MR Safety issues

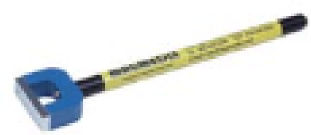
MRI has three types of fields: Static magnetic, gradient magnetic and radiofrequency (RF). There are potential risks associated with each field.

Static Magnetic field:

The potential hazard concerning the static field is the missile effect.

The static magnetic field is the main magnetic field created by the superconducting coils and is measured in Tesla. 10,000 gauss equals 1 Tesla. The earth's magnetic field is .5 gauss or .5mT. So, a 1 Tesla magnet is 20,000 times stronger than the earth's magnetic field which makes our 3T scanner 60,000 times stronger! The stray magnetic field, which is outside of the magnet bore, is known as the fringe field. Superconducting magnets use active shielding which confines the fringe field to the scan room. For our purposes we consider the threshold of the magnet room door as the .5 gauss line. (when speaking of this line it is a general practice to just refer to the line as 5 gauss). Electronic devices and ferromagnetic objects inside the 5 gauss line are strictly prohibited.

The magnetic field of an MR system has the capability to attract metal with a high velocity and force. A paper clip has a terminal velocity of 60mph in a 3 tesla magnetic field. The larger the object, the greater the velocity and force. Therefore metal brought into the magnet room becomes a potential lethal weapon!
NOTE! Objects that do not appear to contain any metal may have ferromagnetic metal inside. Non-ferrous metals such as titanium, gold, silver, copper, brass, and aluminum are safe to go into the magnet but always test with the hand held magnet first since they may contain parts such as screws that are ferromagnetic. Therefore, prior to taking any object into the MRI scan room, you should test it with the 1000 Gauss test magnet (shown at right). Always test and verify! The test magnet is located just right of the MR console in the control room.



Ferromagnetic implants or fragments in the body may rotate or move causing internal injury. Therefore everyone must be carefully screened prior to entering the magnet room. Anyone inside the 5 gauss line MUST be screened and MUST be accompanied by authorized personnel. The control room is restricted to card access only. DO NOT prop the door open.

Gradient Magnetic field:

Gradient coils are a set of resistive wire windings that are used to spatially encode the positions of the information in the emitted signal by varying the magnetic field linearly across the imaging volume. The gradient magnetic field is produced when electrical current is applied rapidly and briefly to the gradient coils during image acquisition. The gradient magnetic field is also referred to as the time-varying field since the strength and speed of the gradients change throughout the imaging process. There are two potential physiological effects associated with the gradient magnetic field, peripheral nerve stimulation and acoustic noise.

Peripheral nerve stimulation

The rapid switching of gradient magnetic fields during image acquisition has the potential of inducing stimulation to the peripheral nerves and contractions to muscles. It is more noticeable in techniques that use ultrafast gradient switching such as EPI (fMRI or BOLD and diffusion weighted sequences). Since humans are conductors of current, sensations of tingling or twitching may be felt. Subjects are instructed not to cross their arms or legs. If they do so, a conducting loop is formed and the potential for peripheral nerve stimulation is possible.

Acoustic noise

Scanner acoustic noise occurs during the rapid alteration of currents within the gradient coils. The rapid rise and fall of currents within the gradient coils in the presence of the static magnetic field cause strong forces that produce minute expansion and contraction of the coils. This causes the gradient coils to move against their mountings and the vibration of the coils and the vibration of their mountings cause the loud knocking noise. Certain types of pulse sequences such as EPI ((fMRI or BOLD and diffusion weighted sequences) and other fast imaging sequences will create a high and potentially dangerous level of acoustic noise. Therefore, everyone, including deaf subjects, is required to wear ear protection. Use either disposable earplugs or headphones with disposable covers. Anyone who stays in the scan room during the study is also required to have ear protection

RF field:

The potential hazards from the RF field are tissue heating and burns.

During the MR scan a short intense burst of RF (radiofrequency) is introduced into the subject. The application of an RF pulse flips the protons and also results in nuclei absorbing energy. The principal effect of RF absorption on body tissues is the potential for a rise in body temperature. Localized heating is caused by RF energy absorption to a volume of tissue. The amount of absorbed energy depends on the static magnetic field and the type of sequence being used. A 180° pulse deposits more RF energy than a 90° pulse. There is more energy deposited using sequences that employ many RF pulses (such as fast spin echo) than those that use fewer RF pulses (such as gradient echo EPI).

Since MR systems are not able to measure RF exposure it is necessary to measure RF absorption. SAR (Specific Absorption Rate) is the measure of RF energy absorbed in the body (watts per kilogram). The FDA has set safety guidelines for this. MR systems calculate the SAR based on the pulse sequence and the participant's weight. For this reason an *accurate* weight must be entered on the computer console.

RF pulses have the potential to heat non-ferrous metallic implants, mainly at the surface.

Although unauthorized implants should never be present in a subject who is being scanned, an authorized implant may lead to unexpected heating.

RF pulses have the potential for burn hazards from an electrical current that is produced in conductive loops. Therefore when using surface coils be sure that no loops are created by the wires, nor allow the wires to touch the animal.

Emergency Shut–off Switches

Emergency stop/shut-down switch (electrical supply only)

By pushing this button all electrical supply to the magnet PDU (power distribution unit) is disrupted. It does not initiate a quench. THE MAGNET REMAINS RAMPED ("ON"). MAKE SURE ALL FERROMAGNETIC OBJECTS REMAIN OUTSIDE OF THE SCAN ROOM.

Use this if there is a fire or electrical accident in the scan room or the electronics cabinets, or if the sprinkler system goes off in either of these rooms. Also, if you see or smell smoke coming from the magnet or a computer cabinet, use this button. Call UR Security at ext. 13. State that you are in the Medical Center Annex Building, room 1B107 and explain the problem.

There are three: 1---inside the scan room, on the wall by the door.
2---in the control room, to the left of the scanner monitor.
3---in the computer cabinet room, on the wall by the door.

Magnet Stop / Quench switch

There are two Magnet Stop buttons: <u>both covered with a plastic flap.</u>

This is located in the magnet room.

---------------------Stop Button. This panel is located in the control room.

The only time this button can be pushed is if someone's life is at risk. Only an RCBI staff member can push this button.

By pushing this button you rapidly reduce the magnetic field strength. The helium coolant boils off suddenly during this process and is released through an exhaust vent. An alarm signal will sound when the magnet stop button is pushed.

Since a quench cost thousands of dollars and may damage the magnet, ONLY quench the magnet if a large metallic object pins or impales a person against the magnet and no other method will free them or prevent further injury.

Never attempt to pull large metallic objects from the magnet field. The object may change its magnetic polarity and re-align itself on the magnet and become a projectile, causing a serious or fatal injury.

If you need to quench the magnet, remove all personnel from the scan room as soon as possible. It takes about 20 seconds for the magnet to lose its power. Initiating a quench will release the helium through a vent to the outside.

There are two Magnet Stop buttons: both covered with a plastic flap

1---just inside the scan room.

2---inside the control room, to the right of the computer console

Notify Siemens service and Dick Aslin immediately if this button is pushed.

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Magnet Quench: Failure of vent

During a quench, the liquid helium boils off through an exhaust vent and the magnet loses its super-conductivity. It takes only 20 sec. for the magnet to quench. When a quench occurs an alarm goes off (which can be silenced on the alarm box) and a hissing noise is heard as the helium is vented outside. Do not attempt to touch the vent during a quench due to the extremely cold temperature. Frostbite will occur. Large plumes of white fog appear outside as a result of the helium release.

One liter of liquid helium will quickly expand to about 800 liters of gaseous helium. If the exhaust vent fails, whereby the helium is vented into the scan room, it will quickly reduce the oxygen level in the scan room and cause asphyxiation. Frostbite and/or hypothermia will also occur.

If you need to quench the magnet, remove all personnel out of the room first! If someone is pinned to the magnet, be absolutely sure that you have propped the scan room door open with the doorstop. If the vent fails, the pressure caused by the expanding gas will slam the door closed and it will be impossible to open until the pressure of the gas is released. There is a passive vent in the ceiling of the magnet room to help alleviate the gas.

Be sure to notify Siemens service immediately in the event of a quench. Also notify the director Dick Aslin. If he is not available notify Daphne Bavelier.

A copy of these procedures and contact personnel are kept in the control room.

Miscellaneous

Standard guideline for metallic foreign body in the eye:

On our screening form there are questions concerning metallic foreign bodies in your eyes. Have you ever had metal removed from your eyes? The standard guideline is if you have had a metallic foreign body removed by a doctor, then it is safe for you to go into the scan room. If you removed it yourself and have had an eye exam (negative for metal) after the event then it is safe for you to go into the scan room.

If you removed the metal yourself and have not had your eyes examined by a doctor then you will not be able to go into the scan room. If you worked around metal such that it was possible for small pieces to get into your eyes and you did not wear safety glasses all the time you will not be able to enter the scan room. Working without safety glasses it is possible for a very small piece to enter your eye and not know it. Sounds odd but it has been known to happen. Once you have had your eyes examined by a doctor and it's negative for metal you will be able to enter the room. The exam you get at the U of R for new employment status is not sufficient.

The concern is that the magnet is powerful enough to pull on that metal fragment and possibly do damage to your optic nerve which would dramatically alter your vision. If anytime in the future there is any change in your medical history concerning metal implants or metal fragments it's in your best interest to check with the MRI technologist before you enter the magnet room. If you have any questions or concerns contact pweber@rcbi.rochester.edu.