Principles and Practice
Clarian Health 2009

Important MRI Safety Topics
- Sentinel events due to projectiles.
- Steps to prevent sentinel events
- Site Planning
- Review Clarian MRI Safety Policy
- Patient and Visitor Screening Procedure
- MRI Emergency Plan
- Surgical Implant Safety for MRI
- Review Clarian Gadolinium Contrast Safety Policy

Types of MRI Sentinel Events
The following are types of injuries that have and can occur during the MRI Scanning process
- “Missile effect” or “projectile injury” from ferromagnetic objects
- Surgical Implant Injury from pacemakers, aneurysm clips, orbital metal
- Patient Burns
- Acoustic Noise
- MRI Contrast Agents
- Cryogen/quench

Is MRI Safety Important?

Magnetic Force and Projectile Effect
- The magnet in a high-field MR scanner produces a very strong magnetic field.
- The field strength increases very rapidly near the magnet.
- The force of attraction will suddenly increase as the object gets closer, causing it to take off and become a projectile.
Preventing Sentinel events

MR Zone Configuration

- Zone 1: This Zone includes all areas freely accessible by the general public. Typically MR patient waiting.
- Zone 2: This area is the interface from the uncontrolled Zone 1 and the restricted areas of Zone 3 and 4. Typically Zone 2 is the MR screening area and patients are under the supervision of MR personnel.
- Zone 3: Should be strictly restricted and is directly adjacent to the magnet room. Zone 3 is typically the MR control room and the entry space before entering the magnet room.
- Zone 4: Magnet room

MR Zones 3 and 4

- Both zones should be strictly prohibited by the general public. Key locks, passkey locking systems can be used to restrict access to this area.
- Zones 3 and 4 should be marked with warning signs that indicate the presence of a strong magnet fields.
- Zones 3 and 4 should be marked with a lighted sign that states that the “Magnet is always on”.
- To gain access to Zones 3 and 4 personnel are required to participate in MRI Safety Training
- All non-MRI personnel should be under constant supervision of an MRI technologist, or MRI engineer

MR Safety Warning signs

Door includes Danger Signs in English and Spanish.
Every MRI Magnet room should have an MRI compatible Fire Extinguisher

Zone 3 and 4 locking systems
Honeywell card reader  Magnet room keypad

MRI Compatible Equipment Labels
The Invivo MRI Monitor labeled with a MRI Safe sticker
The Invivo battery supply is not and must be secured to the floor with proper warning labels.

MRI Compatible Equipment
Have a bar magnet available to double check equipment going into the magnet room
Clarian MRI Safety Policies

- MRI Safety Policy
- Use of equipment in MRI Magnet Room
- MRI Contrast Media Policy

MRI Safety Policy

- The goal of the radiology department is to make every effort to constantly minimize the risks of incidents associated with MRI resulting from the magnetic field and/or cryogens.

- All Radiology personnel will be educated in an annual MRI Safety in-service. MRI personnel will be trained in all aspects of MRI safety and emergency procedures.

- The MRI Safety questionnaire will be completed by all patients and visitors before entering the MRI magnet room.

- All hospital personnel, physicians, patients, nurses, RT’s must pass MR safety screening before entering the MR magnet room. All hospital personnel working in the MRI environment are encouraged to complete the MRI safety training on Pulse.

- There will be no admittance of ferrous metal in the magnet room. Only MRI compatible equipment will be used.

- All patients, visitors, and hospital personnel in the magnet room during the scanning process are required to wear ear protection such as ear plugs, or headphones.

- All patients will be given the MRI Technologist alert button (Squeeze Ball)

- All pregnant MRI personnel should not remain in the MRI magnet room during the actual scanning process.
Use of equipment in MRI Policy

- A policy for the safe use of medical equipment and devices in the MRI magnet room.

- The policy states that any new medical equipment and devices used in the magnet room will be reviewed by the Clarian MRI Safety Committee and labeled accordingly.

Servo i Ventilator for MRI

- Maquet Inc.
- Servo i Ventilator will be placed outside the 20mT (200 gauss) line. For open MR scanners it should be placed outside the 10mT (100 gauss) line.
- Brakes on
- Tether secured.

Servo i Positioned in a Magnet Room

MRI Compatible Anesthesia Machines

- Datex Ohmeda placed outside the 30mT (300 gauss) line.

MrRidium MRI compatible IV pump

iRadimed Corporation
http://www.iradimed.com/en/products/?sf_ses=0
23bf4410f4d
Patient and Visitor Screening

- Greet patient confirm their name and DOB
- Introduce yourself
- Review their MRI Safety questionnaire with them and **verbally confirm** that they do not have metal inside their body.
- Show patient where to get dressed and have them remove all loose metal such as jewelry, watches, hairpins, etc.
- Start IV if needed and inform the patient if their will be a short wait before their MRI begins.

MRI Imaging Safety

MR Safety Screening

All patients and visitors need to complete an MRI safety questionnaire before entering the MR magnet room. For pediatric patients the questionnaire needs to be completed by a parent or guardian. For questionnaires in inpatient rooms prior to the MRI Procedure.

- Patients with a Pacemaker, defibrillator, or ICD should be cancelled and not imaged with MRI. The patient’s referring physician should be notified of cancellation.
- Patients with metal in their body such as bullets, BB’s or Shrapnel should be screened for the type of metal and X-rays can be obtained to review the location of the metal. Patient with a history of orbital metal should be screened with orbit x-rays or CT.
- All Surgical devices such as a brain aneurysm clip, IVC filters, drug infusion pumps should be thoroughly researched and proven to be safe for MRI imaging.

Prevent Patient Burning due to Induced Currents

- Insolate wires and leads.
- Make sure all the coils are plugged into the scanner.
- Position patient so that the arms and legs are not crossing or touching to form current loop.
- Check for metallic ECG pads and tattoos.

Medication patches

- All medication patches should be removed before imaging a patient.
- Medication patches contain a metal backing that can cause a skin burn.
- Clear patches should be removed, as well. Clear medication patches may contain small amounts of metal that can cause a skin burn.

MR Unsafe Implants

- Some implants are paramagnetic, or even ferromagnetic. These implants tend to move and align with the main magnetic field.
- This results in a force and torque on the implant and the implant may become dislodged, resulting in severe injury to the patient.
- Aneurysm clips are examples of implants that can result in death if displaced.
- Clarian MRI Safety policy indicates that documentation and confirmation of MRI safety is required for all surgical implants prior to MRI imaging.
Interference with other Devices

- Some devices may not function properly in MR environment because of the strong static magnetic field and/or radio frequency field.
- Pacemaker and implanted cardiac defibrillator are typical examples of such devices.
- Fringe field should be less than 5 gauss (or 0.5mT) for public area.

Implant and Device Safety Database

- www.mrisafety.com by Frank G. Shellock

Consult with the implant manufacturers such as Medtronic, Cook, etc.

Keep a binder or folder with collected implant MRI safety procedures.

Gradient Switching and Nerve Stimulation

- Temporal variation of magnetic field (dB/dt) \(\rightarrow\) electrical potential \(\rightarrow\) nerve stimulation
- The effect of stimulation varies from minor muscle twitching to severe pain.
- High performance gradient and gradient intensive sequences are more likely to cause PNST.
- Ensure that arms and legs are not crossed to prevent PNST.

Magnet Quenching Safety Concerns

- As liquid cryogen becomes gas, it will displace room air and oxygen. Persons breathing in this environment may suffocate.
- Cold gas may cause skin & body injury.

Quench Safe Guards

- Vent stack to allows cryogen gas to escape.
- Scanner room opens outward to prevent pressure build up.

Emergency quench button Safety

- Emergency quench button should be covered by a clear plastic cover so that it is not accidentally pushed.
- The quench button should only be depressed in the event of a Serious Personal Injury.
MRI Emergency Situations

- Fire or Smoke Alarm
- Magnet Quench
- Inadvertent Metal in the Magnet
- MRI Contrast Reaction
- Other Medical Emergencies

MRI Emergency Procedures

Call for assistance immediately.

Remove the patient from the scan room and secure the door.

Administer emergency first aid if needed until assistance arrives.

Ensure that untrained personnel or ferromagnetic material are not inadvertently allowed to enter the scan room.

Practice MRI emergency drills with your staff.

Surgical Implant Safety

- DBS
- Vagal Nerve Stimulators
- Codman Programmable Shunts

Codman Hakim Programmable Shunts

MRI Safety Procedure

- The Codman Hakim programmable shunt is MRI Conditional according to ASTM F2503.
- MRI can be performed at any time after implantation.
- MRI System with a static magnetic field of 3 Tesla or less.
- Use an MR system with a spatial gradient of 720 gauss/cm or less.
- Limit RF energy to a whole-body SAR of 3 W/kg over 15 min.
- Verify valve pressure setting before and after the MRI procedure.

Vagal Nerve Stimulator

- Cyberonics
  - VNS is used primarily on patients with epilepsy, depression and other debilitating neurological disorders.
  - The VNS Implant delivers electrical pulsed signals to the Vagus nerve.
  - A small generator is implanted in the left chest.

MRI Safety Procedure:

1. Pulse generator output programmed to 0 mA before the MRI procedure.
   - (Neurology will set VNS to 0 mA)
2. After the MRI procedure the VNS will be reprogrammed to the original settings.
   - (Neurology department)
3. Head coil Type: Transmit and Receive only
4. Specific absorption rate (SAR) < 1.3 W/kg for a 154 lb (70 kg) patient
5. Time-varying intensity: < 10 tesla/sec
6. Document MRI sequence parameters and the SAR for each sequence.

Caution: MRI procedures in which the RF is transmitted by a body coil should not be done on a patient who has a VNS.

Medtronic Deep Brain Stimulator

Warnings:

Read and follow the MRI information manual for the Activa Medtronic DBS. Failure to follow all warnings and guidelines will result in serious and permanent injury.

An MRI procedure should not be performed on a patient with an Activa DBS that has a broken lead wire because higher than normal heating may occur at the break.

Use only 1.5 T horizontal bore MRI

Use only a transmit/receive head coil

Use MRI sequence parameters that limit the Average head SAR to 0.1 W/kg.

Limit the gradient dB/dt field to 20 tesla/second or less

Document each sequence parameters and average head SAR setting.
MR Contrast Agent Safety

- Gadolinium Contrast Reaction:
  - Headache (6.5%), Injection site coldness (3.6%), Injection site pain or burning (3.0%), and Nausea (1.9%).
  - Severe allergic reactions (0.01%).

- High Risk Groups:
  - Pregnancy/Breast Feeding
  - Previous Contrast Reaction
  - Renal Deficiency

Clarian MRI Contrast Media Policy

- To inject MRI contrast you must be certified in CPR.
- Clarian MRI Safety form screens patients for renal impairment previous MRI contrast reactions.
- Radiologist will write an order to inject MRI contrast.
- If there are no contraindications to MRI contrast patients are given a contrast dose from the dosing chart based on their weight.
- A Radiologist, a radiology PA, or other designated physician will be available to respond to potential emergencies. If a designated physician is not available MRI contrast will not be administered.
- An emergency cart will be available in the immediate area.
- The following MRI contrast information must be added into the RIS system:
  - MRI contrast brand name
  - Contrast Volume
  - Individual performing the contrast injection
  - Confirm Med. Reconciliation
  - Any complications.

Clarian Guidelines for MRI patients with Potential Kidney Function Impairment

- Nephrogenic Systemic Fibrosis or Nephrogenic Fibrosing Dermopathy (NSF/NFD) is a rare and serious syndrome that involves fibrosis of skin, joints, eyes, and internal organs. In NSF patients develop large areas of hardened skin. There is no cure for NSF/NFD nor is there a consistently successful treatment.
- NSF/NFD is reported in patients with kidney failure after receiving MR contrast containing gadolinium.
- The majority of reported cases are related to Omniscan and Magnevist, and with double and triple doses of contrast.
- The FDA and ACR have issued guidance regarding the usage of gadolinium based contrast agents in patients with impaired renal function.

Patient Screening for MRI contrast

- All patients undergoing MRI procedures will be screened for impairment of renal function using the Clarian MRI Safety screening form.
- If the patient answers “Yes” to the question on the screening form that they have a history of decreased kidney function then current labs must be obtained before MRI contrast is given.
- If available in the patient’s medical records eGFR (estimated Glomerular Filtration Rate) and SCR (Serum Creatinine) can be obtained from Cerner or CareWeb.
- Current labs must be used and should be within the last 30 days.
- iSTAT can be used for current Creatinine. The conversion chart in the policy can be used to obtain the eGFR.
- eGFR/Scr Labs obtained.

NSF


Actions for MR Technologists

- If the patient is on dialysis consult with a radiologist.
- If the patient’s eGFR is less than 30 mL/min/1.73m2 then consult with a radiologist.
- If the patient’s eGFR is between 30 and 60 mL/min/1.73m2 and if the accumulated dose of any gadolinium based contrast agent within the last 7 days including the current MRI contrast order is no more than a single dose (0.1mmol/kg). Patients can only have a single dose of MRI contrast in a 7 day period.
- If the patient’s eGFR is Greater than 60 mL/min/1.73m2, proceed with the MRI exam.
- Document the patient’s eGFR in RIS.
Recommended actions by attending Radiologists

- If eGFR is less than 30 mL/min/1.73m² or patient is currently on dialysis consider alternative imaging sequences that do not require gadolinium.

- If eGFR is between 30 and 60 mL/min/1.73m² give only a single dose of gadolinium at 0.1mmol/Kg within a 7 day period of time.

- If patient is on dialysis and the benefit of giving gadolinium outweighs the risk then dialysis must be done within 3 hours of the gadolinium injection. The second session of dialysis should be done again within 24 hours. A Clarian clinical consent form should be obtained by a radiologist prior to the gadolinium injection.

NSF Remedies

- Avoid/minimize the use of Gd contrast agents in the risk population:
  - Patient screening
  - Reduce dosage
  - Non-contrast enhanced MRI techniques
  - Other modalities
  - Hydration
  - Hemodialysis

Clarian GBCA Safety Guidelines

- Decreased Kidney Function AND Prescription of Gd Based contrast
  - Scan with original protocols and avoid Omniscan & Magnevist
  - Scan with modified protocols and avoid Omniscan & Magnevist or with another modality
  - Scan without contrast or with another modality

MR Safety References and Guidelines

- MRI Safety references
  - http://www.mayoclinic.org/nephrogenic-fibrosing-dermopathy/

Summary

- Identify Zones 3 and 4. Secure both areas with a locking system.
- Make sure all equipment in Zone 3 and 4 are identified, labeled and is MRI compatible.
- MRI zones 3 and 4 must be marked with MRI Warning signs
- Portable O₂ Tanks should never be in the MRI zones 3 and 4. Do not mix MRI compatible O₂ tanks with non-compatible tanks. Use wall Oxygen.
- Every Patient/Visitor is required to have a completed MRI Safety Screening form prior to their MRI procedure.
- Constantly watch non-MRI personnel working in the MRI area.
- Keep your Magnet room door closed at all times.

Thank you