

EMERGENCY MEDICINE ADVANCED IMAGING CASES 2023 Part One

Tracy Leigh LeGros, MD, PhD, FACEP, FAAEM, FUHM
Professor of Emergency Medicine
Director of Faculty Development
UTHSC / Regional One Physicians

I Have No Financial Disclosures to Reveal



MRI ADVANTAGES

- ✓ **Lacks Ionizing Radiation:** safe in pregnancy and with children
- ✓ **Multi-Planer Technology:** manipulates images very nicely (many views)
- ✓ **Gadolinium:** safer than iodinated contrast ???
- ✓ **Long Term Studies:** no adverse effects found
- ✓ **Excellent Resolution vs CT Scans:** for soft tissue, CNS, ligaments

MRI COMPATIBLE DEVICES

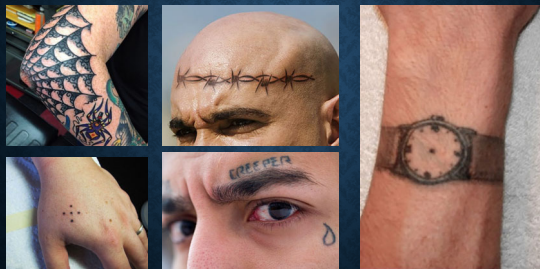
- ✓ Spinal Metallic Hardware
- ✓ Sternal Wires
- ✓ Coronary Stents
- ✓ Prosthetic Heart Valves: exception is the Star-Edwards ball in a cage
- ✓ Dental Hardware



TATTOOS ARE OK FOR MRI SCANNERS

Exception: jail tattoos may contain lead and result in burning

JAIL TATTOOS



MRI DISADVANTAGES

- ✓ **Claustrophobia:** less of an issue
- ✓ **Time and Labor Intensive:** limited availability and use
- ✓ **Early Pregnancy:** generally safe in pregnancy, but avoid in the first trimester, as MRIs will increase body temperature

MRI CONTRAINDICATIONS

- ✓ **Metal:** pacemakers, metal FBs, aneurysm clips, infusion pumps, cochlear implants, some shrapnel
- ✓ **Morbid Obesity:** an issue at some institutions

THE GADOLINIUM CONTROVERSIES



THE USE OF GADOLINIUM

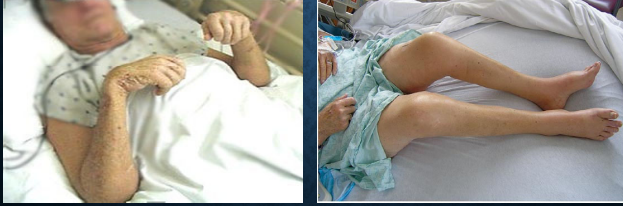
- ✓ **Use of Gd^{3+}** : The development of gadolinium-based contrast has greatly expanded the diagnostic capabilities of MRI
- ✓ **Expanded Use**: > 10 million doses annually
- ✓ **2006**: possible connection to nephrogenic systemic fibrosis (NSF), a debilitating widespread tissue fibrosis in dialysis patients and those with impaired renal function.



NEPHROGENIC SYSTEMIC FIBROSIS

- ✓ **Definition**: serious systemic fibrosis of skin, joint, eyes, and internal organ associated with exposure to gadolinium-based MRI contrast agents in those with severe kidney disease.
- ✓ **First Known As**: Nephrogenic Fibrosing Dermopathy (1997)
- ✓ **Systemic Symptoms**: large areas of hardened skin with fibrotic nodules and plaques, joint contractures, significant pain, limited ROM, fibrosis of the heart, liver and lungs (renamed NSF)

NEPHROGENIC SYSTEMIC FIBROSIS



NEPHROGENIC SYSTEMIC FIBROSIS

Those Most At Risk

GFR < 60 ml/mn	GFR < 30 ml/mn
ESRD on Hemodialysis	ESRD on Peritoneal Dialysis
Immunosuppressive Drugs	Hepatitis C
ESRD Later in Life (DM patients have 50% risk)	
Annual Enhanced MR Imaging	
(Multiple Sclerosis and BRCA gene positive)	

NEPHROGENIC SYSTEMIC FIBROSIS

- ✓ **Significant Under-Reporting:** dialysis registries, dermatopathology files, rheumatology files, radiology information systems
- ✓ **Cumulative Risk:** skin biopsies showed an increasing amount of gadolinium in the skin up to three years after the last exposure to gadolinium contrast
- ✓ **Where Is It Coming From:** is there Gd^{3+} left in the body??

Answer Forthcoming!!

GADOLINIUM

- ✓ **Heightened NSF Awareness:** and strict MRI protocols significantly decreased the number of NSF cases. Subsequent studies have confirmed that the chance of developing NSF or other adverse reactions in those with normal renal function is **generally < 0.1%**
- ✓ **The Good News:** no new cases of NSF have been reported since 2009

GADOLINIUM

- ✓ **Mechanism of Injury:** occurs when the compound disassociates and forms free metal (Gd^{3+}) and uncomplexed ligand due to Zn^{2+} , Cu^{2+} and Ca^{2+} transmetallation in vivo
- ✓ **Safest Contrasts:** least likely to release Gd^{3+} - a **macrocyclic structure**; followed by those with an **ionic linear structure**, and those with a **linear non-ionic structure**

NEW TERMS FOR GADOLINIUM "DISEASE"

- ✓ **GADOLINIUM STORAGE CONDITION:** occurs in those with normal renal function with remnants of gadolinium in their brain tissue or bone.
- ✓ **GADOLINIUM DEPOSITION DISEASE:** occurs in those with normal renal function who develop persistent and painful symptoms, usually in the lower arms and legs, a few hours or weeks after exposure to Gd

GADOLINIUM STORAGE CONDITION

Kanda T, et al. "High Signal Intensity in the Dentate Nucleus and Globus Pallidus on Unenhanced T1-Weighted MR Images: Relationship with Increasing Cumulative Dose of a Gadolinium-Based Contrast Material." *Radiology*. 2014 Mar; 270 (3): 834 – 841.

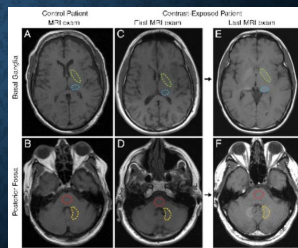
The Study That Renewed Concerns Regarding Gadolinium

- ✓ **Study:** 19 patients who had undergone at least 6 contrasted MRIs were compared to 16 patients who had undergone at least 6 unenhanced MRIs.
- ✓ **Results:** High signal intensities in the **dentate nucleus** and **globus pallidus** on unenhanced T1-weighted images may be the consequence of a number of previous gadolinium-based contrast administrations.

GADOLINIUM STORAGE CONDITION

McDonald RJ, et al. "Intracranial Gadolinium Deposition After Contrast-Enhanced MR Imaging." *Radiology*. 2015 Jun; 275 (3): 772 – 782.

- ✓ **Institution:** Mayo Clinic (Rochester)
- ✓ **Study Design:** Comparison of brain autopsy findings of a contrast group of 13 patients who received between 4 – 29 contrasted MRIs between 2000 – 2014, with a control group of 10 patients who received 1 – 6 unenhanced MRIs.



GADOLINIUM STORAGE CONDITION

McDonald RJ, et al. "Intracranial Gadolinium Deposition After Contrast-Enhanced MR Imaging." *Radiology*. 2015 Jun; 275 (3): 772 – 782.

- ✓ **Findings:** traces of gadolinium in four areas of the brain (dentate nuclei, pons, globus pallidus and thalamus) several years after MRI contrast administration and no gadolinium in the control group.
- ✓ **Clinical Significance:** unknown, but it appears that IV gadolinium contrast agent is associated with a **dose dependent deposition** in neuronal tissues that is unrelated to renal function, age or interval between exposure and death.

GADOLINIUM STORAGE CONDITION

- ✓ **Study:** 134 Post-mortem analyses of those who received only Gd contrast via inductively coupled plasma mass spectrometry (ICP-MS) compared to a smaller group of controls who had never been exposed to Gd.
- ✓ **Results:** Gd was found in **all brain areas** evaluated (putamen, globus pallidus, caudate nucleus, pons and dentate nucleus) with the greatest level in the globus pallidus. There were much **higher levels of Gd in the bone** than in the brain in all cases (**at least nine times greater**) compared to the globus pallidus.
- ✓ **Conclusion:** Gd may deposit in bone compared to other tissues because Gd is similar to calcium in terms of its chemical properties and molecular size.

GADOLINIUM DEPOSITION DISEASE



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E-NEWS EXCLUSIVE
Chuck Norris Lawsuit Claims MRI Agent Poisoned His Wife
By Bruce Y. Lee
Yes, I am writing about a Chuck Norris fight.



CASE ONE

26 y/o woman, who is 16 weeks pregnant, is BIB EMS complaining of chest pain. She is tachycardic and hypotensive but has good fetal heart tones

DIAGNOSIS??

PULMONARY EMBOLISM



V/Q SCANS FOR PE IN PREGNANCY

V/Q Scan Advantages: Low Radiation (10 – 37 mrad)

V/Q Scan Disadvantages:

- ✓ Fills the **Bladder** with **Technetium** During Perfusion: fetus irradiation
- ✓ Have Mom **Void Bladder** Following Scan
- ✓ Risk of Indeterminate Scans

Now What Do You Do?

Physicians Very Hesitant to Order a Second Study In Pregnant Patients Due to an Indeterminate Result

Most PE Studies Exclude Pregnant Patients
Ensure Adequate Hydration After Technetium
½ Dose Perfusion Scans May Be Useful

CT SCANS FOR PE IN PREGNANCY

Helical CT Pulmonary Angiography (HCTPA)

BENEFITS

- ✓ **Fast and Safe in All Trimesters:** (< 6 mrad)
- ✓ **Greater Accuracy:** than V/Q in main, lobar and segmental vessels
- ✓ **Evaluates Alternative Diagnoses**

RISKS

- ✓ **Breast Cancer:** exposes maternal breast tissue to high radiation dosing (35 mGy per breast)
- ✓ **Exposures > 10 mGy:** have been reported to increase breast cancer risks in those > 35 years of age
- ✓ **Non-Diagnostic Scans**

CT SCANS FOR PE IN PREGNANCY

NON-DIAGNOSTIC HCTPA SCANS

In pregnancy there is a higher chance of a non-diagnostic study due to changes in **plasma volume & hemodynamics**

PREGNANT +	ABNORMAL CXR	NORMAL CXR
NON-DIAGNOSTIC SCAN	CT = 16% V/Q = 40%	CT = 30% V/Q = 5%

MRI SCANS FOR PE IN PREGNANCY

MRI PERFUSION or MRI VENOGRAM

Should be Considered

especially in combination with other studies
sensitivities & specificities approaching 100%

BUT IS MRI REALLY SAFE IN PREGNANCY??

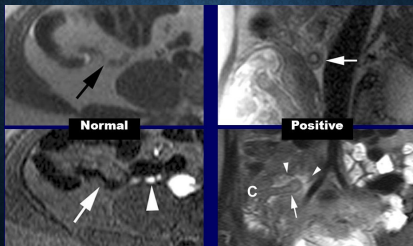
MRI GUIDELINES IN PREGNANT PATIENTS

Policies, Guidelines, and Recommendations for
MR Imaging Safety and Patient Management
Safety Committee of the Society for MR Imaging
Adopted by the American College of Radiology
Considered **"The Standard of Care"**
Applies to MR Systems up to and including 3 – Tesla)

MRI GUIDELINES IN PREGNANT PATIENTS

"MR imaging **may be used in pregnant women** if other nonionizing forms of diagnostic imaging are inadequate or if the examination provides important information that would otherwise require exposure to ionizing radiation. Pregnant patients should be informed that, to date, there has been **no indication that the use of clinical MR imaging during pregnancy has produced deleterious effects.**"

CASE TWO: APPENDICITIS IN PREGNANT PATIENTS



APPENDICITIS IN PREGNANCY

Ultrasound is Test of Choice (ACR 2011)

However, multiple studies revealed show **that US does NOT visualize** the appendix of pregnant patients **68-97%**.

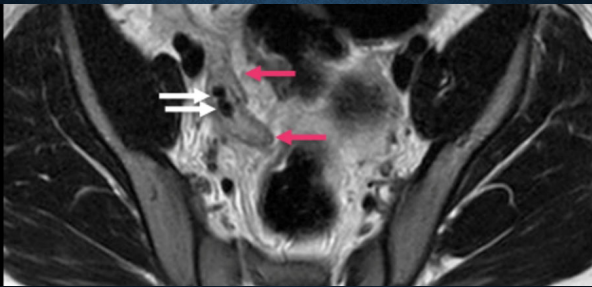
MRI IS Test of Choice

A meta-analysis of 359 pregnant women with suspected appendicitis revealed a specificity of **98%** & **99%** NPV when a normal appendix is visualized.

Reveals Alternative Diagnoses

Diagnostic rate was **43.3%** in finding ovarian masses, ovarian torsion, fibroid tumors, ectopic pregnancies, hernias, renal abscess, as well as appendicitis.

CASE THREE: APPENDICITIS IN CHILDREN



CASE THREE: APPENDICITIS IN CHILDREN

Initial MRI Choice

96.8% sensitive
97.4% specific
97.4%, NPV
98.9%, PPV

MRI Use when US Indeterminate

94% sensitive
100% specific

Additional Diagnoses

Pyelonephritis, Constipation,
PID, Ruptured Ovarian Cyst,
Hemorrhagic Cyst, & Epiploic
Appendagitis

CT vs MRI – No Difference In

time to antibiotics	time to surgery
perforation rate	length of stay

TAKE HOME POINTS

- ✓ **Gadolinium Storage Condition:** accumulation of Gd **within bone and brain**
- ✓ **Gadolinium Deposition Disease:** occurs in those with **normal renal function** and results in **painful lower arms and legs**
- ✓ **MRI has advantage over CT scan** for the **evaluation of stroke** and should be employed in further trials
- ✓ **The American College of Radiology:** has stated that the use of MRI in the **2nd and 3rd trimester of pregnancy** has no deleterious effects.

THANK YOU VERY MUCH!!



tle Gros1@cox.net

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