MR Safety
Safety

Objectives

…Identify hazards to MR patient.
…Identify actions MR technologist can take to minimize hazards to patient.
MR Safety Concerns

- Static Field
- Gradient (time-varying) Field
- Radiofrequency (RF) Field
Static Magnetic Field

- Field limit now at 4 Tesla
- Major Concerns
  - loose ferrous objects
  - electronic devices and/or implants
  - ferrous implants

Fringe Field

- Varies with Field Strength
- Less with Low Field Vertical Systems
Close to the magnet, the field increases in strength rapidly over a short distance.

The more rapidly the change over distance, the greater the attractive force.
Static Field Dangers
Metal

Diamagnetic:
Weakly repels local magnetic fields – (-1)
- Gold
- Copper
- Zinc
- Mercury

Paramagnetic:
Weakly attracts local magnetic fields – (+1)
- Iridium
- Manganese
- Titanium
- Platinum

Ferromagnetic:
Highly attracts local magnetic fields
- Iron
- Nickel
- Cobalt
- Some Alloys
Screening

• Patient
• Family / Visitors
• Ancillary Staff Education
  - Housekeeping
  - Construction / Maintenance
  - Nursing
• Patient Support
• Emergency Response
  - Security
  - Fire Department
Screening Tips

- DO NOT RELY ON THE SCREENING PROCEDURES FROM ANY OTHER MR FACILITY TO BE ADEQUATE.
- SCREEN ALL VISITORS AS IF THEY WERE PATIENTS.
- SCREENING SHOULD BE DONE MORE THAN ONCE.
- SCREENING SHOULD BE PERFORMED BY TRAINED INDIVIDUALS.
- SAMPLE SCREENING FORM AVAILABLE AT: www.mrisafety.com
Use of MR In Pregnant Patients “The safety of MR imaging during pregnancy has not been proved.” FDA

Imaging Pregnant Patients "MR Imaging may be used in pregnant women if other non-ionizing forms of diagnostic imaging are inadequate or if the examination provides important information that would otherwise require exposure to ionizing radiation.“ SMR Safety Committee

MR Technologists / Healthcare Workers: Data suggests no deleterious effects from exposure to the static magnetic field.

Use of contrast agents: Rates of clearance of MR imaging contrast agents from the amniotic fluid and fetal circulation are unknown.
Q. Who would require additional monitoring?

A. 1) Patients who cannot communicate
    2) Patients with weak voices
    3) Patients who do not speak English
    4) Patients who are sedated
    5) Patients with diminished mental capacity
    6) Patients at risk for contrast reaction

**Monitoring Devices**

- Pulse Oximeter
- Expired CO\(_2\)
- ECG (not system gating)
- Blood Pressure

What ever is used it must be be proven to work properly and safely in the MR environment.
Safety

Hazards to patient
- Acoustic
- Metal slivers
- Face and eyes
- Pacemaker
- Internal injury
- RF heating
- Cables and coils

Know your ZONES!
MR Safe Practice Guidelines

Zone I - Public access locations, unrestricted to passage by the public and health care professionals.

Zone II - Semi-restricted areas, such as patients changing rooms or screening areas for the MR exam.

Zone III - Regions around the MR imaging system where non-MR individuals, unscreened and/or unsupervised are denied access to the MR scan room (Zone IV). AKA 5 gauss line.

Zone IV - MR scan room, no code area. Locked when not in use! 

White Paper, ACR
Safety

• Acoustic
Gradient Magnetic Fields

- Maximum Amplitude (mT/m) 
  - “Horsepower”
- Slew Rate (T/m/sec) 
  - Measure of switching speed (acceleration)

Magnetic fields that vary in intensity over distance

直言 switching of the gradient field can induce current in conductor (Faraday’s Law of Induction)
Gradient Safety Concerns

- **Acoustic Noise**
  - Increases with gradient strength
  - Greater with faster imaging sequences

- **Current induction**
  - Peripheral nerve stimulation
  - Care should be taken when imaging patients with implanted leads
Safety

- Metal slivers
Intraocular Foreign Bodies

Plain Film Radiograph or CT Scout of the Orbits
Safety

Face and eyes
Safety

Pacemaker
Pacemakers

At this time, the presence of a cardiac pacemaker should be considered an absolute contraindication for MR imaging!!!!

For General Public: 5 Gauss line
Safety

Internal injury
Implants

- Often a risk vs. benefit decision
- Up-to-date information is crucial
- www.mrisafety.com
- kanal.arad.upmc.edu/mrsafety.html
Bone Growth Stimulator
Aneurysm Clip

- Safe (?) for MRI at 1.5 T or less
- Specific information must be known with regard to type and material
- Original package: made from Phynox, Elgiloy, MP35N, titanium alloy, titanium
  - no testing
- If not in original package and labeled
  - testing required

Radiologist and surgeon are responsible
Aneurysm Clip Artifacts
Safety

RF Heating
Radio Frequency (B₁ field)

- Oscillating magnetic field
- Responsible for heating of tissues
- Amount of RF deposition dependent on many factors which include
  - Flip angle
  - Field strength
  - Coils
- RF deposition expressed by the Specific Absorption Rate (SAR)
• The greater the amount of RF energy used for imaging, the greater the amount of tissue heating

• The amount of power necessary for a 90 degree RF pulse increases with field strength

• Doubling the flip angle requires a 4x increase in RF power
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Safety

Cables and coils

Note: Read Safety Chapter of Operators Documentation
Safety
Don’t let this happen to you!
The MR technologist should screen anyone (not just the patient) for any possible contraindications prior to entering the MR scan room!