MRI Safety

CAMRIS
University of Pennsylvania

CAMRIS

- The Center for Magnetic Resonance Imaging and Spectroscopy (CAMRIS) is the designated body in charge of regulating use of the University Of Pennsylvania Radiology Research MRI units
- Currently CAMRIS oversees Research use of 4 MRI Units operating in CAMRIS and 3 other MRI systems that share time with the Clinical Services.

CAMRIS MR Scanners

*Superconducting Magnets

- Hup5 is a 1.5T magnet* housed in the basement of Founders Building
- Hup6 is a 3.0T magnet* housed in the Basement of Rhoads Building
- SMILOW MRI is a 3T magnet* on the 1st Floor SMILOW Building
- Hup7 is a 7.0T Ultra-high Field superconducting magnet housed in the basement of Stellar-Chance Building
- 3T Stellar Chance System is a 3T magnet housed in the basement of the Stellar Chance Building

MRI Scanners (Shared)
*Superconducting Magnets

- Perelman Center (CAM) houses:
  - 3 – 1.5T Magnets* on Ground floor Radiology Department (not for Research use)
  - 2 – 3T Magnets* on Ground floor Radiology Department (not for Research use)
- DEVON Center houses:
  - 2 – 1.5T Magnets* (available through arrangement)
  - 1 – 3.0T Magnet* (Shared Time)

SAIF (Small Animal Imaging Facility)

- SAIF operates several vertical and horizontal bore magnets housed in Smilow and Morgan Buildings.
- These magnets have the same safety issues as Clinical Service MRI systems
- The SAIF units are housed in specific rooms that are both RF shielded and magnetically shielded

SAIF MR Scanners

*Superconducting Magnets

- 4.7 Tesla 50 cm horizontal bore MR System: (Small Animal Imaging Lab 1st Floor of SCTR) equipped with 30 cm ID 3 gauss/cm and a 12 cm ID 25 gauss/cm gradient tube and interfaced to an Agilent DirectDrive console.
- 9.4 Tesla 8.9 cm vertical bore MR System: (Small Animal Imaging Lab 1st Floor of SCTR) equipped with 55 mm ID 100 gauss/cm gradient tubes and interfaced to an Agilent DirectDrive console..
- 9.4 Tesla 31 cm horizontal bore MR System: (B100 John Morgan Building) equipped with a 21 cm ID 25 gauss/cm and a 12 cm ID 40 gauss/cm gradient tube and interfaced to an Agilent DirectDrive console.

MRI

- All of these MRI systems makes it important to educate as many personnel as possible about the safety issues related to the MRI and the field it generates.
- This presentation is Basic Safety information intended for all Research Personnel involved in MR imaging. At the end of this presentation you will asked to fill out a MR Screening form and take a test.

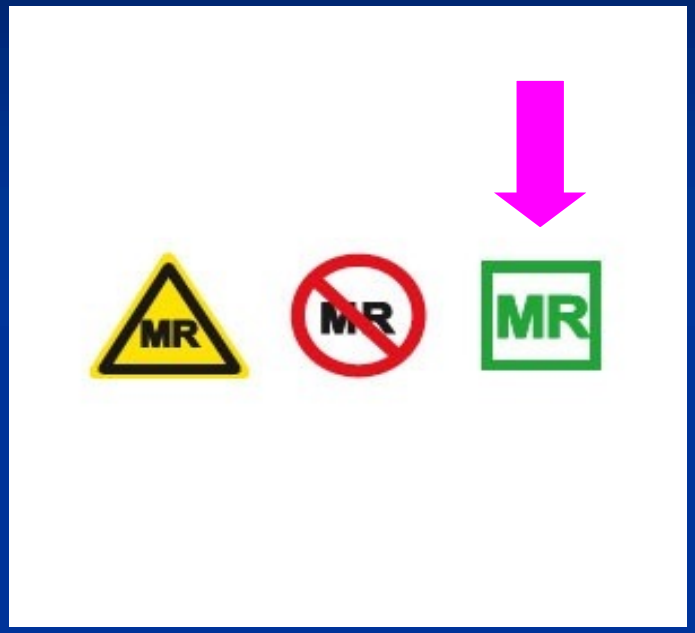
- These terms SAFE, CONDITIONAL, and UNSAFE are used within MRI to define the compatibility of devices, ancillary equipment, and/or implants.
- SAFE – this can go into the scanner or scanner room
- Conditional – cannot go into the scanner or scanner room unless specific requirements are met
- UNSafe – cannot go into the scanner or scanner room at any time

MRI

ASTM - American Society for Testing and Materials has a designated system for classifying objects and their compatibility in the MRI Environment. These classifications are listed on the following slides and the terms used in this presentation.

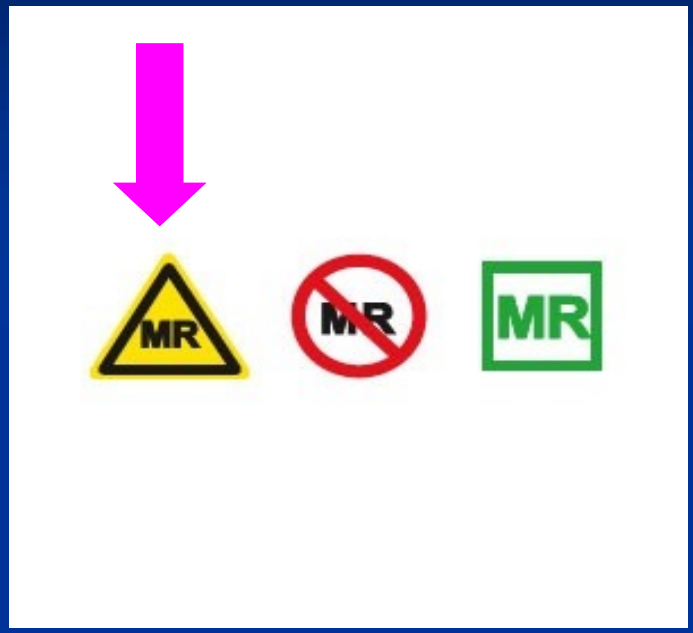
These classifications have been adopted by the American College of Radiology

ASTM Standards



MR SAFE as defined by the ASTM International document is applied to an item that poses no known hazards in all MR environments. MR SAFE items would include non-conducting, nonmagnetic items such as a plastic Petri dish. Items marked with the green MR SAFE icon may be taken into, used, or placed anywhere within any MR environment without risk or potential harm.

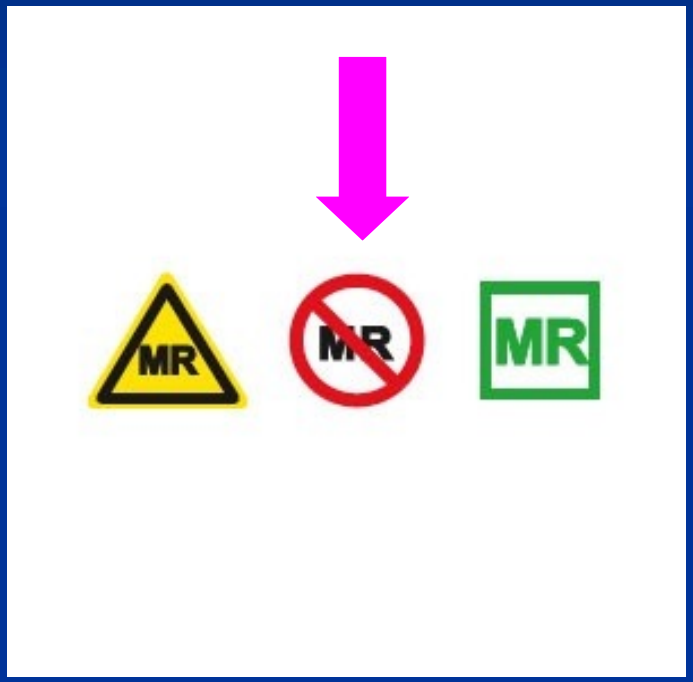
MR Conditional



is defined by the ASTM International as an item that has been demonstrated to pose no known hazards in a specified MR environment with specified conditions of use. Conditions that may be used to define the specified MR environment include field strength, spatial gradient, RF fields, specific absorption rate (SAR) as well as the potential for additional conditions such as operational conditions for a device.

Conditional Devices are considered UNSAFE for the MR unless used by individuals trained with that device.

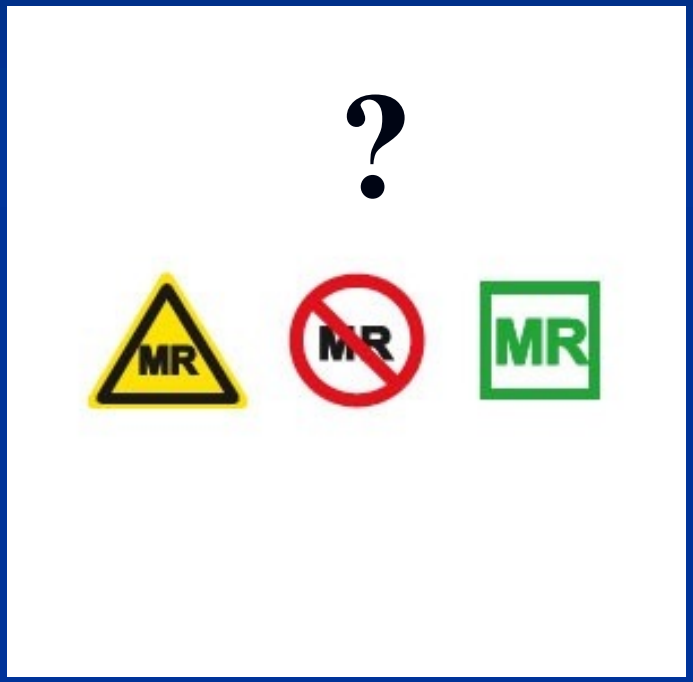
MR Unsafe



is defined as any item that is a known threat or poses a hazard in all MR environments. An example of an MR UNSAFE item would be a pair of ferromagnetic scissors, or any item constructed of ferrous metals. The MR UNSAFE icon consists of a white circle with red border and diagonal strike through and the capital black letters "MR" inside.

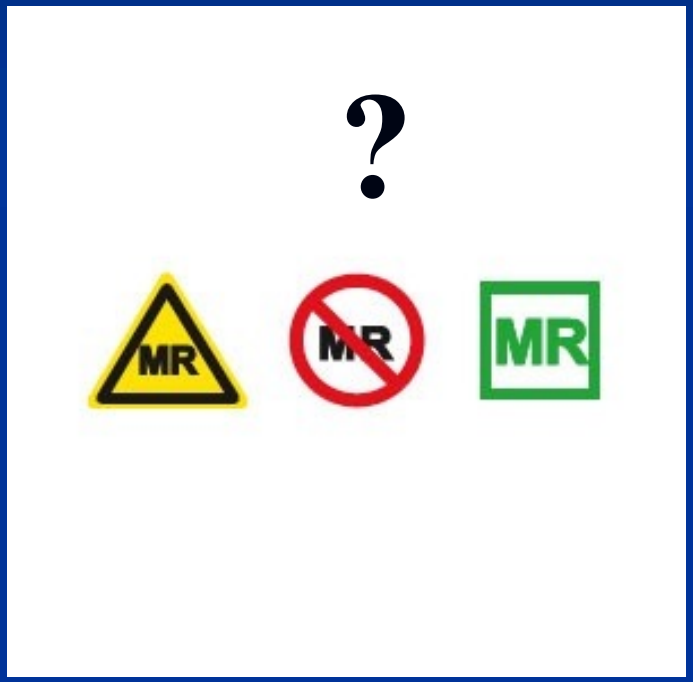
MR UNSAFE Items CANNOT be in the same room as the magnet or the designated MR Field Area

Anything that is not labeled must be considered UNSAFE



If there is no label attached to the device one must assume it is UNSAFE. Please contact the HUP MR Tech or the system administrator about this situation.

Anything that is not labeled must be considered UNSAFE



If the device is in the MRI area do not attempt to move or reposition, the device in anyway. Do not unplug or modify it current state. Do not attempt to remove it from the room. If the device is in the room do not continue you session until the question is resolved.

MRI

- Magnetic Resonance Imaging is a modality uses an "extremely" powerful magnet to make images.
- MRI does not use ionizing radiation to generate images. Instead it use the interaction between magnetic and electric fields.
- The magnetic field is invisible to the user so signage is in place and access is limited
- It does present a danger that can cause CATASTROPHIC INJURY and DEATH

MRI

- To produce an MRI Image we use:
  - A strong strong static magnetic field
  - An intermittently generated secondary Magnetic Field (Generated by RF Energy)
  - Intermittent changing of the these fields
  - Antennae that allow for transmission of RF and reception of the RF energy.

MRI

- To generate the strong static magnetic field we use a large **Superconducting Magnet**
- Transmission antennae (coils) generate Secondary Magnetic Field
- Gradients change the magnetic fields
- Receiving Antennae (coils) receive signal from the tissues imaged

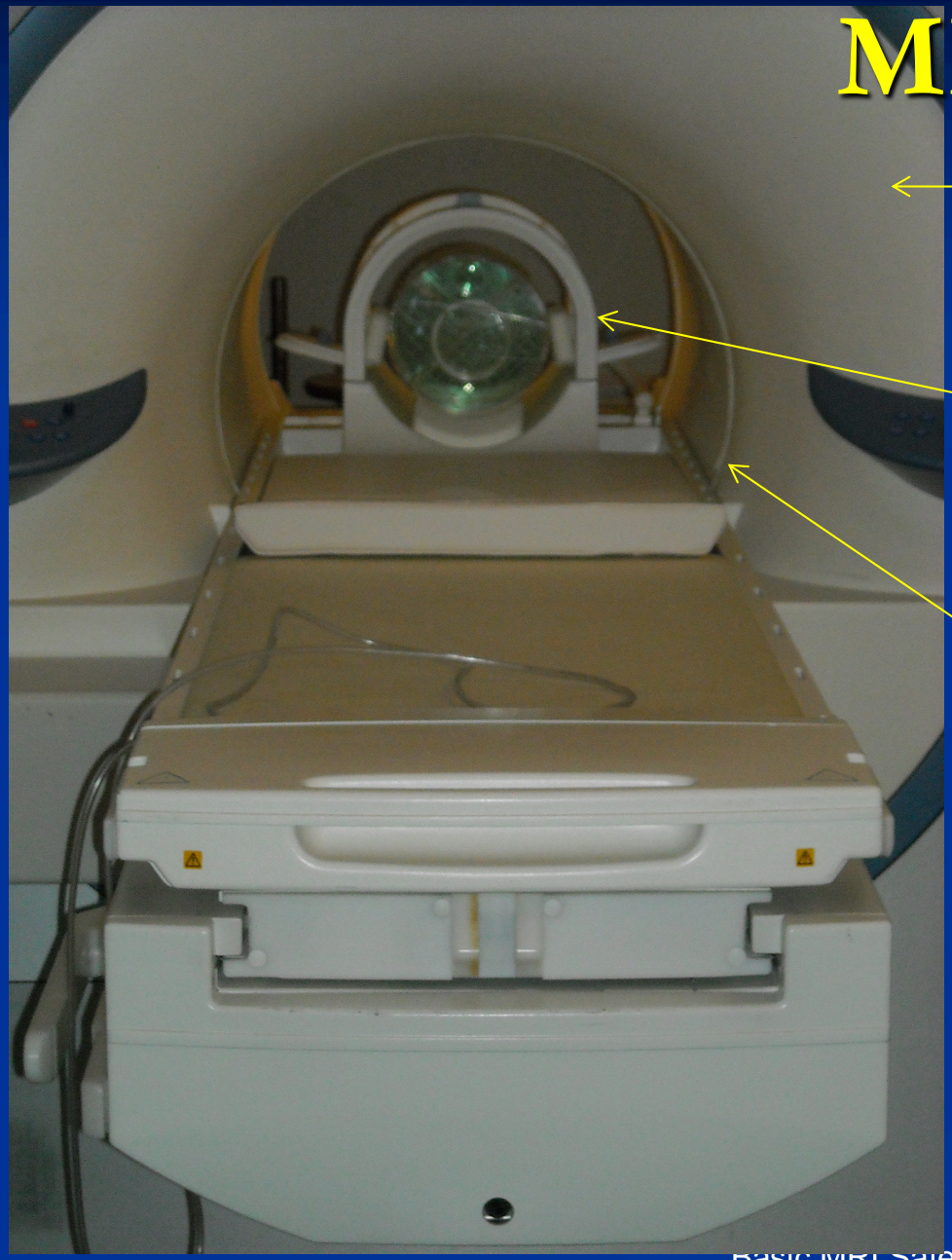
MRI

Magnet

Bore of Magnet

Patient Table

MRI



Magnet

Head Receiving Antenna

Body Transmit Receive/Transmit Antenna and Gradient Coil in polymer housing

MRI

- Each aspect of the MR Imaging process presents its own safety issues. These issues have been evaluated by the FDA and specific operating limits have been set for Human Subjects and operating personnel.
- Operation at or below these FDA limits is determined and maintained through MRI system Manufacturer's settings and CAMRIS oversight.

MRI

- The three main aspects of the MRI system that present safety issues and that are monitored by the FDA are:
  - Static (non-changing) Magnetic Field
  - Gradient Field Switching (dB/dt)
  - RF energy absorbed by subjects undergoing an MRI (SAR – specific absorption rate)

Static Magnetic Field SAFETY

- THE MAGNET IS ALWAYS ON
- THE MAGNET IS A SUPRE MAGNET
- OPERATORS/PERSONNEL MUST UNDERSTAND AND RESPECT ITS POWER
- EVERYONE ENTERING THE MRI AREA MUST BE SCREENED

Static Magnetic Field

Equipment

- The operating field strength of the MRI unit is 5,000 to 30,000 times the earth's magnetic field in Clinical applications. The units used to measure magnetic field strength are Tesla or Gauss. The strength of Earth's magnetic field is .5 Gauss or (.00005) Tesla
- 1Tesla (T) = 10,000 Gauss
- The strength of an electromagnet used by a lifting crane may reach 1.0 Tesla during activation. An MRI magnet maintains a field as strong or stronger than this at all times.

Static Magnetic Field

Equipment

- The operating field strength of some of some small bore animal systems can be 3-5 times that of Clinical service systems (some even higher).
- For context keep in mind the strength of an electromagnet used by a lifting crane may reach 1.0 Tesla during activation.
- An MRI magnet maintains a field as strong or stronger than this at all times.

Static Magnetic Field

Equipment

- After initial Installation and activation (Ramping) A SUPERCONDUCTING MAGNET IS NEVER TURNED OFF. The magnetic field is always present.
- All of the CAMRIS systems are Superconducting Magnets
- Every MRI system at PENN is always on!

Static Magnetic Field

Safety Issues

- THE MAGNET IS ALWAYS TURNED ON!

Static Magnetic Field

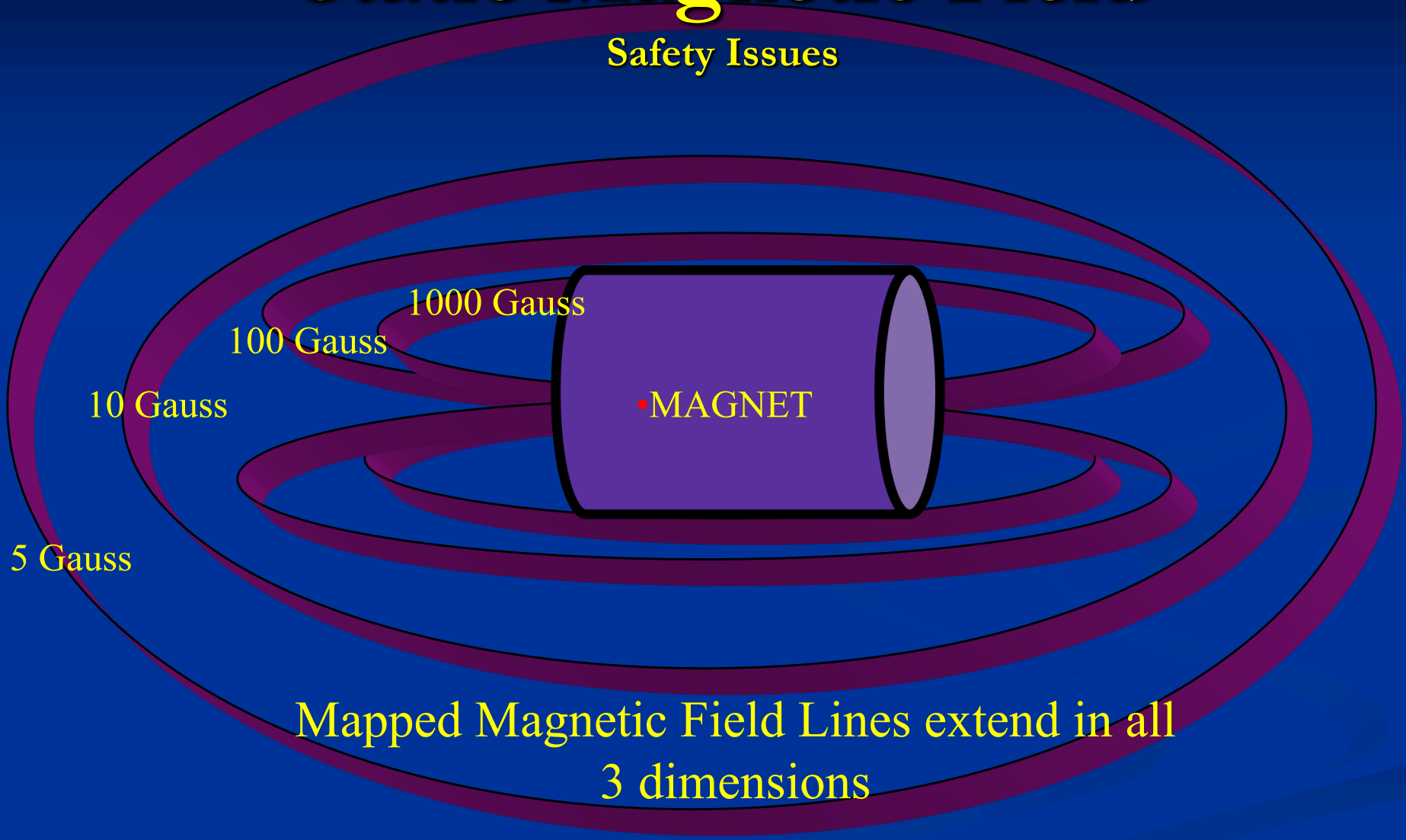
Safety Issues

The Static Magnetic field generated extends away from the magnet in all directions (3 Dimensionally)

- The field drops off dramatically (exponentially) with the distance from the magnet
- The field is "mapped" during installation in the form of GAUSS Lines and specific field strengths are at known distances from the magnet.
- It is important to know where the 5 Gauss Field line is with relationship to the magnet. The 5 Gauss Field line is the distance (proximity) to the magnet at which damage and injury can happen.

Static Magnetic Field

Safety Issues



Mapped Magnetic Field Lines extend in all 3 dimensions

Static Magnetic Field

Safety Issues

Dangers presented by the Static Magnetic Field are:

Missile Effect

Torque - produced on ferromagnetic objects moving through the magnetic field

Medical Device sensitivity

Quench – rapid cessation of the magnetic field

Static Magnetic Field

Safety Issues

Dangers presented by the Static Magnetic Field are:

All of the SAFETY issues of concern to patients are ALSO a concern to operators or support personnel that are around the magnet. BE aware of where you are. Check the signs.

NEVER ENTER AN MRI AREA without knowing where the magnetic field is.

NEVER TAKE anything into the MR ROOM without knowing it MR Safety status.

Static Magnetic Field

Safety Issues

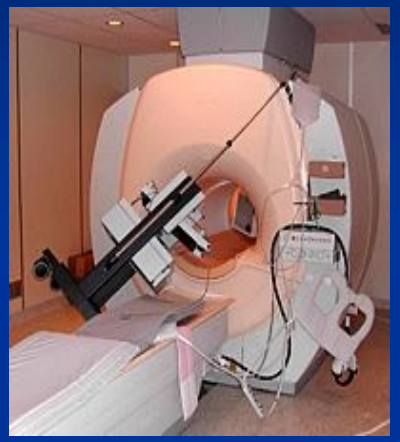
Missile Effect – the force with which a ferromagnetic object is pulled and accelerated toward the magnet. This effect is:

Directly related to the size of the ferromagnetic object - the bigger the object the greater the pull

Inversely related to the distance the object is from the magnet – the greater the distance from the magnet the less force is exerted on that object. The force increases EXPONENTIALLY as one nears the magnet.

Static Magnetic Field

Safety Issues



Missile Effect – magnet is strong enough to draw ferromagnetic material into the magnet with great force and acceleration.

•Any Ferromagnetic object can become a flying object if brought into the MRI room. Any object accelerating toward the bore of the magnet can cause injury and/or catastrophic results. This is the greatest RISK to subjects and personnel in the MRI environment.

Missile Effect

TheJournalNews.com
The online information source for Westchester, Rockland and Putnam

NEWS

Tuesday July 31

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Health

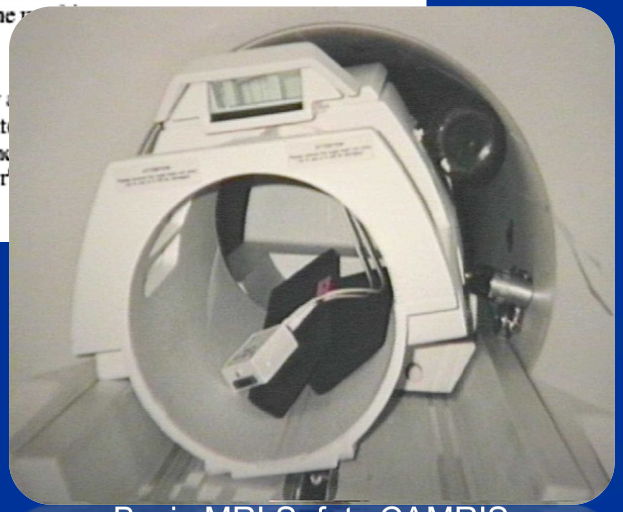
Boy, 6, killed in MRI accident

By MELISSA KLEIN AND OLIVER W. PRICHARD
THE JOURNAL NEWS
(Original publication: July 31, 2001)

VALHALLA — A 6-year-old boy died two days after he was smashed in the head by a metal oxygen canister that was pulled by magnetic force into the MRI machine where he was being examined, Westchester Medical Center officials said yesterday.

An unidentified hospital employee brought the oxygen tank within reach of the 10-ton magnet's field, and it shot through the air to the center of the
the hospital said.

The boy, Michael Colombini of Croton-on-Hudson, died Sunday
hospital, where he had undergone surgery before the MRI. An aut
revealed that he died of a blunt force trauma to the head with a fra
and brain hemorrhage, the Westchester County Medical Examiner
said.

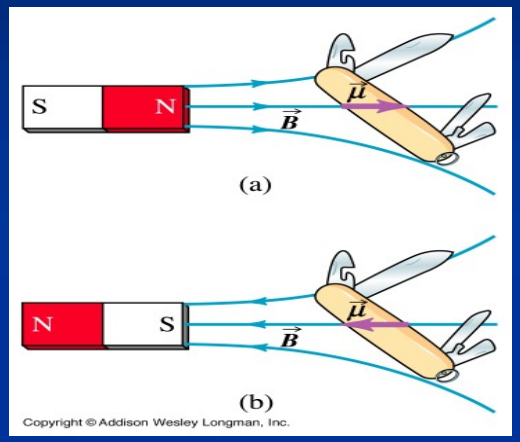


2001 - 6 Year old boy killed by an oxygen tank that was pulled into the magnet.

Photos courtesy Ralph Lundquist

Static Magnetic Field

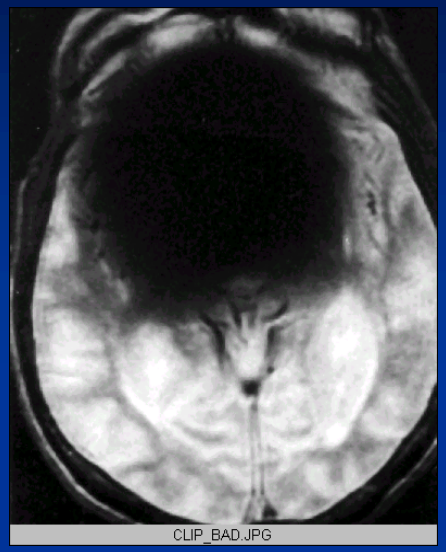
Safety Issues



Torque – Ferromagnetic material can change position due to its movement through a strong magnetic field.

•This means that objects that are moved in or out of the changing field lines will experience twisting/turning forces which might cause them to become dislodged or loosened. In cases of vascular clips or implants the effects could be catastrophic. It can also cause objects to be pulled out of your hands.

Torque Effect

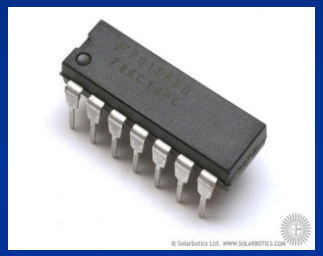


In 1992, a 74-year-old woman hemorrhaged and died after an aneurysm clip in her brain shifted while she was on a table preparing for an MRI.

Static Magnetic Field

Safety Issues

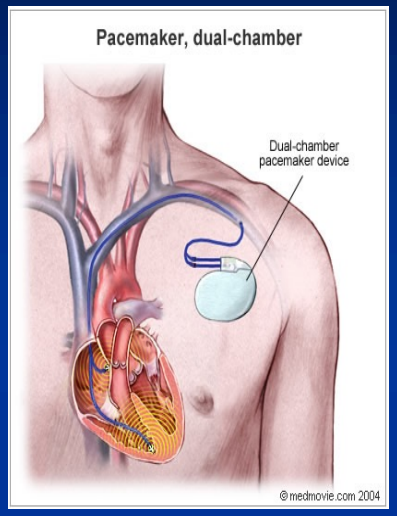
Medical device sensitivity due to components susceptible to failure when exposed to strong magnetic fields



•Exposure of certain types of medical devices to the Magnetic Field can cause malfunction or failure of the device in turn causing harm to that individual.

Static Magnetic Field

Medical Device Sensitivity



A Hospital has announced a review of its safety procedures after the death of a man whose pacemaker malfunctioned during a magnetic resonance imaging scan.

The patient involved in the fatal incident was twice asked if he had a pacemaker, but inexplicably failed to provide the information.

Static Magnetic Field

Medical Device Sensitivity

Pacemakers and ICD are not the only active devices that are effected. There are many already in use and more on the way. Some of these are:

Cochlear Implants

Tens Units

Baclofen Pumps

Insulin Pumps

Static Magnetic Field

Medical Devices, Implants and Foreign Bodies

All implants, devices, and foreign bodies inside a potential subject's body must be evaluated for MR Safety prior to the subject having an MRI Scan.

Static Magnetic Field

Quench

In some emergency situations it may become necessary to turn off the magnetic field immediately. In these situations there may be an operator initiated QUENCH.

Striking a button like the one shown will remove the magnetic field in less than 90 seconds. This means that the Superconductivity of the magnet's coils are stopped and the Liquid Helium surrounding those coils is boiled off rapidly.

Static Magnetic Field

Quench

The expansion ratio of liquid to gaseous Helium is 1 to 746. So, 1 cubic meter of liquid Helium will expand to 746 cubic meters of gaseous Helium. The venting system built for the MR system is made to handle this expansion and release the helium outside your building harmlessly. In the event that the vent malfunctions the room could become filled with gaseous Helium and displace life giving oxygen. It is also possible for an occult leak of Helium to occur and the same displacement of oxygen takes place. To monitor this all Research scanners have O_2 Monitors.

Quench

- Rapid cessation of the magnetic field.
  - A quench can be operator initiated or spontaneous
  - Safety issues during a quench are:
    - Viable Oxygen levels in the MRI Suite
      - We monitor O2 levels in the scanner room with a monitor constantly. It will alarm if the Oxygen level Drops.
    - Positive pressure within the room
    - Acoustic Noise
    - Spillage of Cryogens

Static Magnetic Field

Safety

• To maintain a safe MR Environment around this extremely high magnetic field we:

- •Control Site Access
- •Implement ACR (American College of Radiology) MRI ZONES
- •Demarcate the 5 Gauss Line
- •Post appropriate Signage
- •Incorporate a comprehensive Subject and Personnel screening
- •Education

Procedures

Control Site Access and Implement ACR MRI Zones

Controlling Site Access means:

No persons shall enter into the MRI area without being screened

All potentially dangerous material must be removed or placed in a secure location outside the MRI Suite

Only essential personnel should enter the MRI

Nothing should be brought into the room if it has not been evaluated for safety

Nothing is brought in and out of the room after the subject is in the magnet bore

Procedures

ACR MRI Zones

- Zone 1 – Open Public Area such as a Reception Area or outer hallway
- Zone 2 – Area of controlled entry where Subject screening takes place – Interview Area or dressing room
- Zone 3 – Area designated as the MR control area. Screening must be completed before entering this area.
- Zone 4 – MR Scanner Room

Procedures

Control Site Access and Implement ACR MRI Zones

ZONE 1 – hallway outside of Hup5 and 6

Procedures

Control Site Access and Implement ACR MRI Zones

Zone 2 and 3 are area inside this code lock door at Hup5 but outside scanner room door

Ancillary Equipment

•All equipment used for patient monitoring and life support is kept outside ZONE4.

•There is some MR SAFE ancillary equipment kept inside the MR room but, other equipment outside the room never goes into the room.

•CAMRIS (Upenn) does not take any gas tanks into the MR Rooms. There are NO compatible Tanks in our facility.

Emergency Procedure for Subject Needing Immediate Care

The first action is to remove the subject from the Magnetic field to a designated safe staging area.

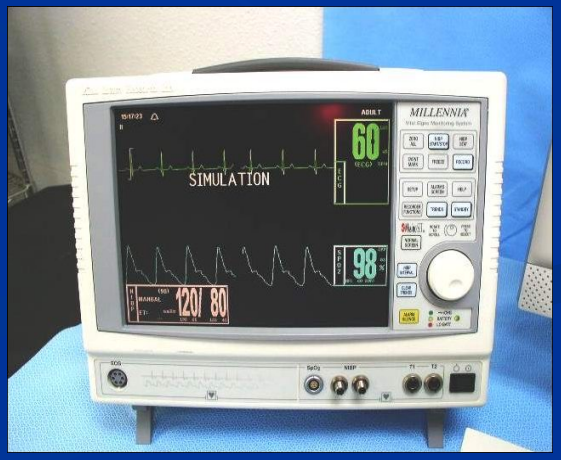
This will be in Zone2 or 3 of the MRI Department.

Never bring equipment into the MRI Room !

Ancillary Equipment

Zone 2-3

- Monitoring devices
- O2 tanks
- Ventilators
- Crash Carts



Procedures

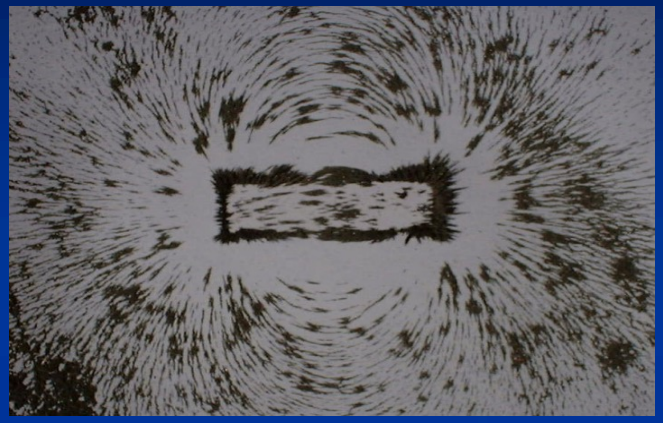
Control Site Access and Implement ACR MRI Zones

- Zone 4 – inside the scanner room

- Nothing is ever brought into this room until it has been evaluated for safety.

Knowing the 5 Gauss Line

5 Gauss Line:



This line specifies the perimeter around an MR scanner within which the static magnetic fields are higher than five gauss. Five gauss and below are considered "safe" levels of static magnetic field exposure for the general public.

5 Gauss Line is a very important field line position because at 5 gauss the magnetic field can be a hazard.

Static Magnetic Field

Posting Signage

Static Magnetic Field

Posting Signage

•MR Safety sign stating the presence of the Magnetic Field are posted on all doors that lead to ones 2,3 and 4. The signs state:

•There is an extremely high magnetic filed or access to the field behind the door.

•The MAGNET is always ON and the field is present.

•WARNS all that People with Medical Devices (ex. Pacemakers) should not enter past the designated point.

Screening

- If you are intending to participate in an imaging session or are working in the MRI Research Areas you must be screened. You can ask you lab supervisor or call CAMRIS Administration for the current screening forms if you find you cannot use the one on this page.
- Even if you have filled a form out for screening in the past you must fill this one out as part of the refresher course.

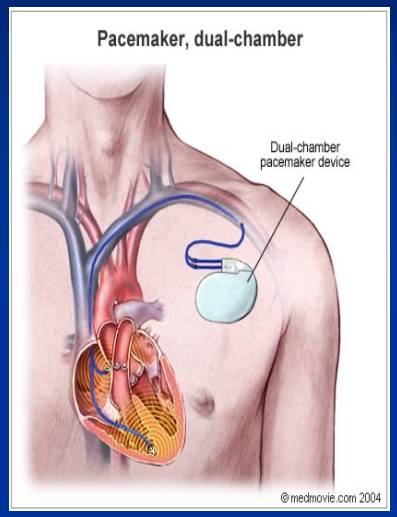
Screening

CAMRIS Contact Information

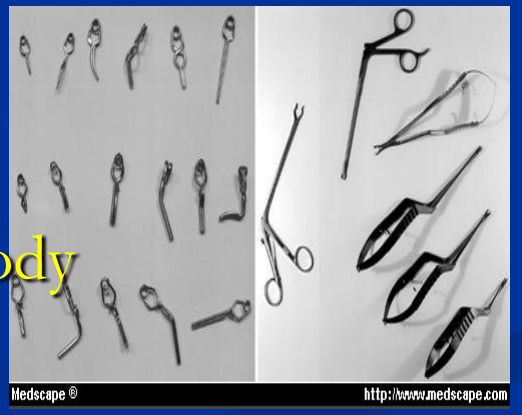
If you need to be screened this can be done by any of the MR Radiologists or MR Technologists.

You may not “self-evaluate” this form.

Screening (Subjects and Operators)



- Major Concerns – Medical History
- - Pacemakers
- Magnetically activated reed switch
- - Any other magnetically or electrically activated device
- * TENS units
- * Cochlear Implants
- * Certain Implanted Pumps
- - Intra-ocular Ferrous Foreign Body
- - Intracranial Aneurysm Clips
- MEDICINAL Patches



Screening Procedure

- The appropriate form is given to the subject for review and completion
- This form is then reviewed by the MR Technologist and confirmed through interview with the subject
- The form is then signed after review by the MR Technologist or Radiologist
- Any concerns about safety of the subject must be resolved prior to the MRI

Screening Suggestions

- MR Safety trained personnel can review the information on the MR screening form prior to patient's arrival in the department but, the form will be reviewed again and signed by the MR Technologist
- Multiple screenings is very useful and often helps in getting a good Medical History

Screening at PENN

- Penn Radiology:
  - Does not consider outside (other facilities) screening adequate
  - Does not consider previous MRI exams as a screening method
  - Subjects are to be screened multiple times if possible
  - Screening is done by trained individuals
  - MRI Screening forms must be completed and signed prior to the subject entering the MRI
- The screening form is to be checked and confirmed by the MRI Technologist PRIOR to subject entering the MRI Room

Subject Preparation Procedure

- All patients entering the magnet should be gowned (In Devon Center this is mandatory)
- All subjects and operators must remove jewelry, piercings, and any metal object from their body and/or pockets
- A final check should be made by the operator of themselves and the patient before entering the MRI room.

Subject and OPERATOR Preparation

- Empty their pockets and empty your pockets!
  - Pockets sometimes hold the darndest things. A great method of preparation is to have the subject turn out their pockets before the examination. Their pockets must be empty.

- Every Human subject scanned is given the Call Bell and ear plugs! NO EXCEPTIONS!

Some Suggestions for Subjects and operators

- Tell subjects to wear sweat clothes or bring some for exam
- Tell subjects to not bring items that could be damaged by the magnetic field
- Have subjects remove piercings and not wear jewelry to the session.
- Do not wear steel toed boots
- Remove shoes if you are getting into the Human full bore MRI system.
- Remind the subject that their having an MRI elsewhere does not screen them for their current visit

MRI in DEVON

- All subjects scanned in the Devon MR Pavilion will have to change into a GOWN. This is mandatory. You should prepare the patient for this prior to their arrival.

Research Personnel

- All metal should be removed and secured outside of the room
- All operators must submit a completed screening form
- If you are pregnant you may not be in the room during the scanning procedure
- Jewelry should not be worn into the room
  - Although it might not be a direct problem it presents subjects with the ability to make assumptions about their own belongings

Some Common "Stuff" that is fine with MRI – but let the Tech know about it.

- Dental Fillings
- Most Ortho Implants
- Braces – these may cause imaging issues
- SOME Dentures – although we would rather they be removed for image quality
  - The exception to this is if they are held in place with magnets

Ok and No-k!

•OK

•SAFE

•OK-sometimes

•CONDITIONAL

•UNSAFE

•No-k!

Surgical Steel(s)

- Most surgical equipment is made out of MARTENSITIC steel—it is much harder than Austentitic steel, and easier to keep sharp. Depending on the type of equipment, the alloy recipe is varied slightly to get more sharpness, or strength. Equipment such as this should never be taken into the MRI.

•UNSafe

Surgical Steel(s)

•Implants and equipment that are put under pressure (bone fixation screws, prostheses, body piercing jewelry), are made out of austenitic steel, often 316L and 316LVM, because it is less brittle. 316L and 316LVM Grades are slightly magnetic. These implants are usually SAFE but should be noted and evaluated.

•Conditional

Some common things that MUST be evaluated before MRI

- Eye Injuries
  - We need to know if there is any risk of IFFB (Intraocular foreign body) that is ferromagnetic
- Metal foreign bodies
- Shunts, Stents, Pumps, Clips, and/or medical devices that are attached to the patient

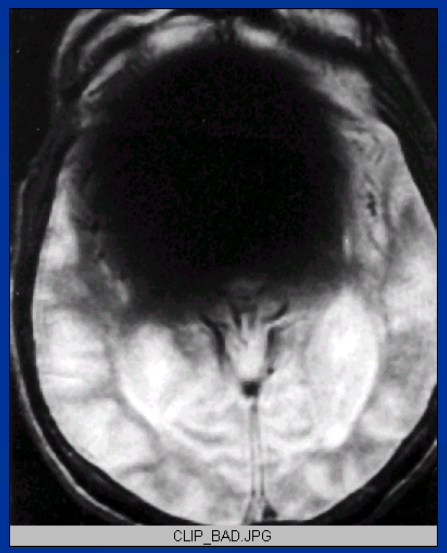
Static Magnetic Field

Intracranial Aneurysm Clips

Only patients with non-ferrous or weakly ferromagnetic clips be safely imaged with MR

There have been instances where clips that were thought to be non-ferrous exhibited ferromagnetic characteristics

Good clip



Bad clip

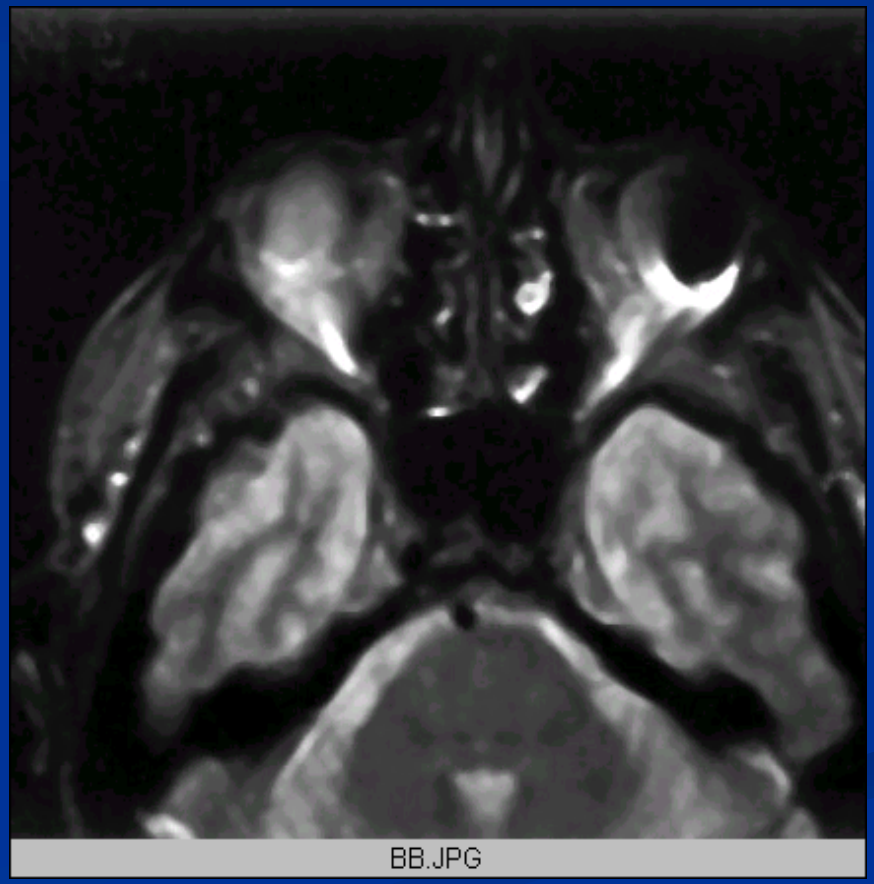
Static Magnetic Field

Intraoccular Ferrous Foreign Body

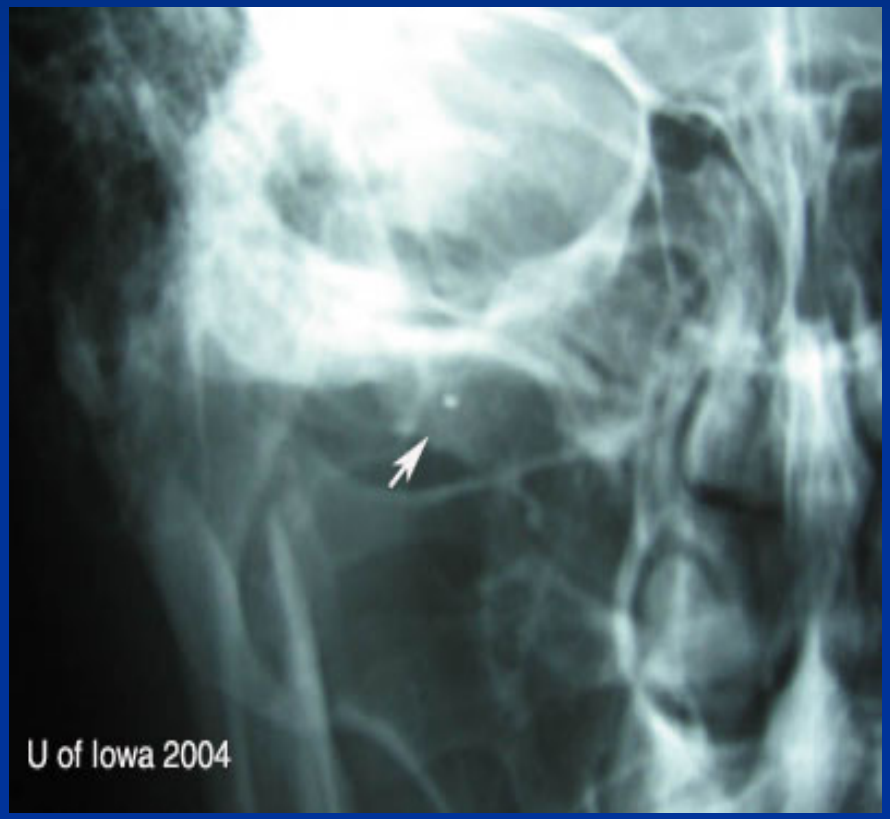
IFFB

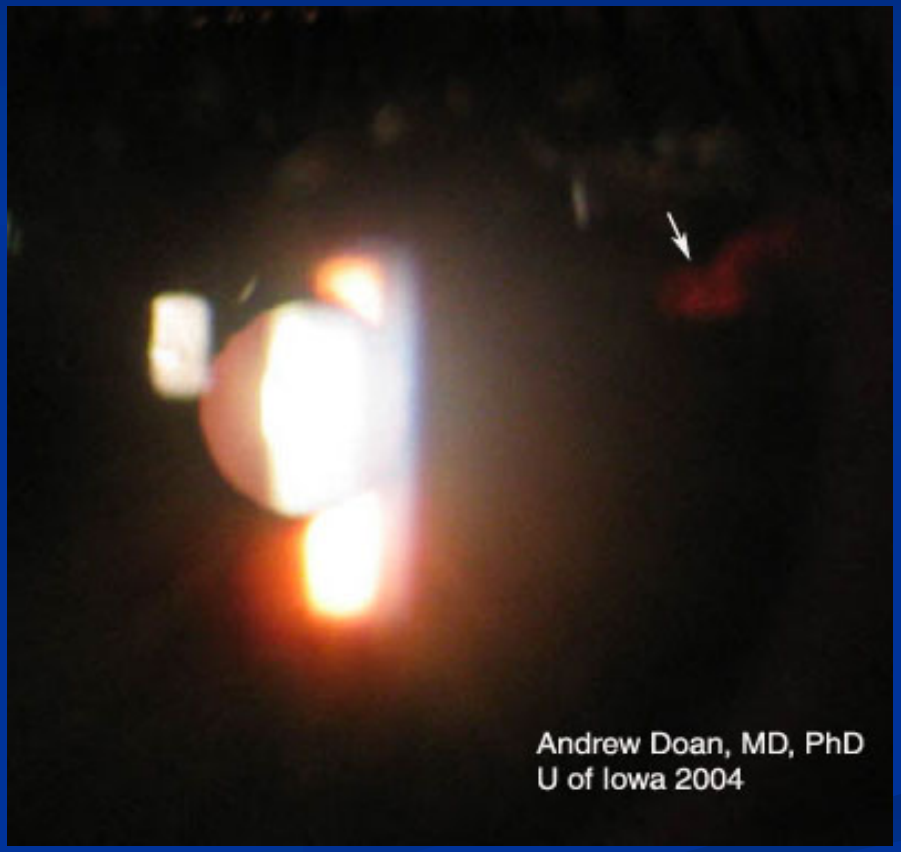
- **Orbital X-rays**
- **Orbital Cat Scan**
- **Opthamalogic Exam**

CAMRIS uses Orbital X-rays as screening



IFFB





Metallic Foreign Bodies
Shrapnel

CAMRIS does allow for outside X-rays for screening shrapnel and other metallic foreign bodies. It is the Investigator's responsibility to arrange for a Radiologist to evaluate these films.

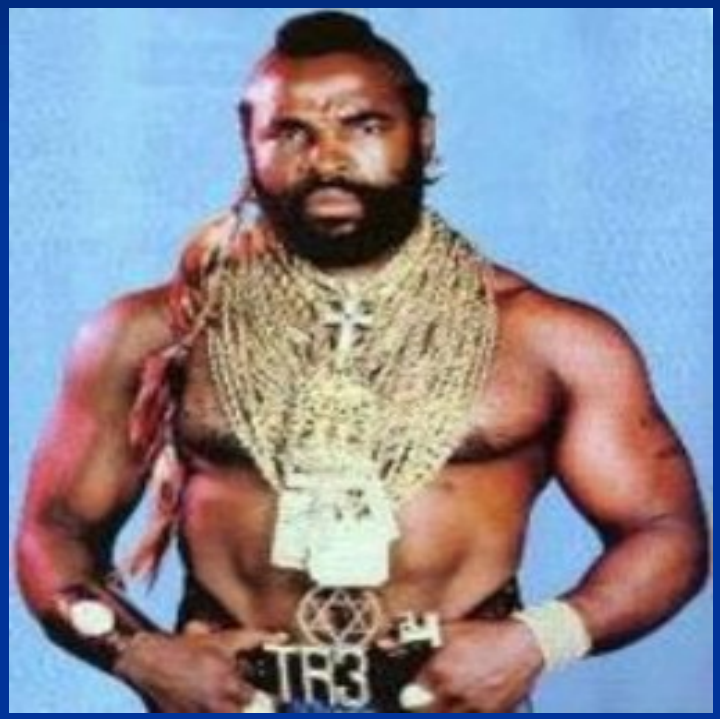
What if something does fly into the magnet???

- If there is no injury to patient or personnel then an Advanced MR Users or Technologist will need to assess the situation before removal efforts.
- NEVER ATTEMPT REMOVAL OF AN OBJECT WITHOUT CONSULTING TRAINED FACILITY PERSONNEL
- Removal without assistance from trained personnel puts you and others at risk for injury. It also risks the MR Device itself.

What if something does fly into the magnet???

- If an injury does occur as a result of an object flying into the magnet:
  - If possible remove the person(s) from the MRI Suite. Lock the scanner door and either call for help or transfer individual to Emergency Department
  - If person(s) are unable to be removed from MRI Suite due to being pinned against the magnet – QUENCH the magnet

Don’t be a “FOOL!” Fool!



•Do Not assume any metal object, device and/or implant is safe. We must evaluate it before scanning the subject !

Static Magnetic Field

Bio-Effects

- Long Term Effects – to date there are no known long term effects to exposure to a strong static magnetic field. The FDA has set the following Guidelines:

- Humans older than 1 month of age can be exposed to a magnetic field of up to 8Tesla
- Infants 1 month and younger can be exposed to a field of no more than 4Tesla

Static Magnetic Field

Bio-Effects

•Short Term Effects – There are no known short term effects to exposure to a strong magnetic field. However there have been reports of increased nausea, dizziness, headaches, and metallic taste in some subjects exposed to fields at and in excess of 3 Tesla. These effects are temporary . Further investigation into these effects is ongoing.

After the subject is placed in the MRI NOTHING should be brought into the MRI room.

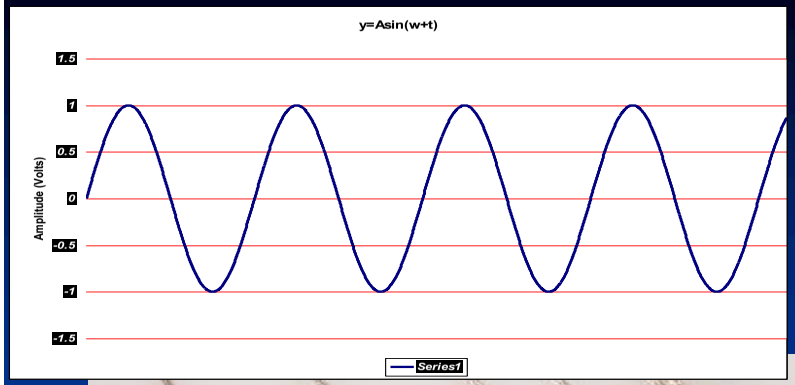
RF Safety Issues

The RF power used in MR imaging

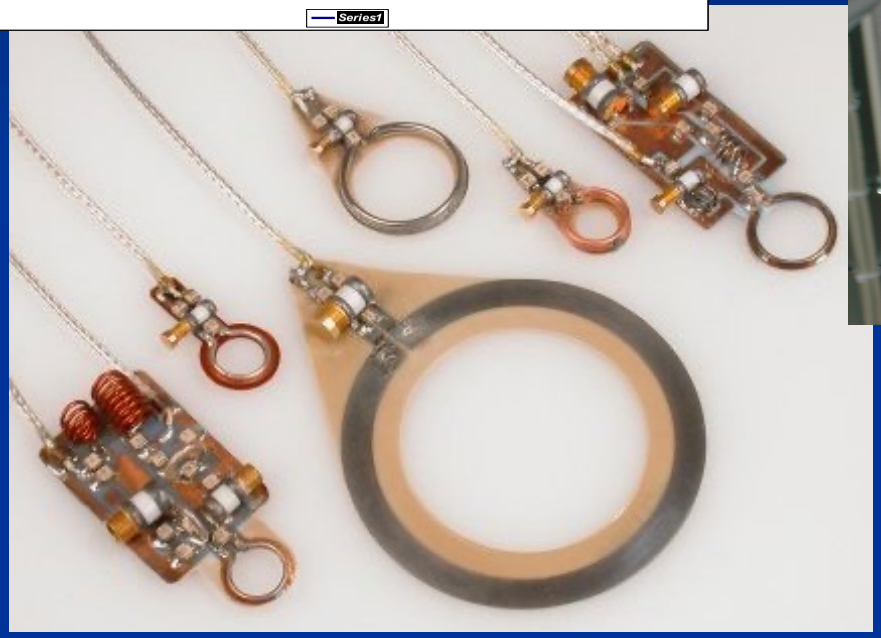
can heat tissue and conductive objects within the field it generates.

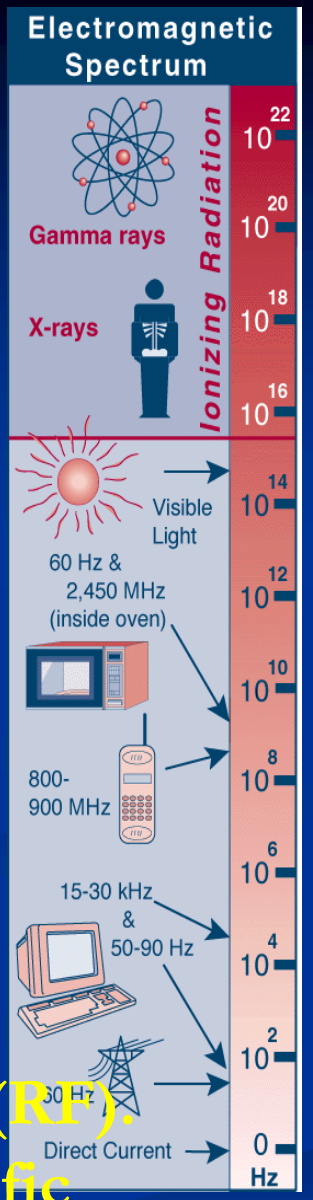
Therefore heating and burns are a possible safety issue

when generating RF for MRI Imaging.



- RF Coils





The FDA limits the absorption of radiofrequency (RF). This absorption rate is referred to as SAR (Specific Absorption Rate)

RF Safety Issues

- Heating
  - During the course of the MRI Imaging examination it is possible that the patient can become warm and uncomfortable. This is especially true when the examination being done is very RF intensive in its pulse sequences.
  - Patient disposition also plays a large role in the possible heating effects. If the patient is has problem thermo-regulating their body temperature due to an underlying problem this could be exacerbated during imaging.

RF Safety Issues

- **Diabetics**
- **Hypertensive**
- **Elderly or Young**
- **Large amounts of subcutaneous fat**
- **Compromised with fever**
- **Poor Physical Condition**

- **Some medication will also cause decreased ability to thermo-regulate**

RF Safety Issues

- Operation of the MRI Unit is limited by internal calculations to keep SAR under FDA guidelines. For this calculation to be accurate it is essential that the subjects body weight be entered accurately.
- Ambient temperature in the Magnet bore is also a factor. Whenever possible the bore fan should be used to keep the temperature down.
- Patients often start out a bit chilled due to the room temperature then get too warm as the scans progress. It is best to have them not overdress and offer blankets instead. This way the blankets can be removed without moving the subject.

RF Field

Antennae

The RF antennae (Coils) used for the MRI Scan have the potential for burning a subject if they are set up incorrectly or are malfunctioning.

The MRI scanner does self checks to avoid this but there are some things the operator must do to avoid possible burns.

The MR Technologist (or Operator) must be aware of the following for safe use of RF Coils:

- The cabling of the coils must not loop upon itself
- The coil's voltage adjustment must be within reasonable limits for that specific coil
- The coil must be recognized by the system
- There should be no visible cracks or burn marks on the coils housing or cables
- There should be no frayed or broken cables
- The connector of the coil must seat correctly to the scanner. This connector should not be loose
- There should be no bent, loose. Or missing pins on the connector or the scanner plug interface

RF Safety

Any conductive material introduce into the Field Generated by the RF coil has the potential for substantial heating. There are many things that determine whether a conductor will heat when exposed to the RF field. This is a complicated issue and has many factors. The more prevalent being the shape or orientation of the conductor with relation to the field. The field strength and frequency of the imaging MR and the conductivity of the conductor.

This includes things like :

- PACER Wires – (connected to pacer or not)
- Bone stimulator wires
- Ortho Rods
- Tens Units
- MEDICINAL PATCHES

Any object or device must be determined MR SAFE or Conditionally Safe BEFORE the subject enters Zone 4 >

RF Safety

- In fact any conductor can be heated. As evidenced by the image below of a Tattoo that contained Iron flecks for color. It heated during scanning. As you can see it is important that a thorough history be taken and all question on the form be answered.
- Tattoos are not a contraindication and rarely have this reaction but in the case of large tattoos or body tattoos we must be aware of the possibility.

Gradient Fields

Peripheral Nerve Stimulus

- Application of the Gradient Field is necessary to encode image information for image formation. At time when the gradients are applied at a high amplitude and/or at a great enough speed it can cause a patient to have peripheral nerve stimulus (PNS). This is involuntary firing of the peripheral nerves in certain areas of the body.

The likelihood of this occurring is based on many different factors. The overall sensation is that of a tingling, or small muscle twitch. It can happen anywhere in the body. It is temporary and stops when the scanning stops.

Gradient Fields

Peripheral Nerve Stimulus

Some of the factors in PNS are:

Orientation of slice along the body axis
Number of Phase encodings
Repetition Time and FOV
Patients hand and foot position
Slice thickness

Gradient Fields

Peripheral Nerve Stimulus

Gradient intensive imaging protocols are most likely to cause PNS in a subject.

One of the simplest ways to avoid common PNS is to make sure the patient does not hold his hands together or cross his feet and legs during their time in the scanner.

GRADIENT FIELDS

Acoustic Noise

- These noises are generated by the gradient inside of the magnet bore
- The Gradient coil is used to spatially encode information to be mapped as the MR Image
- The coil is turned on and off rapidly – when activated it torques and strikes the inside of the magnet housing causing a rapping or clanking noise

Acoustic Noise Levels

- Although the noise levels have dropped it is still mandatory that all subjects wear ear plugs or ear muff hearing protection during the MRI examination.

- The acoustic noise presents some challenges to subject and operator:
  - Difficulty communicating between operator and subject
  - Annoyance of subject
  - Temporary hearing impairment
  - Worst Case – permanent hearing impairment

Please!

- Ask if you are not sure!
- The only DUMB question is the one you did not ask.
- Report issues and problems so we may take corrective action.
- Call – Norman Butler 610-888-9366