12.2 MRI Registry Review

Part II
Patient Care & Imaging Procedures Review

Carolyn Kaut Roth, RT (R)(MR)(CT)(M)(CV) FSMRT
CEO Imaging Education Associates
www.imaginged.com candi@imaginged.com

Objectives
Upon completion of this course, the attendee should...
1. Know aspects of MR safety
2. Understand General Patient Care
3. Understand Imaging Procedures & Anatomy

Categories of Questions

Slide # 5

Patient Care Category ... MRI Safety & Patient Care

Slide # 6

Patient Care Category ... MRI Safety Issues

Outline

- Patient Care Review
  - MR Safety
  - General Patient Care
- Imaging Procedures Review
  - Sectional Anatomy Overview
  - Imaging Procedures

Slide # 4

Objectives
Upon completion of this course, the attendee should...
1. Know aspects of MR safety
2. Understand General Patient Care
3. Understand Imaging Procedures & Anatomy

Categories of Questions

Slide # 5

Patient Care Category ... MRI Safety & Patient Care

Slide # 6

Patient Care Category ... MRI Safety Issues

Outline

- Patient Care Review
  - MR Safety
  - General Patient Care
- Imaging Procedures Review
  - Sectional Anatomy Overview
  - Imaging Procedures
Magnetic Forces

- Rotational
  - Strongest at isocenter
- Translational
  - Greatest where the fringe field change is most severe (near the bore)
  - Contributes to "missile effects"

Fringe Field Considerations

- Magnetic Field strength can be expressed in units of tesla (T) or gauss (g)
  - $10,000 \text{ g} = 1 \text{ T}$
- The isocenter is generally expressed in units of Tesla
- The General Public is to be kept outside the 5 gauss line – of the fringe field!

Imager Considerations - Zoning

Zone I:
This includes all areas that are freely accessible to the general public.

Zone II:
This area is the interface between the publicly accessible uncontrolled Zone I and the strictly controlled Zone III.

Zone III:
This area is the region in which free access by unscreened Non-MR Personnel and/or ferromagnetic objects and equipment can result in serious injury or death. All access to at least Zone III is to be strictly restricted, with access...

Zone IV:
This area is synonymous with the MR scanner magnet control room itself.

MR Personnel

- Level 1
  - Individuals who have passed minimal safety educational efforts to ensure their own safety as they work within Zone III regions will be referred to as Level One MR Personnel (e.g., M.R.I. department office staff, patient aides).

- Level 2
  - Individuals who have been more extensively trained and educated in the broader aspects of MR safety issues including issues related to the potential for thermal loading/burns, direct neuromuscular excitation from rapidly changing gradients, etc., will be referred to as Personnel (e.g., M.R.I. Technologists, Radiologists, Radiology Department nursing staff).

- Non-MR Personnel
  - Patients, visitors, or facility staff who do not meet the criteria of Level One or Level Two MR Personnel.

Who needs Patient Screening

- Everyone who want to enter the MR environment
- Patient
- Family / Visitors
- Ancillary Staff Education
  - Transport personnel
  - Construction / Maintenance
  - Nursing
  - Patient Support
- Emergency Response
  - Security
  - Fire Department

Anyone who intends to enter The MRI Scan room!

How should MR Screening be done?

- Should be performed by trained individuals (Level 2)
- Screening should be performed more than once
- Screening with written, verbal interview & "visual" screening
- Screen all visitors as well as patients and document screening
- Screen and document each time a patient presents for an MR exam
- Document & Maintain screening documentation with patients records

- It is prudent to change all patients into a hospital gown, prior to the MR procedure, to avoid any metal from accidentally entering the MR scan room and/or to possibly notice surgical scars that the patient may have forgotten.
- Screen everyone that enters the room as if they are having the procedure themselves
- Forms available at www.mrisafety.com
Why should screening be performed?

To determine...

- MR Unsafe
- MR Safe
- MR Conditional

*The big 3 contraindications*

- Pacemaker
- Metal eyes
- Aneurysm clip

**MR Safe**
**MR Conditional**

---

Implants in MR

- Medical Risk vs. Benefit Decision
- Be sure to check field strength that the device / implant has been tested
- Up-to-date information is crucial
- Beware of blanket statements!
  - Example: all stents are not safe
    - [www.mrisafety.com](http://www.mrisafety.com)
    - [www.imirs.org](http://www.imirs.org)
    - [www.drkanal.com](http://www.drkanal.com)
- Concerns for Implants & Devices
  - Torque / movement (translational forces)
  - Electrical current induction (burns)
  - Tissue Heating (burns)
  - Device Failure

---

Patient Emergency

All MR personnel should be familiar with the procedure for removing a patient from the MR scan room in the event of a medical emergency

- MR “safe” supplies for imaging
  - Non-ferrous IV poles
  - Non-ferrous Wheel chairs
  - Non-ferrous IV poles
  - Stretchers
  - Non-ferrous IV poles
  - MR “safe” monitoring devices & more!

- “Zone III & Zone IV site access restriction must be maintained during resuscitation and / or other emergencies.” Excerpt from the ACR White paper on MRI Safety.

---

Quench Potential for Superconducting Magnets

- Uses Cryogens
  - Liquid Helium
  - Helium Stable as gas
    - Helium 750 (air) to 1 liquid
    - 1,000 liquid liters per magnet
    - 750,000 liters of gas inside the magnet!
- Quench
  - Boil off of cryogen
  - Quench Hazards in the MR Scan room
    - Increased pressure, can’t open door
    - Reduced room Temperature – Frostbite
    - Reduced Oxygen – Asphyxia

---

Magnet – Hemodynamic Effect

Blood flowing in the Aorta

MRA or the thoracic vasculature

---

Gradient Magnetic Fields

**Produced by gradient Coils**

**FDA/CDRH**

Criteria for Significant Risk Investigations of Magnetic Resonance Diagnostic Devices
Issued - 07/14/03

"Any time rate of change of gradient fields (dB/dt) sufficient to produce severe discomfort or painful nerve stimulation."
Temporary hearing loss has been reported using conventional sequences.

Earplugs - can reduce noise by 10 to 20 dB
- Recommended for all patients
- Recommended for anyone in scan room
- To reduce temporary, and permanent acoustic damage

Gradient Sounds
- Scans & options
  - high speed gradients
  - EPI
  - Diffusion
  - Perfusion
- No loops within the magnet
- Patients for increased risk of anxiety due to acoustic noise:
  - head trauma
  - elderly
  - pediatric
  - psychiatric disorders

FDA Limit for Static Field

<table>
<thead>
<tr>
<th>Population</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults, children and infants &gt; 1 Month</td>
<td>8 T</td>
</tr>
<tr>
<td>Infants 1 month or less</td>
<td>4 T</td>
</tr>
</tbody>
</table>

Bioeffects of RF
- Most of the RF power used in MR imaging is transformed into heat that is absorbed in the patient’s tissues
- Bioeffect of RF absorption is heating of tissue
- FDA limits to an increase in core body temperature of 1°C

Radiofrequency Fields

<table>
<thead>
<tr>
<th>Site</th>
<th>Specific Absorption Rate (SAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose (W/kg)</td>
</tr>
<tr>
<td>whole body</td>
<td>averaged over</td>
</tr>
<tr>
<td>head</td>
<td>averaged over</td>
</tr>
<tr>
<td>head or torso</td>
<td>per gram of tissue</td>
</tr>
<tr>
<td>extremities</td>
<td>per gram of tissue</td>
</tr>
</tbody>
</table>

Scans with increased RF
- Scans & options
  - Magnetic Transfer MTI
  - Fast Spin Echo FSE
- More heat / more RF pulses
- Double the flip, 4 x the power
- Patients with compromised thermoregulatory systems
- Higher risk for RF effects
- Patients with higher risk
- Cardiovascular disease, hypertension, diabetes, fever, elderly & obese
- Certain medications can alter thermoregulatory response to heat load
- Areas of Particular Concern
  - Eyes
  - Testis

Other Burn Possibilities
- Tattoos
- Metal in transdermal patches
- Metallic leads/probes
  - Coil cables
  - ECG leads
- Risk increases with field strength
Contrast Safety

- Extravasation
- Nephrotoxicity
- Adverse Events

ACR Recommendations for Claustrophobic Patients

1. Prepare the patient (explanation)
2. Allow a family member to accompany
3. Maintain verbal/visual contact
4. Headphones
5. Monitor – distraction
6. Virtual reality
7. Feet-first
8. Prone
9. Mirrors or prism glasses
10. Blindfold
11. Lights
12. Fan
13. Lemon or vanilla scent
14. Relaxation techniques
15. Systematic desensitization
16. Hypnosis

Monitoring Devices

MR compatible monitors & devices
- ECG
- Pulse Oximeters
- Blood Pressure
- Respiratory & Apnea
- Temperature
- Multi-parameter monitoring systems

Safety Category … New Patient Care Issues

Vital Signs

- Pulse
- Respiration
- Blood Pressure
- Temperature
- Oxygen Saturation

Vital Signs - Respiration

- Normal Adult: 12-20 BPM
- Bradypnea: 12 or below
- Tachypnea: 25 or above
- Description
Pediatric Respiratory Rate

- Average Ranges:
  - Ages 1-8 years: 15-30 BPM
  - Infants (1-12 months): 25-50 BPM
  - Neonates (1-28 days): 40-60 BPM

Vital Signs – Blood Pressure

- Normal Adult Range
  - 90 - 120 mm Hg
  - 60 - 80 mm Hg

- Hypertension
  - Stage 1
    - Systolic 140-159
    - Diastolic 90-99
  - Stage 2
    - Systolic 160 or higher
    - Diastolic 100 or higher

- Hypotension
  - below 50 diastolic
  - below 90 systolic

Vital Signs - Temperature

- Normal
  - 96.8F-100.4F oral
  - 0.5 to 1 degree F higher (rectal)
  - 0.5-1 degree F lower (axillary)

- Low temperature
- High temperature

Pulse Oximetry

- Monitors oxygen saturation of hemoglobin (SaO₂)
- Sensor is usually attached to finger tip
- Normal range
  - 95%-100%
- Mild Hypoxia
  - 91% - 94%
- Moderate Hypoxia
  - 86% - 90%
- Severe Hypoxia
  - 85% or below

Oxygen Administration

- Oxygen is a medication
- In emergency situations administer 2L/min
- High L/min delivery requires a humidification system to preserve mucosal membranes

Observation & Blood Lab values

- Observation
  - Actually look at and evaluate the patient.
  - Skin color
  - Skin temperature
  - Level of consciousness
    - Sudden change in mental acuity may indicate a serious problem occurring
  - Breathing
  - Anxiety
    - ALWAYS NOTE ANY CHANGES

Renal Function
- Blood Urea Nitrogen
  - Indicates gross glomerular function.
  - The ability to produce and excrete urea.
  - Child: 5 – 18 mg/dL
  - Adult: 7 – 18 mg/dL
  - Adult: 8 – 20 mg/dL... over 60

Creatinine
- Creatine breaks down to form creatinine
- Creatinine is excreted entirely by the kidneys and levels should remain constant
- Amount of nitrogenous waste
- Index for kidney disease
  - 0-3 yrs 0.3-0.7 mg/dL
  - 3-12 yrs 0.5-1.0 mg/dL
  - 12 yrs over 1.3 mg/dL
Informed Consent

- Written form of consent
- Used for contrast administration and imaging guided biopsies
- Full explanation of procedure, risks and benefits by healthcare personnel determined to be an expert on the exam or procedure
- Explanations must be given and consent form signed prior to sedation administration
- Patient must be deemed competent to sign
- All blanks must be filled in before form is signed
- All conditions stated on form must be met
- Consent can be revoked at any time!

Legal Issues for Imaging

Why should we care?
- Code of Ethics
- Practice Standards
  - ASRT www.asrt.org
  - ARRT www.arrt.org
  - JCAHO www.joint.commission.org
  - Institutional Polices

Types of Law

- **CIVIL LAW**
  - Money
- **CRIMINAL LAW**
  - Fines and jail time
- **ADMINISTRATIVE LAW**
  - Loss of license

Latin Terms

- **Respondeat superior**
  - Let the master answer
- **Res ipsa loquitur**
  - The thing speaks for itself
- **State decisis**
  - To stand by things decided
  - Prevents multiple suits based on the same evidence

Malpractice

- To establish a claim of malpractice, four conditions must be proved true:
  - The defendant had a duty to provide reasonable care to the patient
  - The patient sustained some loss or injury
  - The defendant is the party responsible for the loss
  - The loss is attributable to negligence or improper practice

Health Insurance Portability Accountability Act

- Increased incidence of breach of confidentiality
- Easier access to patient records
- HIPAA (1996)
- Provides regulations to establish criteria in authorizing release of medical information
- ANY INFORMATION THAT A HEALTHCARE PROVIDER LEARNS WHILE TAKING CARE OF A PATIENT IS CONFIDENTIAL, EVEN IF IT DOES NOT RELATE DIRECTLY TO TREATMENT OF THE PATIENT.
**Imaging Procedures… Now**

<table>
<thead>
<tr>
<th>Imaging Procedure</th>
<th>Sequence</th>
<th>FOV</th>
<th>Matrix</th>
<th>TR (ms)</th>
<th>TE (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial T1 _pre</td>
<td>Generally SE – can be GE</td>
<td>22 cm x 16 cm</td>
<td>192 x 256</td>
<td>600</td>
<td>10</td>
</tr>
<tr>
<td>Axial T1 _post Gadolinium</td>
<td>Generally SE – can be GE for dynamic</td>
<td>22 cm x 16 cm</td>
<td>192 x 256</td>
<td>600</td>
<td>10</td>
</tr>
<tr>
<td>Coronal T1 _post Gadolinium</td>
<td>Generally SE –</td>
<td>22 cm x 16 cm</td>
<td>192 x 256</td>
<td>600</td>
<td>10</td>
</tr>
</tbody>
</table>

**Basic Brain “Vanilla” Protocol with sprinkles**

- **Axial T1 _pre**
  - Generally SE – can be GE
  - 22 cm x 16 cm FOV
  - 192 x 256
  - TR = 600 ms
  - TE = 10 ms

- **Axial T1 _post gadolinium**
  - Generally SE – can be GE for dynamic
  - 22 cm x 16 cm FOV
  - 192 x 256
  - TR = 600 ms
  - TE = 10 ms

**Overview Neuro Anatomy**

- Anterior Horns
- Lateral Ventricles
- 3rd vent
- 4th ventricles
- Anterior Horns of the Lat. Vents
- Genu
- Corpus callosum
- Anterior Horns
- Lateral Ventricles
- Caudate nucleus
- Putamen nuclei
- Thalami tons
- 4th ventricles
- Posterior Horns of the Lat. Vents

**Brain Anatomy: Circle of Willis**

- Anterior Communicating Artery
- Middle
- Posterior Communicating Artery
- Posterior

**Spinal Anatomy Brachial Plexus & Lumbar Plexus**

- Fracture
- Brachial plexus
- Cervical vertebrae
- Lumbar vertebrae
- Lumbar plexus
- Sacral plexus

**Imaging Planes**

<table>
<thead>
<tr>
<th>Imaging Modality</th>
<th>Imaging Plane</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Images</td>
<td>Parasagittal Plane</td>
</tr>
<tr>
<td>MRI Images</td>
<td>Sagittal Axial Coronal</td>
</tr>
</tbody>
</table>
**Axial chest**

- Pectoralis Muscle
- Aortic Arch
- Latissimus Muscle
- Spine (vertebral body)
- Ascending Aorta
- Pulmonary arteries
- Pulmonary veins
- Descending Aorta
- Heart

**Basic Body Protocol**

- 3-plane GrE localizer
  - 40 – 49 cm FOV
  - 5 mm / 1
  - 128 x 256
  - TR = min
  - TE = min
  - Flip = 90°
- Axial T2 - axial
  - Generally TSE (aka FSE or RARE)
  - FOV = 30 cm (to fit anatomy)
  - 5 mm / 1
  - 192 x 256
  - TR = 4000 ms
  - TE = 100 ms
  - ETL = 16
- Axial T1 GE IN / OUT phase - axial
  - 22 cm x 16 cm FOV
  - 5 mm / 1
  - 192 x 256
  - TR = 150
  - TE = 2.1 / 4.2 ms
  - Flip = 90°
- T1 GE post gad DYNAMIC (axial or coronal)

**Basic “Vanilla” Knee Protocol**

- Sagittal T1 localizer: 400TR/min TE, 5mm/0 skip, 12 FOV, 128x256 matrix, 1 nex
- Axial T1 - 600-800 TR/min TE, 4mm/.5 skip, 12 FOV, 192x256 matrix, 2 nex
- Axial FSE T2 - 4000 TR, 90 TE, 5 mm, skip .5 12 FOV, 192x256, 2 nex
- T2 FSE - 4000 TR, min/80 TE, 5 mm, 12 FOV, 128x256, 2 nex
- Coronal FSTIR - 4000 TR, 90 TE, 150 TI, 5mm, 12 FOV, 192x256, 2 nex
- Sagittal FSE PD - 3000 TR, 2x min TE, 5 mm, 12 FOV, 192x256, 2 nex

**Lower Extremity Anatomy**

- Anterior cruciate ligament (ACL)
- Posterior cruciate ligament (PCL)
- Femoral artery
- Patellar ligament

**Outline**

- Patient Care Review
  - MR Safety
  - General Patient Care
- Imaging Procedures Review
  - Sectional Anatomy Overview
  - Imaging Procedures

**12.2 MRI Registry Review**

Part II – Patient Care & Imaging Procedures Review

Thank you for your attention!

Click to take your post test and get your credits

Carolyn Kaut Roth, RT (R) (MR) (CT) (M) (CV) FSMRT
CEO, Imaging Education Associates
www.imaginged.com
candi@imaginged.com