, carotid duplex and transcranial Doppler are discussed. Ophthalmic and systemic indications and contraindications, ordering, and special sequences are reviewed.

LEARNING OBJECTIVES
1. Review the ophthalmic indications for plain film x-ray, CT and MR technologies
2. Understand the projections and special sequences
3. Know the contraindications for scanning
4. Review contrast dye relative and absolute contraindications
5. Understand the ophthalmic indications for vascular echography
6. Acquire the fundamental concepts of neuroimaging in eye care

CME QUESTIONS
1. Which of the following best describes the neuroimage?

   a. Plain film x-ray
   b. CT brain
   c. MRI brain, T1WI
   d. MRI brain, T2WI
2. Which of the following blood tests are recommended prior to the use of contrast dyes?
   a. CBC w/ diff & CMP
   b. CMP
   c. BUN & creatinine
   d. LFT

3. Which of the following is a fat suppression technique?
   a. ADC
   b. DWI
   c. FLAIR
   d. STIR

4. Which of the following techniques can be used to evaluate for perfusion abnormality within a few minutes of ischemia when conventional MR images are normal?
   a. DWI
   b. FLAIR
   c. STIR
   d. T2WI GRE

5. Which of the following is the gold standard for evaluating the intracranial vasculature?
   a. CTA
   b. CCA
   c. MRA
   d. TCD

KEYWORDS
1. Plain film x-ray
2. Computed tomography
3. Magnetic resonance imaging
4. Angiography
5. Echography

INTRODUCTION

Advances in the resolution of neuroimaging techniques have revolutionized the diagnosis, treatment, and management of neuro-ophthalmic disorders. A thorough ocular and medical history in addition to the clinical examination is critical in the neuroimaging selection process. It remains crucial that the eye physician communicate the history and clinical findings to the neuroradiologist. Together, an effort to understand the relevant topographical and localizing anatomy will lead to the most accurate diagnosis. This course addresses the fundamentals of neuroimaging. The basics of neuroimaging interpretation and fundamental concepts with attention to error avoidance will be discussed.
NEUROIMAGING

Plain Film X-ray

Also known as a skull radiograph, the plain film x-ray has fallen out of favor since the more widely utilized CT scanner was developed. The patient is exposed to radiation. Images are visualized using 5 different radiodensities where air is the least dense and appears dark while metal is the densest and appears bright white. An x-ray beam travels through the tissue. The organ or body part closest to the x-ray film will be visualized best. Four projections are commonly used in eye care as specified in Figure 1. Ophthalmic indications include intraocular foreign body (IOFB), skull fracture, or facial trauma. Tear drop sign is typically noted with orbital blow-out fracture.

<table>
<thead>
<tr>
<th>Projection</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antero-posterior (AP)</td>
<td>Back of skull</td>
</tr>
<tr>
<td>Posterior-anterior (PA)</td>
<td>Front of skull, sinuses</td>
</tr>
<tr>
<td>Lateral</td>
<td>Side profile</td>
</tr>
<tr>
<td>Waters / Occipitomental</td>
<td>Orbits, frontal &amp; maxillary sinus</td>
</tr>
</tbody>
</table>

*Figure 1* Projections and structures best visualized with plain film x-ray

Order: 50 y.o. WM w/ multiple metallic corneal foreign bodies OS (ICD10: XXX.XXXX), s/p orbital trauma. Order plain film x-ray skull w/ attn to orbits; evaluate x IOFB. Do PA, lateral, and Waters views.

*Figure 2* Plain film x-ray order example

Computed Tomography

CT scans are the most efficient screener for acute hemorrhage, bone, calcium, and acute head trauma\(^1\)\(^2\)\(^3\). The patient is exposed to radiation; it is advisable to avoid this study in children and pregnant women when possible\(^4\). A series of x-rays, or photons, are passed through the body along one plane; the attenuated beam that emerges is detected\(^5\). The beams are then passed through the same tissue at a different angle and the attenuated data is measured again. Spiral or helical technology refers to a rotating x-ray source such that the x-ray beam creates a spiral path around the body. Typical beams produce images that are 1-10 mm thick. Multiple x-ray projections are used to reconstruct tissue structures based on complex mathematical algorithms\(^6\). The attenuated value is expressed on an arbitrary scale named Hounsfield Units (HU) with a range of 2000 units where +1000 is the attenuation of bone (bright white) and -1000 is air (black) as shown in Figure 3\(^1\). Projections include axial, coronal, and sagittal scans as depicted in Figure 4\(^2\). The weight limit for this study is ~450 pounds.
Iodine-based contrast dye may be requested to improve the visibility of the vasculature and detect areas of abnormal blood brain barrier (BBB)\(^5\). Contrast dye should be avoided in patients allergic to iodine, shellfish and those with abnormal kidney function\(^7\). Blood urea nitrogen (BUN) and creatinine studies are helpful to determine adequate kidney function prior to the use of contrast dye. Additional contraindications are listed in Figure 5.

When ordering orbit studies, it is preferable to specify thin slices of 1 or 2 millimeters in order to ensure adequate analysis of extremely small lesions\(^2\). Larger routine slices of 3 to 5 millimeters may miss small lesions. It is also valuable to specify the use of bone windowing which is a technique that allows optimal evaluation of the tissues by suppressing the bright white bone signal and intraconal fat. A sample CT protocol and order are listed in Figures 6 & 7.

<table>
<thead>
<tr>
<th>Structure</th>
<th>HU</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone / metal</td>
<td>+1000</td>
<td>WHITE</td>
</tr>
<tr>
<td>Calcification</td>
<td>+140-200</td>
<td></td>
</tr>
<tr>
<td>Acute blood</td>
<td>+56-76</td>
<td></td>
</tr>
<tr>
<td>Gray matter</td>
<td>+32-41</td>
<td></td>
</tr>
<tr>
<td>White matter</td>
<td>+23-34</td>
<td></td>
</tr>
<tr>
<td>Cerebrospinal fluid (CSF)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>-30 - -100</td>
<td></td>
</tr>
<tr>
<td>Air</td>
<td>-1000</td>
<td>BLACK</td>
</tr>
</tbody>
</table>

Figure 3 Hounsfield Units of central nervous system (CNS) structures on CT scan

Figure 4 Projections for CT and MR imaging
Aminoglycoside exposure
Anuria
Cardiovascular insufficiency
Diabetes (glucophage)
Hepatorenal syndrome
Hyperthyroidism
Hypertonus
Hyperuricemia
Multiple myeloma / paraproteinemias
Plasmacytoma

*Figure 5* Contraindications for CT iodinated-contrast dye

Age, race, gender
Description of case
Dx / ICD10 code
Brain and / or orbits
+ / - contrast dye
Routine studies: 3-5 mm slices
Orbit studies: 1-2 mm slices
+ / - Bone windowing
Advise the radiologist what to look for & where to look

*Figure 6* CT order protocol

50 y.o. WM s/p MVA w/ facial airbag trauma, EOM entrapment & ecchymosis OS (ICD10: XXX.XXXX).
Order CT brain & orbits w/o contrast; evaluate for blow-out fx & intracranial heme. Do 1.5 mm thin cuts through orbits; use bone windowing technique.

*Figure 7* Sample CT brain & orbits w/o contrast order

**Magnetic Resonance Imaging**

MRI uses a magnetic field to align hydrogen atoms in tissue. Named after the physicist, Nikola Tesla, the Tesla (T) is a measure of magnetic field strength. Commercial scanner strengths typically range from 0.3 – 3T with the most readily available being the 1.5T scanner. 3T units have the highest level of resolution. There is no radiation exposure.

MRI is superior to image soft tissue and is the primary study of choice in the majority of neuro-ophthalmic disorders. Pulse sequences include T1-weighted imaging (T1WI) and T2-weighted imaging (T2WI). T1 images are sometimes used with the contrast dye gadolinium, a rare earth metal. Figure 8 illustrates the T1 and T2 relaxation times. Projections are shown in Figure 4. The weight limit for this study is ~350 pounds.
Special sequences are critical to pathology detection and should be ordered based on clinical history and examination to increase the diagnostic yield of a study.

A fat suppression technique, known as short T1 inversion recovery or short-time inversion recovery (STIR), transforms the bright signal of fat into a black signal allowing better orbital imaging before and after contrast administration\(^1\). This technique should be ordered for all orbital studies and is best completed in a closed gantry as opposed to an open gantry MRI.

Fluid-attenuated inversion recovery (FLAIR) allows transformation of the bright CSF signal into a black signal while maintaining the other characteristics of a T2WI. The technique is ideal for detecting periventricular white matter lesions in demyelinating processes including multiple sclerosis.

Diffusion weighted imaging (DWI) is used to detect recent vascular perfusion alterations. It is ideal for identifying recent ischemic episodes including stroke. The signal is abnormal within minutes of infarction and persists for three weeks; routine CT and MRI sequences may be normal in acute infarct\(^1\). DWI is used as a time marker for acute and subacute ischemic events; old ischemic lesions do not show restricted diffusion. This special sequence is also valuable in differentiating cystic tumors and abscesses. The apparent diffusion coefficient, or ADC map, is an alternative view of the DWI; lesions appearing black in the ADC map will appear white with DWI\(^3\), \(^6\).

Susceptibility weighted image (SWI), a newer imaging sequence offering higher resolution and reduced artifact relative to gradient echo (GE) sequences, offers information about any tissue that has a different susceptibility than its surrounding structures such as deoxygenated blood, hemosiderin, ferritin, and calcium. Neurologic disorders where monitoring the amount of iron in the brain, whether in the form of deoxyhemoglobin, ferritin, or hemosiderin, would benefit from this sequence. Such diseases and conditions include, but are not limited to, aging, multiple sclerosis, stroke, trauma, vascular malformations, and tumors.

Fast spoiled gradient recalled (FSPGR) is a novel MR technique using 1 mm slices with very high spatial resolution.

Fast imaging employing steady state acquisition (FIESTA-C) also known as constructive interference in the steady state (CISS) is a new MR technique involving 0.6 – 0.8 mm slices with very high spatial...
resolution of particular interest for imaging the cranial nerves. FIESTA-C is available on GE platforms; CISS is available on Siemens platforms.

MRI carries a multitude of absolute and relative contraindications which are reviewed in Figures 9 & 10. Among the most concerning absolute contraindication is that of metal in the body which may increase in temperature due to the magnetic field required to capture images. When in doubt regarding the safety of an imaging study, the physician should always discuss the most appropriate study with a radiologist.

<table>
<thead>
<tr>
<th>Metallic implants / foreign body</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic, magnetic, &amp; mechanically activated implants</td>
</tr>
<tr>
<td>Cardiac defibrillators</td>
</tr>
<tr>
<td>Cardiac pacemakers</td>
</tr>
<tr>
<td>CNS ferromagnetic hemostatic clips</td>
</tr>
<tr>
<td>Neurostimulators</td>
</tr>
</tbody>
</table>

**Figure 9 Absolute contraindications for MRI**

<table>
<thead>
<tr>
<th>Cardiac stents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cochlear implants</td>
</tr>
<tr>
<td>Hemostatic clips (body)</td>
</tr>
<tr>
<td>Insulin pumps</td>
</tr>
<tr>
<td>Lead wires or similar wires</td>
</tr>
<tr>
<td>Nerve stimulators</td>
</tr>
<tr>
<td>Non-ferromagnetic stapedial implants</td>
</tr>
<tr>
<td>Other pacemakers (e.g. carotid sinus)</td>
</tr>
<tr>
<td>Prosthetic heart valves</td>
</tr>
<tr>
<td>Transdermal patch</td>
</tr>
</tbody>
</table>

**Figure 10 Relative contraindications for MRI**

Gadolinium (Gd) contrast dye improves visibility of the intracranial vasculature and detects abnormalities in the BBB. The dye improves the anatomical detail and differentiates signal enhancement of normal and pathological tissues. It is metabolized in the kidneys; BUN and creatinine clearance are valuable prior to the study to evaluate for kidney function. Patients with severe renal failure, stages IV or V, with a glomerular filtration rate (GFR) <30 mL/min are at a high risk to develop nephrogenic systemic fibrosis (NSF), a rare dermopathy leading to fibrosis of the skin and internal organs. Contrast dye contraindications are highlighted in Figure 11. Gadolinium does not enhance rapidly flowing blood; hence, flow voids or black vessels are often seen on scans.

In July 2015, the United States Food and Drug Administration (FDA) issued a safety announcement regarding the risk of brain deposits with repeated use of gadolinium-based contrast agents for MR with particular concern for the linear-Gd chelates. Macrocyclic Gd-chelates are preferred to prevent “brain stain”. The clinical and long term implications, if any, are evolving.
A sample MRI order protocol is outlined in Figure 12; it is valuable to specify thin slices of 1-2 millimeters for all orbital scans and may be equally important when evaluating the cranial nerve and visual pathways.

<table>
<thead>
<tr>
<th>Abnormal kidney function</th>
<th>Gadolinium allergy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemodialysis</td>
<td>Hepatorenal syndrome</td>
</tr>
<tr>
<td>NSF</td>
<td>Pregnancy</td>
</tr>
</tbody>
</table>

**Figure 11** Contraindications for MRI-associated gadolinium contrast dye

<table>
<thead>
<tr>
<th>Age, race, gender</th>
<th>Description of case</th>
<th>Dx / ICD10 code</th>
<th>Brain and / or orbits</th>
<th>+ / - contrast dye</th>
<th>Routine studies: 3-5 mm slices</th>
<th>Orbit studies: 1-2 mm slices</th>
<th>+ / - STIR, FLAIR, DWI/ADC, SWI, FSPGR, FIESTA-C / CISS</th>
<th>Advise the radiologist what to look for &amp; where to look</th>
</tr>
</thead>
</table>

**Figure 12** MRI order protocol

**VASCULAR IMAGING**

*Computed Tomography Angiography*

CTA uses a CT scanner to evaluate intracranial and extracranial arteries. 3D reconstruction is utilized to formulate the images. The most common indications for ophthalmic use include arterial and carotid stenosis, aneurysms greater than 3 mm in size, arteriovenous malformation (AVM), carotid cavernous fistula (CCF), carotid dissection of the head / neck, vascular thrombosis, and vascular tumors. The study requires contrast dye. CTA is complementary to MRA, but CTA is somewhat preferred due to its slightly superior detection of cerebral aneurysm and AVM. Contraindications are the same as those mentioned for cranial CT.

*Computed Tomography Venography*

CTV uses a CT scanner to evaluate intracranial and extracranial veins via 3D reconstruction. The study is valuable to diagnose cerebral venous sinus thrombosis (CVST) or stenosis. Bilateral optic disc edema may be the presenting sign of CVST or stenosis and is frequently included in a papilledema work-up. Contrast dye is preferred. The study is complementary to MRV. Cranial CT scan contraindications apply.
Magnetic Resonance Angiography

MRA uses an MR scanner to evaluate the intracranial and extracranial arteries using 3D reconstruction. Ophthalmic indications are similar to those of CTA. The scan does not require contrast dye, but it may be used to distinguish flowing blood versus stationary tissue water. Contraindications are the same as those previously addressed for cranial MRI.

Magnetic Resonance Venography

MRV uses an MR scanner to evaluate the intracranial and extracranial veins using 3D reconstruction. Ophthalmic indications are similar to CTV. The scan does not require contrast dye. Contraindications are the same as those previously addressed for cranial MRI.

Conventional Catheter Angiography

CCA, also known as digital subtraction angiography (DSA), is the gold standard for intracerebral vascular imaging. Image resolution is superior to CTA and MRA with improved ability to detect aneurysms less than 3 mm in size utilizing 3D reconstruction. The technique is invasive and typically performed in a hospital-based setting under the direction of an interventional radiologist. A femoral artery catheter is placed with local anesthesia. Selective catheterization of the cervical and intracranial arteries occurs via the aorta. Radiodense non-iodinated or iodinated contrast dye is injected. X-rays are used for imaging resulting in radiation exposure. Morbidity occurs in 1-5% of patients due to embolism, vasospasm, transient ischemic attack, cerebrovascular accident, aortic or cervical artery dissection, dye-related reaction, groin hematoma, or femoral artery pseudoaneurysm².

STUDY SELECTION

The clinical history and examination is imperative to the understanding of when to order neuroimaging. Utilization of the exam data will assist the clinician in understanding what study is most appropriate bearing in mind the potential etiologies and anatomic location of the lesion. Figures 6 & 12 reviewed sample order protocols that may assist the eye physician in writing neuroimaging orders.

It is particularly important to specify the suspected lesion and region of interest to the neuroradiologist prior to study completion. It is recommended to personally review the neuroimages for clinical correlation. Negative studies may require a re-examination or discussion with the neuroradiologist. Errors in interpretation are frequently the result of poor quality information or lack of information provided to the radiologist¹. Depending on the training, skills, and experiences of the interpreting radiologist, neuroimaging errors may occur; it is preferable to request a neuroradiologist read for neuroimaging orders¹. Common ophthalmic indications for neuroimaging are outlined in Figure 13.
<table>
<thead>
<tr>
<th>CLINICAL INDICATION</th>
<th>PREFERRED STUDY</th>
<th>CONTRAST</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bitemporal hemianopsia</td>
<td>MRI Head</td>
<td>Yes</td>
<td>Attention to sella</td>
</tr>
<tr>
<td>B/L optic disc edema</td>
<td>MRI / MRV head</td>
<td>Yes</td>
<td>Evaluate for CVST</td>
</tr>
<tr>
<td>Carotid-cavernous sinus or Dural fistula</td>
<td>CT or MRI head/orbits</td>
<td>Yes</td>
<td>Consider CCA</td>
</tr>
<tr>
<td>Central retinal artery occlusion</td>
<td>MRI head w/ DWI</td>
<td>Yes</td>
<td>Carotid duplex vs. MRA neck</td>
</tr>
<tr>
<td>Cortical visual loss or visual association cortex (e.g. cerebral, achromatopsia, alexia, prosopagnosia, simultagnosia, optic ataxia)</td>
<td>MRI Head</td>
<td>Yes</td>
<td>Retrochiasmal pathway; Use DWI</td>
</tr>
<tr>
<td>Cranial nerve 3, 4, 6 palsy</td>
<td>MRI head</td>
<td>Yes</td>
<td>Angiography may also be warranted; CT head w/o contrast first line for trauma Consider FIESTA-C / CISS</td>
</tr>
<tr>
<td>Demyelinating optic neuritis</td>
<td>MRI head &amp; orbits</td>
<td>Yes</td>
<td>Use FLAIR/STIR</td>
</tr>
<tr>
<td>Homonymous hemianopsia</td>
<td>MRI Head</td>
<td>Yes</td>
<td>Attention to retrochiasmal pathway; Use DWI</td>
</tr>
<tr>
<td>Homonymous lower quadrant defect ‘Pie on the floor’</td>
<td>MRI head</td>
<td>Yes</td>
<td>Consider FLAIR/DWI</td>
</tr>
<tr>
<td>Homonymous upper quadrant defect ‘Pie in the sky’</td>
<td>MRI head</td>
<td>Yes</td>
<td>Consider FLAIR/DWI</td>
</tr>
<tr>
<td>Horner Syndrome</td>
<td>MRI/MRA head &amp; neck to T2</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Inflammatory, infiltrative, or compressive optic neuropathy</td>
<td>MRI head &amp; orbits</td>
<td>Yes</td>
<td>Use STIR</td>
</tr>
<tr>
<td>Internuclear ophthalmoplegia</td>
<td>MRI head</td>
<td>Yes</td>
<td>1 mm slices Attention medial longitudinal fasciculus</td>
</tr>
<tr>
<td>Nystagmus</td>
<td>MRI head</td>
<td>Yes</td>
<td>Attention brainstem; Localize nystagmus</td>
</tr>
<tr>
<td>Optic nerve drusen</td>
<td>CT orbits</td>
<td>No</td>
<td>Detects calcification B-scan preferred</td>
</tr>
<tr>
<td>Thyroid eye disease</td>
<td>CT orbits</td>
<td>No</td>
<td>Bone windowing</td>
</tr>
<tr>
<td>Transient monocular vision loss</td>
<td>MRI/MRA head</td>
<td>Yes</td>
<td>Carotid duplex vs. MRA neck</td>
</tr>
<tr>
<td>Traumatic optic neuropathy</td>
<td>CT orbits</td>
<td>No</td>
<td>Superior for canal fx</td>
</tr>
</tbody>
</table>

Figure 13 Common ophthalmic indications for neuroimaging with special considerations 6, 12.
FUNDAMENTAL CONCEPTS

In summary, the majority of neuro-ophthalmic disorders benefit from MRI studies with contrast dye using thin slices, particularly in orbital scans\textsuperscript{11}. Fat suppression (STIR) or bone windowing technique is valuable for orbital MR and CT scans, respectively. A detailed clinical history and specification of potential lesion location is extremely valuable information for the radiologist for error avoidance. Personal review of all neuroimages for clinical correlation is recommended. Communication with a neuroradiologist may be useful to improve patient care, particularly with negative studies.

CME ANSWERS

1. d
2. c
3. d
4. a
5. b

REFERENCES

Neuroradiology

Tina R. Porzukowiak OD, FAAO

Please silence all mobile devices and remove items from chairs so others can sit. Unauthorized recording of this session is prohibited.
Neuroradiology
Tina R. Porzukowiak OD, FAAO

No financial disclosures
Course Learning Objectives

- *Review* the ophthalmic indications for plain film x-ray, CT & MR technologies

- *Understand* the projections & special sequences

- *Know* the contraindications for scanning

- *Review* contrast dye relative & absolute contraindications

- *Understand* the ophthalmic indications for vascular echography

- *Acquire* the fundamental concepts of neuroimaging in eye care
Pre-Test
Question 1: Which of the following best describes the neuroimage?

a. Plain film x-ray
b. CT brain
c. MRI brain, T1WI
d. MRI brain, T2WI
Question 2: Which of the following blood tests are recommended prior to the use of contrast dyes?

a. CBC w/ diff & CMP  
b. CMP  
c. BUN & creatinine  
d. LFT
Question 3: Which of the following is a fat suppression technique?

a. ADC
b. DWI
c. FLAIR
d. STIR
Question 4: Which of the following techniques can be used to evaluate for perfusion abnormality within a few minutes of ischemia when conventional MR images are normal?

a. DWI
b. FLAIR
c. STIR
d. T2W Gradient Echo
Question 5: Which of the following is the gold standard in evaluating the intracranial vasculature?

a. CTA  
b. CCA  
c. MRA  
d. TCD
Neuro-imaging in Patients Referred to a Neuro-ophthalmology Service: The Rates of Appropriateness and Concordance in Interpretation

Collin McClelland, MD1, Gregory P. Van Stavern, MD2, J. Banks Shepherd, MD3, Mae Gordon, PhD4, and Julia Huecker, MS5

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2Department of Ophthalmology and Visual Sciences, Washington University, St. Louis, Missouri; Department of Neurology, Washington University, St. Louis, Missouri
3Department of Ophthalmology and Visual Sciences, Washington University, St. Louis, Missouri
4Department of Ophthalmology and Visual Sciences, Washington University, St. Louis, Missouri
5Department of Ophthalmology and Visual Sciences, Washington University, St. Louis, Missouri

Abstract

Objective—Neuro-imaging studies are frequently ordered to investigate neuro-ophthalmic symptoms. When misused these studies are expensive and time-consuming. This study aimed to describe the type and frequency of neuro-imaging errors in patients referred to an academic neuro-ophthalmology service and to measure how frequently these neuro-imaging studies were re-interpreted.

Design—Prospective cohort study

Participants—84 consecutive patients referred to an academic neuro-ophthalmology practice

Methods—From November 2009 through July 2010 we prospectively enrolled 84 consecutive new patients who had received a neuro-imaging study in the last 12 months specifically in evaluation of their presenting neuro-ophthalmic symptoms. Participants then underwent a complete neuro-ophthalmic evaluation followed by a review of prior neuro-imaging. Questions regarding appropriateness of the most recent imaging, concordance of radiological interpretation, and re-evaluation of referring diagnoses were answered by the attending physician.

Main Outcome Measures—1. The frequency and types of errors committed in the utilization of neuro-imaging. 2. The frequency of re-interpretation of pre-referral neuro-imaging studies following neuro-ophthalmic history and examination.

Results—Most study participants (84.5%; 71/84) underwent magnetic resonance imaging (MRI) prior to referral; 15.5% (13/84) underwent only computed tomography (CT). The rate of sub-
Improper neuroimaging is multifactorial

- Clinical localization
- Imaging region
- Imaging method
- Image quality
- Communication
- Contrast dye
Clinical history

Fat Suppression

MRI
<table>
<thead>
<tr>
<th>DENSITY</th>
<th>APPEARANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>Least</td>
</tr>
<tr>
<td>Fat</td>
<td>↓</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>↓</td>
</tr>
<tr>
<td>Bone</td>
<td>↓</td>
</tr>
<tr>
<td>Metal</td>
<td>Most</td>
</tr>
</tbody>
</table>
X-RAY Order

50 y.o. WM s/p MVA w/ facial airbag trauma, EOM entrapment & ecchymosis OS (ICD10). Order plain film x-ray skull (w/ attn to orbits); evaluate for blow-out fx. Do PA, lateral, & Waters views.
## Hounsfield Unit of CNS Structures

<table>
<thead>
<tr>
<th>STRUCTURE</th>
<th>HU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone / metal</td>
<td>+1000</td>
</tr>
<tr>
<td>Calcification</td>
<td>+140-200</td>
</tr>
<tr>
<td>Acute blood</td>
<td>+56-76</td>
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<td>Gray matter</td>
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</tr>
<tr>
<td>White matter</td>
<td>+23-34</td>
</tr>
<tr>
<td>CSF</td>
<td>0</td>
</tr>
<tr>
<td>Fat</td>
<td>-30 - -100</td>
</tr>
<tr>
<td>Air</td>
<td>-1000</td>
</tr>
</tbody>
</table>

**WHITE**

**BLACK**
Acute heme
Bone
Calcium
Trauma
Contraindications
IODINE-based
CONTRAINDICATIONS

IODINE

SHELLFISH

ABNORMAL KIDNEY FUNCTION
CONTRAINDICATIONS

- Cardiovascular insufficiency
- Diabetes (metformin)
- Plasmocytoma
- Hypertonus
- Hyperuricemia
- Multiple myeloma / paraproteinemias
- Aminoglycoside exposure
- Anuria
- Hepatorenal syndrome
- Hyperthyroidism
50 y.o. WM s/p MVA w/ facial airbag trauma, EOM entrapment & ecchymosis OS (ICD10). Order CT brain & orbits w/o contrast; evaluate for blow-out fx & intracranial heme. 2.0 mm thin cuts through orbits; use bone windowing technique.
Case 1
Case 2
Case 3
Case 4
↑ TESLA
Soft Tissue
STIR: Short TI Inversion Recovery
Diffusion-Weighted Image

Apparent Diffusion Coefficient
SWI Susceptibility Weighted Image

Thick section Clinical GRE

Thin section SWI
FSPGR Fast Spoiled Gradient Recalled

SPGR

NORMAL STUDY
FIESTA-C
Fast Imaging Employing Steady State Acquisition
CISS Constructive Interference in the Steady State

Ax T2  Ax T1 Gd  CISS
ABSOLUTE CONTRAINDICATIONS

- Metallic implants / FB
- Electronic, magnetic, & mechanically activated implants
  - Cardiac defibrillators
  - Cardiac pacemakers
  - CNS ferromagnetic haemostatic clips
- Neurostimulators
RELATIVE CONTRAINDICATIONS

Cochlear implants

Prosthetic heart valves

Other pacemakers (e.g. carotid sinus)

Haemostatic clips (body)

Insulin pumps

Non-ferromagnetic stapedial implants

Nerve stimulators

Cardiac stents

Lead wires or similar wires

Transdermal patch
FDA Drug Safety Communication: FDA evaluating the risk of brain deposits with repeated use of gadolinium-based contrast agents for magnetic resonance imaging (MRI)

[7-27-2015]

Safety Announcement

The U.S. Food and Drug Administration (FDA) is investigating the risk of brain deposits following repeated use of gadolinium-based contrast agents (GBCAs) for magnetic resonance imaging (MRI). MRIs help detect abnormalities of body organs, blood vessels, and other tissues. Recent publications in the medical literature have reported that deposits of GBCAs (See Table 1) remain in the brains of some patients who undergo four or more contrast MRI scans, long after the last administration. It is unknown whether these gadolinium deposits are harmful or can lead to adverse health effects.

FDA, including its National Center for Toxicological Research (NCTR), will study this possible safety risk further. We are working with the research community and industry to understand the mechanism of gadolinium retention and to determine if there are any potential adverse health effects. Based on the need for additional information, at this time, we are not requiring manufacturers to make changes to the labels of GBCA products.
eGFR > 30
Nephrogenic Systemic Fibrosis
Contraindications

GADOLINIUM

NSF
Contraindications

- Abnormal kidney function
- Hemodialysis
- Pregnancy
- Hepatorenal syndrome
MRI Order Protocol

Age, race, gender

Description of case

Dx / ICD10 code

Brain and / or orbits

+ / - contrast dye

Routine studies

3-5 mm slices

Orbit studies

1.5 – 2 mm slices

+ / - STIR, FLAIR, DWI/ADC, SWI

Advise the radiologist what to look for & where to look.
Case 1
Case 2
Case 3
Case 4
Case 5
Vascular Imaging

Computed Tomography Angiography
Computed Tomography Venography

Magnetic Resonance Angiography
Magnetic Resonance Venography

Digital Subtraction Angiography
CLINICAL EXAMPLES
VASCULAR ECHOGRAPHY

Carotid Duplex

Transcranial Doppler
Carotid Artery Duplex Scan

Internal Carotid Artery

External Carotid Artery

Common Carotid Artery

Ultrasound Transducer
Post-Test
Question 1: Which of the following best describes the neuroimage?

a. Plain film x-ray
b. CT brain
c. MRI brain, T1WI
d. MRI brain, T2WI
Question 2: Which of the following blood tests are recommended prior to the use of contrast dyes?

a. CBC w/ diff & CMP  
b. CMP  
c. BUN & creatinine  
d. LFT
Question 3: Which of the following is a fat suppression technique?

a. ADC
b. DWI
c. FLAIR
d. STIR
Question 4: Which of the following techniques can be used to evaluate for perfusion abnormality within a few minutes of ischemia when conventional MRI images are normal?

a. DWI
b. FLAIR
c. STIR
d. T2W Gradient Echo
Question 5: Which of the following is the gold standard in evaluating the intracranial vasculature?

a. CTA  
b. CCA  
c. MRA  
d. TCD
What Have We Learned?
History
Thin Slices
Fat Suppression
Neuroradiologist
Negative Studies
QUESTIONS
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