
EMERGENCY MEDICINE
ADVANCED IMAGING CASES 2023
Part Two
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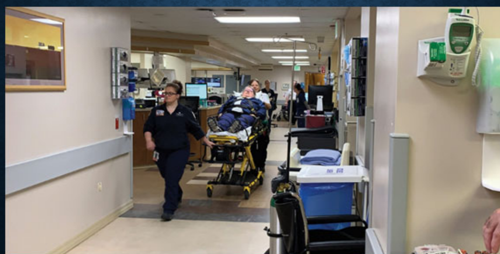
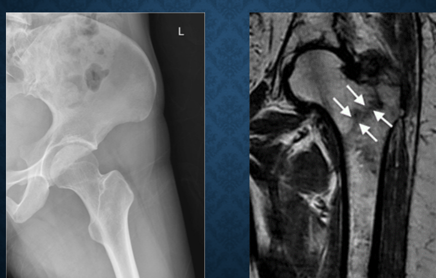
I Have No Financial Disclosures to Reveal

GIVING PRO TIPS DURING TURNOVER



OCCULT HIP FRACTURES



CASE ONE

An 85-year-old woman is BIB EMS for evaluation of a **probable left hip fracture.** She fell into hole and was rescued at once. On arrival, VSSAF, and only observed injury is a **medially rotated and shortened LLE** with intact motor, sensory and pulses noted. She is fully trauma scanned and no fractures or other traumatic or medical issues are identified. **What are your next moves?**

OCCULT HIP FRACTURES

X-Rays: miss ***10%-35%*** of hip fractures
CT Scans: still miss ***2%-4%*** of hip fractures
Highly Suspected Hip Fractures: need further evaluation

Delay to Surgery > 48 Hours: higher mortality
Surgery within 12 Hours: improves survival

MRI Scans for Hip Fractures: 100% sensitive & 99% specific
MRI Scans for AVN: 97% sensitive & 100% specific

CASE TWO

You have recently been diagnosed as having a disc prolapse **at L4-L5**. You are referred to a neurosurgeon who wants to order a **CT Myelogram and an MRI**.

What are the benefits with both tests?
What are the complications for each test?

CT MYELOGRAM

Reasons to Consider a CT Myelogram
MRI quality varies markedly; some have **very low-strength magnets** or **poor rendering software**

Open MRIs
have **poor image quality**

All MRIs are prone to artifacts
(like the way a magnet near a TV warps the picture)

MRIs have Misrepresentations of Images
due to **motion** (anxiety or breathing), as well as dental **fillings or hardware**

CT MYELOGRAM

CT MYELOGRAMS
Have **higher resolution** than MRI
Identifies **more subtle signs** of disease
Identifies **bony anatomy** much better
Helps to plan **surgical procedures**

CT MYELOGRAMS
Use **dye** to fill the actual **nerve root sleeves,** allowing the surgeon better **visualization** and assessment of the **nerve root compression**.

CT MYELOGRAM COMPLICATIONS

spineuniverse

HEADACHE IS THE MC COMPLICATION: due to increases in spinal fluid pressure and treated with **bed rest** and sometimes a **blood patch.**

ALLERGIC REACTION: Contrast dye contains iodine, and patients sensitive to shellfish are susceptible this side effect. **WHY IS THIS FALSE?**

RADIATION: Women who are pregnant should not get a myelogram since it exposes the baby to radiation. MRIs do not use radiation, so they are safe for use in pregnancy. **WHY IS THIS FALSE-ISH?**

CT MYELOGRAM COMPLICATIONS

spineuniverse

ARACHNOIDITIS: inflammation of the arachnoid lining overlying the nerves.

OTHER COMPLICATIONS: nerve root injury, infections, and bleeding (stop blood thinners) & infection.

EPIDERMOID (benign tumor): rare complication from needle insertion when skin cells are tracked Into the patient.

CASE THREE

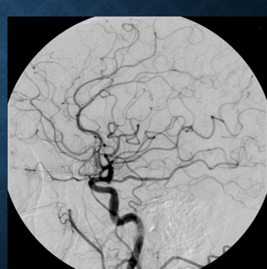
A 71-year-old woman was **admitted to Neurology with tinnitus**. The cerebral MRA detected atherosclerotic cerebral arteries and bilateral MCA stenosis. The patient underwent **Digital Subtraction Angiography (DSA).** The total amount of **iopamidol** used was 110 ml.

The patient experienced **headache** during the procedure, followed by **dizziness with nausea and vomiting.**

Despite treatment with **anti-edema medications**, she gradually deteriorated, went into a **deep coma** due to **irreversible cerebral edema**. The patient **died 56 days in-hospital** following the procedure.

DIGITAL SUBTRACTION ANGIOGRAPHY

This is a **fluoroscopic** technique used by **IR** to clearly visualize blood vessels in a bony or dense soft tissue region. Images are produced using contrast medium by subtracting a "pre-contrast image" from subsequent contrasted images. DGA: first described in 1935, **made practical in the 1970s**.



CONTRAST INDUCED ENCEPHALOPATHY

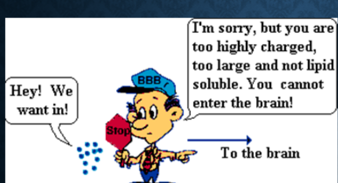
CIE: Complications from the use of **Iodinated Contrast** Agent during **Angiography** and **Vascular Interventions**.

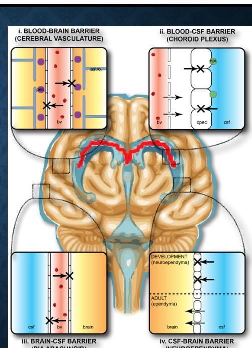
Manifestations: **hemiparesis, cortical blindness**, speech changes, Parkinsonism, confusion, **seizure**, and coma.

Most CIE Cases: are **transient and reversible**
Fatal CIE Cases: rare; almost all involve the use of **high osmolar ionic contrast** agents. However, there does exist, **at least one case** involving **iopamidol** (non-ionic monomer low osmolar contrast agent).

SO WHAT HAPPENED WITH THE PATIENT?

BLOOD BRAIN BARRIER





CONTRAST INDUCED ENCEPHALOPATHY

CIE PROGNOSIS

generally good with a rapid recovery. **Persistent deficits are rare.**

CIE FATALITIES

Eight cases of autopsy-proven cerebral edema due to contrast neurotoxicity have been reported. These include 6 infants, 5 of whom underwent cardiac angiography. Three others received aortography. **All fatal cerebral edema cases** involved the use of **ionic high osmolar contrast** agents. which are no longer used in routine angiography and intervention procedures.

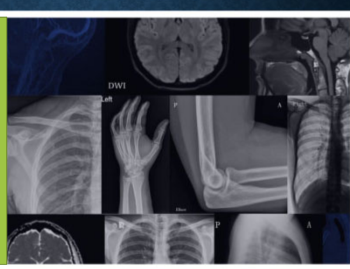
CIE DEATH DUE TO IOPAMIDOL

Perhaps the first case of its type used, and highlights the potential for **other types of iodinated contrast** agents to induce fatal encephalopathy.

CONTRAST INDUCED ENCEPHALOPATHY

- ✓ **CIE Mechanism of Injury:** **controversial**
- ✓ **BBB Disruption:** following iodinated contrast injection **most likely**
- ✓ **Opening of BBB:** results in **brain edema**
- ✓ **Contrast Agents:** also have **direct neurotoxic effects** on neurons & astrocytes and contribute to **progressive edema**
- ✓ **Possible CIE Therapy:** The use of **continuous renal replacement** therapy and continuous blood purification.
- ✓ **Further Studies:** needed to define **risk factors, mechanism of injury, and additional complications**

LAWSUITS IN RADIOLOGY



TLL RADIOLOGY CASE

A 36-year-old woman presents with right hip pain.

She was previously seen at another ED, and they said nothing was wrong.

She is wheeled into her room, tearful and requesting pain medication and something for her anxiety.

TLL RADIOLOGY CASE

TRACY'S MANY FAILURES

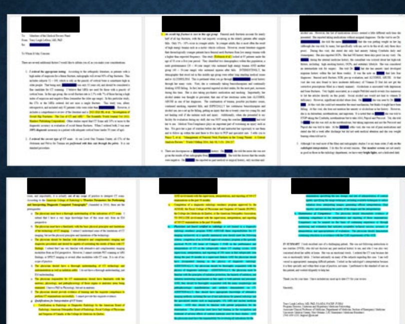
properly obtain and record a **precise medical history**	perform a **proper physical exam and** evaluation.
properly order and read **x-rays and/or a CT scan**	to perform **all diagnostic tests with** no risk of serious harm

FAILURE FAILURE FAILURE

NOT possessing the requisite knowledge and/or skill required of an emergency department physician.

NOT exercising medical judgement based on sound medical principles.

NOT properly supervising those to whom the care, management, evaluation & care of the pt was delegated.



SPINAL PATHOLOGY AND MRI

Osteomyelitis	Disciitis	Spinal Hematoma
Cauda Equina	Conus Medullaris	Syringomyelia
Meningomyelocele	Tethered Cord Syndrome	Multiple Sclerosis
Transverse Myelitis	Neuromyelitis Optica	Spinal Neoplasm
Central Cord Syndrome	Amyotrophic Lateral Sclerosis	Arachnoiditis
Epidural Abscess	Brown-Sequard Syndrome	Anterior Cord Syndrome
Meningioma	Ependymoma	Lumbar Stenosis

TAKE HOME POINTS

- ✓ ED Doctors: are NOT responsible for formal reads
- ✓ MRI is Mandatory: to Evaluate Inability to Bear Weight, in the Elderly, and those with a Paucity of Cortical Bone
- ✓ CT Myelograms: Augments findings of MRIs but may have Significant Complications (Contrast-Induced Encephalopathy)

THANK YOU VERY MUCH!!

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SO WHAT HAPPENED WITH THE PATIENT WITH DSA?

DSA and fluoroscopy[edit]

In traditional angiography, images are acquired by exposing an area of interest with time-controlled x-rays while injecting a contrast medium into the blood vessels. The image obtained includes the blood vessels, together with all overlying and underlying structures.[3] The images are useful for determining anatomical position and variations, but unhelpful for visualizing blood vessels accurately.

In order to remove the distracting structures to see the vessels better, first a mask image is acquired. The mask image is simply an image of the same area before the contrast is administered. The radiological equipment used to capture this is usually an X-ray image intensifier, which then keeps producing images of the same area at a set rate (1 to 7.5 frames per second). Each subsequent image gets the original "mask" image subtracted out. (Mathematically, the incoming image is divided by the mask image) The radiologist controls how much contrast media is injected and for how long. Smaller structures require less contrast to fill the vessel than others. Images produced appear with a very pale grey background, which produces a high contrast to the blood vessels, which appear a very dark grey.[5]

Intravenous digital subtraction angiography[edit]

Intravenous digital subtraction angiography (IV-DSA) is a form of angiography which was first developed in the late 1970s.

IV-DSA is a computer technique that compares an X-ray image of a region of the body before and after radiopaque iodine based dye has been injected intravenously into the body. Tissues and blood vessels on the first image are digitally subtracted from the second image, leaving a clear picture of the artery which can then be studied independently and in isolation from the rest of the body.

Some limited studies have indicated that IV-DSA is not suitable for patients with diabetes or kidney failure because the dye load is significantly higher than that used in arteriography.[6] However, IV-DSA has been used successfully to study the vessels of the brain and heart and has helped detect carotid artery obstruction and to map patterns of cerebral blood flow. It also helps detect and diagnose lesions in the carotid arteries, a potential cause of strokes.[7][8][9]

IV-DSA has also been useful in assessing patients prior to surgery and after coronary artery bypass surgery and some transplant operations.

- Coronary CT Angiography
- Aorta and Great Vessels
- Pulmonary Arteries
- Renal Arteries
- Brain and Neck Vessels

Applications[edit]

DSA is primarily used to image blood vessels. It is useful in the diagnosis and treatment of arterial and venous occlusions, including carotid artery stenosis, pulmonary embolisms, and acute limb ischaemia; arterial stenosis, which is particularly useful for potential kidney donors in detecting renal artery stenosis (DSA is the gold standard investigation for renal artery stenosis[10]); cerebral aneurysms and arteriovenous malformations (AVM).

The future[edit]

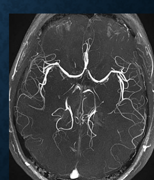
DSA is done less routinely in imaging departments. It is being replaced by computed tomography angiography (CTA), which can produce 3D images through a test which is less invasive[11] and stressful for the patient,[12] and magnetic resonance angiography (MRA), which avoids X-rays and nephrotoxic contrast agents.[13]

CT ANGIOGRAPHY

- **Computed tomography angiography** (also called **CT angiography** or **CTA**) is a computed tomography technique used for angiography—the visualization of arteries and veins—throughout the human body. Using contrast injected into the blood vessels, images are created to look for blockages, aneurysms (dilations of walls), dissections (tearing of walls), and stenosis (narrowing of vessel). CTA can be used to visualize the vessels of the heart, the aorta and other large blood vessels, the lungs, the kidneys, the head and neck, and the arms and legs.[citation needed] CTA can also be used to localise arterial or venous bleed of the gastrointestinal system [1]
- History[edit]
- By 1994 CT angiography began to replace conventional angiography in diagnosing and characterizing most cardiovascular abnormalities.[16] Prior to this, conventional angiography had been in use for 70 years.[16]

MAGNETIC RESONANCE ANGIOGRAPHY

- **Magnetic resonance angiography** (**MRA**) is a group of techniques based on magnetic resonance imaging (MRI) to image blood vessels. Magnetic resonance angiography is used to generate images of arteries (and less commonly veins) in order to evaluate them for stenosis (abnormal narrowing), occlusions, aneurysms (vessel wall dilatations, at risk of rupture) or other abnormalities. MRA is often used to evaluate the arteries of the neck and brain, the thoracic and abdominal aorta, the renal arteries, and the legs (the latter exam is often referred to as a "run-off").



- Acquisition[edit]
- A variety of techniques can be used to generate the pictures of blood vessels, both arteries and veins, based on flow effects or on contrast (inherent or pharmacologically generated). The most frequently applied MRA methods involve the use intravenous contrast agents, particularly those containing gadolinium to shorten the T_1 of blood to about 250 ms, shorter than the T_1 of all other tissues (except fat). Short-TR sequences produce bright images of the blood. However, many other techniques for performing MRA exist, and can be classified into two general groups: 'flow-dependent' methods and 'flow-independent' methods.[citation needed]

- **Flow-independent angiography**[edit]
- Whereas most of techniques in MRA rely on contrast agents or flow into blood to generate contrast (Contrast Enhanced techniques), there are also non-contrast enhanced flow-independent methods. These methods, as the name suggests, do not rely on flow, but are instead based on the differences of T_1, T_2 and chemical shift of the different tissues of the voxel. One of the main advantages of this kind of techniques is that we may image the regions of slow flow often found in patients with vascular diseases more easily. Moreover, non-contrast enhanced methods do not require the administration of additional contrast agent, which have been recently linked to nephrogenic systemic fibrosis in patients with chronic kidney disease and kidney failure.
- Contrast-enhanced magnetic resonance angiography uses injection of MRI contrast agents and is currently the most common method of performing MRA.[2][6] The contrast medium is injected into a vein, and images are acquired both pre-contrast and during the first pass of the agent through the arteries. By subtraction of these two acquisitions in post-processing, an image is obtained which in principle only shows blood vessels, and not the surrounding tissue. Provided that the timing is correct, this may result in images of very high quality. An alternative is to use a contrast agent that does not, as most agents, leave the vascular system within a few minutes, but remains in the circulation up to an hour (a "blood-pool agent"). Since longer time is available for image acquisition, higher resolution imaging is possible. A problem, however, is the fact that both arteries and veins are enhanced at the same time if higher resolution images are required.

- **Flow-independent angiography**[edit]
- Subtractionless contrast-enhanced magnetic resonance angiography: recent developments in MRA technology have made it possible to create high quality contrast-enhanced MRA images without subtraction of a non-contrast enhanced mask image. This approach has been shown to improve diagnostic quality,[7] because it prevents motion subtraction artifacts as well as an increase of image background noise, both direct results of the image subtraction. An important condition for this approach is to have excellent body fat suppression over large image areas, which is possible by using mDIXON acquisition methods. Traditional MRA suppresses signals originating from body fat during the actual image acquisition, which is a method that is sensitive to small deviations in the magnetic and electromagnetic fields and as a result may show insufficient fat suppression in some areas. mDIXON methods can distinguish and accurately separate image signals created by fat or water. By using the 'water images' for MRA scans, virtually no body fat is seen so that no subtraction masks are needed for high quality MR venograms.
- Non-enhanced magnetic resonance angiography: Since the injection of contrast agents may be dangerous for patients with poor kidney function, others techniques have been developed, which do not require any injection. These methods are based on the differences of T_1, T_2 and chemical shift of the different tissues of the voxel. A notable non-enhanced method for flow-independent angiography is balanced steady-state free precession (bSSFP) imaging which naturally produces high signal from arteries and veins.

- Clinical use[edit]
- MRA has been successful in studying many arteries in the body, including cerebral and other vessels in the head and neck, the aorta and its major branches in the thorax and abdomen, the renal arteries, and the arteries in the lower limbs. For the coronary arteries, however, MRA has been less successful than CT angiography or invasive catheter angiography. Most often, the underlying disease is atherosclerosis, but medical conditions like aneurysms or abnormal vascular anatomy can also be diagnosed.
- An advantage of MRA compared to invasive catheter angiography is the non-invasive character of the examination (no catheters have to be introduced in the body). Another advantage, compared to CT angiography and catheter angiography, is that the patient is not exposed to any ionizing radiation. Also, contrast media used for MRI tend to be less toxic than those used for CT angiography and catheter angiography, with fewer people having any risk of allergy. Also far less is needed to be injected into the patient. The greatest drawbacks of the method are its comparatively high cost and its somewhat limited spatial resolution. The length of time the scans take can also be an issue, with CT being far quicker. It is also ruled out in patients for whom MRI exams may be unsafe (such as having a pacemaker or metal in the eyes or certain surgical clips).
- MRA procedures for visualizing cranial circulation are no different from the positioning for a normal MRI brain. Immobilization within the head coil will be required. MRA is usually a part of the total MRI brain examination and adds approximately 10 minutes to the normal MRI protocol.