

MAGNETIC RESONANCE (MR) SAFETY: ENSURING THE SAFETY OF NON-MR PERSONNEL

Self-Study Packet & Test

Approved for 1.0 contact hour for nurses by provider number 50-182.

*A Professional Education Training Program for **One** Contact Hour from:
Baptist Health South Florida*



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Course Objectives

1. Identify safety risks in the magnetic resonance (MR) area.
2. Describe the “missile effect” as it relates to magnetic force.
3. Explain safety precautions in an MR area.
4. Cite how to prepare your patient to have an MRI.

INTRODUCTION

On July 3, 1977, an event took place that would forever alter the landscape of modern medicine. This event was the first MRI exam ever performed on a human being. It took almost five hours to produce one image. The images were, by today's standards, very rudimentary. Dr. Raymond Damadian, a physician and scientist, along with colleagues Dr. Larry Minkoff and Dr. Michael Goldsmith, worked tirelessly for seven years to reach this point. They named their original machine "**Indomitable**" to capture the spirit of their struggle to do what many said could not be done.

This machine is now in the Smithsonian Institution. As late as 1982, there were but a handful of **MRI scanners** in the entire United States. Today there are thousands. We can image in seconds what used to take hours.

If you have ever seen an MRI machine, you know that the basic design used in most is very similar to CT scanner. There is a **horizontal tube** running through the **magnet** from front to back. This tube is known as the **bore** of the magnet. MRI scanners vary in size and shape, and newer ultra-short bore models have some degree of openness around the sides. The typical MR scanner is just under 6 feet long with an inside diameter of 60cm. The new ultra-short bore scanners are just under 4 feet long with an inside diameter of 70cm. These new ultra-short bore scanners are very patient friendly and most patients can have a comfortable MR experience despite their claustrophobia.

The patient, lying on his or her back, slides into the bore on a special table. Whether or not the patient goes in head first or feet first, as well as how far in the magnet they will go, is determined by the type of exam to be performed. Once the body part to be scanned is in the exact center or **isocenter** of the magnetic field, the scan can begin.

MRI does not use radiation like CT and x-ray. MRI uses [radio wave](#) pulses of energy, to pinpoint a very small **point** inside the patient's body and ask it, essentially, "What type of tissue are you?" The point might be a cube that is half a millimeter on each side. The MRI system goes through the patient's body point by point, building up a 2-D or 3-D **map** of tissue types. It then integrates all of this information together to create **2-D images** or **3-D models**.

MRI provides an unparalleled view inside the human body. The level of detail we can see is extraordinary compared with any other imaging modality. MRI is the method of choice for the **diagnosis** of many types of injuries and conditions because of the incredible ability to **tailor** the exam to the particular medical question being asked. By changing exam parameters, the MRI system can cause tissues in the body to take on different appearances. This is very helpful to the radiologist in determining if something seen is normal or not. We know that when we do "A," normal tissue will look like "B" -- if it doesn't, there might be an abnormality.

MRI systems can also image flowing [blood](#) in virtually any part of the body. This allows us to perform studies that show the **arterial system** in the body, but not the tissue around it. In some cases, the MRI system can do this without a **contrast injection**, which is required in vascular radiology.



*MRA Head non-contrast
Images compliments of BHM MRI*



*MRA Neck with contrast
Images compliments of BHM MRI*

Magnetic Fields

To understand how MRI works, let's start by focusing on the "magnetic" in MRI. The biggest and most important component in an MRI system is the **magnet**. The magnet in an MRI system is rated using a unit of measure known as a **tesla**. Another unit of measure commonly used with magnets is the **gauss** (1 tesla = 10,000 gauss). Most MRI scanners being used today are 1.5 tesla; but the number of 3 tesla scanners are increasing steadily. Magnetic fields of 7 **tesla** are currently being used for research, and are pending FDA approval for use in medical imaging. Compared with the Earth's 0.5-gauss magnetic field, you can see how incredibly powerful these magnets are.

Numbers like that help provide an intellectual understanding of the magnetic strength, but everyday examples are also helpful.



Photo courtesy Siemens
In this MRI scan, you can clearly see the wrist bones and ligaments.

In Baptist Health, every person who works in the MRI department must be concerned with magnetic resonance safety. To ensure the safety of patients, the staff and others, it is critical that every one of us continuously follows the MR safety guidelines and standards for a safe MR environment.

MRI'S STRONG MAGNETS CITED IN ACCIDENTS

The pictures and stories are the stuff of slapstick comedy: wheelchairs, stretchers, floor polishers jammed deep inside MRI scanners whose powerful magnets grabbed them from the hands of careless hospital workers.

The sprinkler repair-man whose acetylene tank was yanked inside the magnet, breaking its valve and starting a fire that burned the building to the ground.

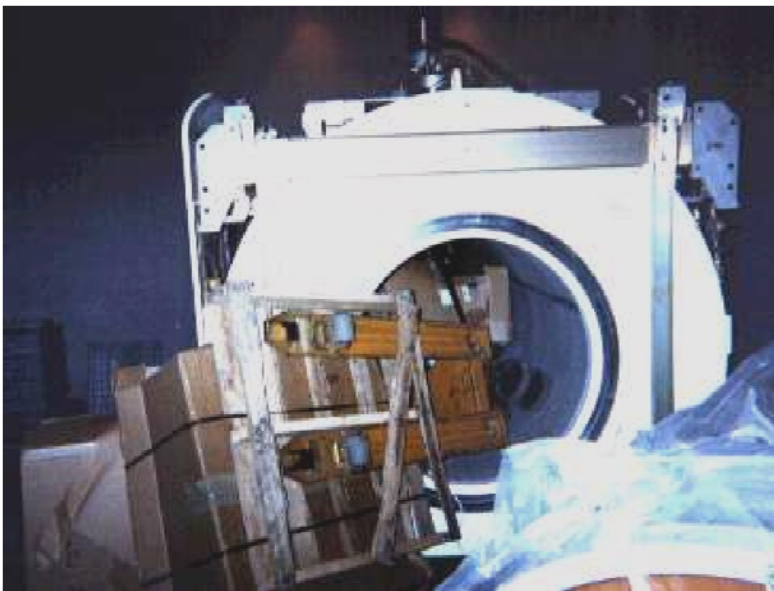
A fireman fighting a blaze in an adjacent location, sucked into the scanner's bore by his air tank. Folded in half, with his knees pressed into his chest, he nearly choked to death.

But the bigger picture is anything but funny. Careless accidents have become more frequent. Many people are killed or seriously injured every year because of carelessness.

The most notorious accident was the death of a 6 yr old boy in 2001 at the Westchester Medical Center in Valhalla, N.Y. The boy was sedated for the MRI when his oxygen supply failed. An oxygen tank was quickly brought into the scan room. Unfortunately, everyone present failed to notice that the oxygen tank was ferrous and it immediately flew into the scanner crushing the boy's skull. He died two days later from his injuries.

Most accidents are caused by "human error," not scanner malfunction. In almost every case, the accident was caused by personnel who let ferromagnetic objects into the MRI scan room.

The MRI suite can be a very dangerous place if strict precautions are not observed. Metal objects can become dangerous projectiles if they are taken into the scan room. For example, paperclips, pens, keys, scissors, hemostats, stethoscopes and any other small objects can be pulled out of pockets and off the body without warning, at which point they fly toward the opening of the magnet (where the patient is placed) at very high speeds, posing a threat to everyone in the room. [Credit cards](#), bank cards and anything else with magnetic encoding will be erased by most MRI systems.



The magnetic field of an MRI system is many times stronger than the earth's magnetic field. We currently have two MRI scanners in the main MRI Department at Baptist Hospital and one MRI scanner upstairs in BCVI. There currently 20 MRI scanners throughout Baptist Health. All of these scanners have high field, superconducting magnets with a field strength of 1.5 Tesla (15,000 gauss) or 3 Tesla (30,000 gauss).

In this photograph, you can see a fully loaded pallet jack that has been sucked into the bore of an MRI system.

THE MISSILE EFFECT

The "missile effect" refers to the capability of the static magnetic field to attract a ferromagnetic object, drawing it into the scanner with considerable force. The magnetic field is very powerful and can turn everyday hospital items into dangerous projectiles. Such objects will fly into the magnet at tremendous speed and can even pin an adult to the scanner. An object pulled by the magnetic field can often carry a person with it.

We may not feel the strong magnetic force at first, but as soon as we approach the bore of the magnet, the magnetic force increases dramatically. The magnetic force exerted on an object increases exponentially as it nears the magnet. Imagine standing 15 feet (4.6 m) away from the magnet with a large pipe wrench in your hand. You might feel a slight pull. Take a couple of steps closer and that pull is much stronger. When you get to within 3 feet (1 meter) of the magnet, the wrench likely is pulled from your grasp. The more mass an object has, the more dangerous it can be -- the force with which it is attracted to the magnet is much stronger.

The missile effect can pose a significant risk of injury not only to the patient inside the MR scanner, but also to anyone in the path of the moving object. Several patients and healthcare professionals have been struck and injured by common objects involved in missile-effect incidents. Projectiles can cause substantial damage to the MR system, even if there is no injury to a patient or individual.

To guard against accidents, injuries or damage to the MRI system, admittance to the MRI scan room is strictly supervised and controlled.

EDUCATION IS KEY

It is necessary to educate everyone who needs to enter the MR environment on a regular or intermittent basis regarding the potential hazards related to the powerful magnetic field of the MR system.

THE MAGNET IS ALWAYS ON

The Magnet is ALWAYS ON, even when not in use. Turning off the power will not affect the magnet

The Magnetic Field is:

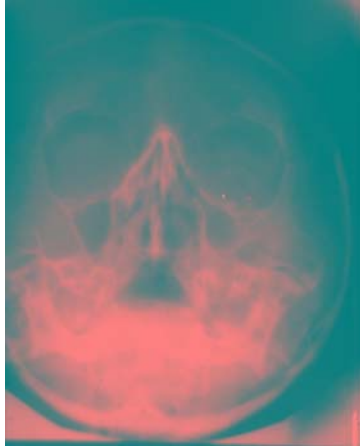
- | | | |
|------------------------------|---|---|
| An Invisible Force | → | You cannot see it |
| It makes no sound | → | You cannot hear it |
| It gives no warning | → | You cannot feel it until it is too late |
| It is absolutely unforgiving | → | It will not permit even one mistake |

**The magnetic field of the magnet is always on even when the power is turned off.....
even when the whole hospital is without power.**

THE MAGNET IS ALWAYS ON.

Safety Check

Prior to allowing a patient or support staff member into the scan room, he or she is thoroughly screened for metal objects. Many people have implants inside them that make it very dangerous for them to be in the presence of a strong magnetic field.



Metallic fragments in the eye are very dangerous because moving those fragments could cause [eye](#) damage or blindness.

Your eyes do not form scar tissue as the rest of your body does. A fragment of metal in your eye that has been there for 25 years is just as dangerous today as it was then -- there is no scar tissue to hold it in place.

Up until recently, people with **pacemakers or implanted defibrillators** cannot be scanned or even go near the scanner because the magnet can cause the pacemaker to malfunction. Medtronic has developed an MRI Conditional Pacemaker. The first Medtronic Revo Pacemaker was FDA Approved for MRI use in January 2011. These pacemakers can be programmed by the Medtronic representative to work properly in the magnetic field. To date, ALL Implanted defibrillators ARE UNSAFE.

Many **aneurysm clips** in the [brain](#) can be very dangerous as the magnet can move them, causing them to tear the very artery they were placed on to repair. Detailed information on the make and model number of the aneurysm clip must be obtained to ensure the patient's safety during the MRI scan.

Some **dental implants** are magnetic. Most orthopedic implants, even though they may be ferromagnetic, are fine because they are firmly embedded in bone. Even metal staples in most parts of the body are fine -- once they have been in a patient for a few weeks (usually six weeks), enough scar tissue has formed to hold them in place. Each time we encounter patients with an implant or metallic object inside their body, we investigate thoroughly to make sure it is safe to scan them. Some patients are turned away because it is too dangerous. When this happens, there is usually an alternative method of imaging that can help them.

CONTRA-INDICATIONS

Any medical device that may be damaged by the magnetic field or that may injure you:

- Most** Cardiac Pacemakers
- All** Implanted Cardiac Defibrillator
- Some Aneurysm clips
- Cochlear Implant
- Magnetically activated implants
- Heart Valves - *most are safe except newer magnetic types*
- Insulin pump or morphine pump
- Neurostimulators
- Metallic implant *recently placed*
- Stents/Filters *recently placed*
- Artificial limbs/braces
- Hearing aid - *must be removed*

The Radiologist in charge of MRI is responsible for evaluating available information pertaining to the safety of various implants, and for permitting any implant to enter the magnetic field.

No individual should rely on the opinion of a friend who may work in the medical profession to determine the safety of an implanted device.

KEEP ALL FERROUS OBJECTS OUT OF THE SCAN ROOM

- **REMOVE ALL FERROUS OBJECTS FROM YOUR PERSON**
 - Loose metal objects from your person – hairpins etc.
 - Loose metal objects from your pockets e.g. keys, penknife, etc.
 - All credit cards, bankcards or other magnetic strip cards
 - Analogue watch
 - Hospital ID
 - Beepers or portable phones
 - Gold or silver Jewelry is safe and does not have to be removed. Cosmetic jewelry however will need to be removed.

- **YOUR EQUIPMENT – IS IT FERROMAGNETIC - IS IT SAFE TO GO INTO THE SCAN ROOM**
 - Know your equipment
 - Check your equipment to make sure that everything on it or attached to it is safe to enter the scan room
 - Ask the technologist to check equipment with a hand magnet if you are not sure if it is "MR SAFE".

SAFE MR PRACTICES

1. Restricted Access

Access to the MR Department

- Restricted except for the outpatient waiting area.
- You need to "badge in" or be admitted by MR Personnel.

Access to the MRI Scan Room

- Strictly supervised and controlled
- Comprehensive screening of all non-MRI personnel

2. Warning Signs

Stop Signs are placed

- at the entry to MR scan room and
- on the floor inside the scan room.

Note: These signs serve as a reminder not to enter the MR scan room until you have been cleared by MRI personnel.

3. Screening of all non-MR Personnel

- MRI safety-trained personnel are responsible for performing comprehensive screening of all non-MRI personnel before allowing them to enter the MR scan room.
- Prior to entering the MRI scan room, all non-MRI personnel are required to
 - complete a written screening form and
 - remove all metal objects from their person

4. Identifying Personnel designated "SAFE" to enter the MR Room

Individuals that have been screened and cleared to enter the MR scan room must wear a large green sticker that reads "MR SAFE". This enables MRI personnel to easily identify persons trying to enter the MR scan room who have not been screened. Individuals designated "MRI Safe" are instructed to remove the sticker if they leave the MRI Dept and they will need to be re-screened prior to re-entering the MR scan room.

PERSONNEL SCREENING

Careful personnel screening is the most effective way to avoid potential safety hazards.

Comprehensive personnel screening involves three concepts:

- The use of a printed form to document the screening procedure
- A review of the information provided on the form
- A verbal interview to verify the information provided

The magnetic field may be hazardous for individuals with certain types of implanted devices

- Electrically activated implants
- Magnetically activated implants
- Ferromagnetic implants

Although many modern surgical implants, (artificial joints etc.) are made of non ferromagnetic materials, many are not. Remember...

- A patient died when an aneurysm clip on an artery in the brain was dislodged.
- Several patients with pacemakers have died after inadvertently being scanned.
- Shrapnel and machine-shop debris can also cause problems.
- A patient was blinded in one eye when a metal sliver from a previous accident moved during the MRI scan.

PATIENT SCREENING

Careful patient screening prior to arrival in the MRI department is the most effective way to expedite the exam. Once arriving in the department, the patients will be comprehensively screened involving:

- Review of the *Pre-MRI Screening Form* **
- Review of the *Imaging Contrast Screening and IV Documentation Form* **
- A review of the information provided on the Forms
- A verbal interview to verify the information provided on the Forms

*** These forms can be found on the intranet and should be completed prior to arriving in the MRI Department. See instructions on where forms are located in MRI Screening Forms Section Below.****

By completing the *Pre-MRI Screening Form* and the *Imaging Contrast Screening and IV Documentation* forms prior to arriving in the MRI Department, we are able to pre-screen the patient and obtain any additional information necessary to ensure that it is SAFE for the patient to undergo the MRI procedure. If the patient comes down to the MRI Department and we then find out that they have an implant, we may not be able to perform the MRI and may have to send the patient back up to their room.

MRI SCREENING FORMS

The MRI Inpatient Pre-Screening Packet can be found on the Intranet and should be filled out prior to arriving in the MRI Department:

To Access MRI Screening Forms

1. Access the Sun Intranet
2. Select *Online Resources*
3. Scroll down... Under *Forms*, Select *Physician's Order Forms*
4. Select *Baptist Hospital of Miami*
5. Select *Imaging Department Orders*
6. Select *MRI Inpatient Pre-Screening Packet*
7. *Print*

Oxygen Tanks

The O2 tanks used by the hospital are NOT MR Safe.

Oxygen tanks must **NOT** be taken into the MR scan room. Every MR scan room has piped oxygen available on the wall. The patients are brought down to the department with a portable O2 tank; prior to and during their MRI procedure, they are transferred to the O2 piped into the scan room.

The following are some of the items that may **not** be taken into the MR scan room:-

Oxygen cylinders	Stretchers
Anesthesia Supply Cart	Wheelchairs
IV pumps	Crash Carts
IV poles	Tool Belts
Portable lamps (unless MR Safe)	Hammers, screwdrivers, wrenches, Pliers
Garbage cans	Flashlights
Laundry carts	Guns
Floor buffers	Fire extinguishers/axes
Mop buckets	Ladders with metallic screws/rivets
Scissors	

If you are not sure if something is MR safe, do not take it into the scan room. If something is stored outside the scan room, you must assume that it is NOT safe to go into the scan room.

It is not possible to remember every detail. We expect you to remember that you need to be careful and if you are not sure..... ask!

CRITICAL CARE PATIENTS

Critical Care Patients require extra time and planning than routine patients.

ICU nursing, respiratory therapy and MRI staff put their heads together in order to minimize the time an ICU patient has to be out of the unit for an MRI. We met and brainstormed, here is what we came up with:

Prior to leaving the ICU:

- ☯ Are you MRI safe?
 - If there is anything on the MRI Patient Checklist that applies to you, you are probably not MRI safe and would need to get another staff member to take your patient.
- ☯ If the patient has had an MRI for this admission the old MRI checklist should be filed in the Radiology section of the medical record. This can be used as a reference for the new checklist.
- ☯ Stop any IV fluids/ drips that are able to be stopped, for example KVO IV's. MRI has only 4 IV Pumps that are MRI safe.
- ☯ Remove transducers from hemodynamic monitoring equipment. If unsure how to do this, contact Stat Lab for assistance.
- ☯ Empty your pockets. **Everything in your pockets must be removed and cannot enter the MRI scan room. It is best to leave it in your department so that it does not get lost.**
- ☯ If you are unsure if patient is safe to travel, call and discuss with the Intensivist.
- ☯ Contact the respiratory therapist. Only the MRI compatible ventilator and circuit are allowed to enter the MRI scan room.

Once in the MRI Department:

- ☯ If you are new to going to MRI, the staff will give you a tour of the department layout, and show the location of the crash cart and emergency equipment.
- ☯ The new staff member will need to complete an MRI Checklist to remain on file in the MRI department. **If any changes occur, (surgeries, implants, pregnancy) inform a member of the MRI staff to ensure that you are still MRI safe and update your MRI checklist accordingly.**
- ☯ Once the MRI Safe sticker has been placed on your uniform you may not place anything in your pockets, including stethoscope.
- ☯ The MRI staff will need to switch out the IV pumps, and change out the EKG electrodes.
- ☯ The MRI Staff will need to do their safety checks of the patient and the healthcare team with the patient. This must be done and there are no shortcuts.
- ☯ Although there are times when the magnet interferes with the EKG reading on the monitor, the pulse oximeter reading and the pulse rate are still accurate.
- ☯ The MRI staff wants to ensure the utmost safety to our ICU patients as well as peace of mind to the ICU staff accompanying them.
 - If you have a patient concern during the MRI scan, the MRI staff will stop the scan so you may assess the patient.

CONTRAST AGENTS

The **oral contrast** agent used in MRI is called **Gastromark**. Gastromark is an FDA approved oral contrast agent that is used to distinguish bowel loops from abdominal organs. Gastromark DOES NOT contain Barium; and Barium CANNOT be used as an oral contrast for MRI.

The **intravenous contrast** agent used in MRI is called **Gadolinium**. Gadolinium is an FDA approved contrast agent that is well visualized with MRI and is used for certain exams, as indicated. Gadolinium DOES NOT contain Iodine.

CONTRAST ALLERGIES

Although Gadolinium DOES NOT contain Iodine, a patient with a severe Iodine allergy is twice as likely to be allergic to Gadolinium. If a patient has a history of a major reaction to Iodine, (respiratory or cardiovascular distress) they must be premedicated prior to receiving contrast. The type of premedication used is up to the discretion of the ordering physician. There is a *Contrast Allergy Premedication Order Form* available on the intranet.

To access Iodine Allergy Standing Order

1. Access the Sun Intranet
2. Select *Online Resources*
3. Scroll down... Under *Forms*, Select *Physician's Order Forms*
4. Select *Baptist Hospital of Miami*
5. Select *Imaging Department Orders*
6. Select *Contrast Allergy Pre-Medication Order Form (DO#540)*
7. Under medication order sheets, select *Contrast Allergy Premedication Order Form*
8. Print out the form and place it in the patient's chart for the ordering physician to fill out and sign.
9. **Call the MRI Department** to schedule a time for the exam so that you know when to medicate the patient.

NSF

A rare condition known as Nephrogenic Systemic Fibrosis (NSF) has been identified. It is a systemic disorder characterized by widespread tissue fibrosis. This condition is identified almost exclusively in patients with compromised kidney function who have had MRI scans with intravenous gadolinium contrast.

In accordance with the most recent American College of Radiology Contrast Committee recommendations, it is recommended that, prior to elective gadolinium based MR contrast agent administration; a recent (within the last six weeks) glomerular filtration rate assessment is reviewed for any patients with a history of any one of the following:

1. Renal disease (including solitary kidney, renal transplant, renal tumor).
2. Patient over 60 years of age.
3. History of hypertension.
4. History of Diabetes.
5. History of severe hepatic disease/liver transplant/pending liver transplant. For patients in this category only, it is recommended that the patient's GFR assessment be nearly contemporaneous (within the past three days) with the MR examination for which the gadolinium based MR contrast agent is to be administered.

Baptist Hospital radiologists require that **ALL** emergency room and hospital patients have a recent GFR prior to contrast administration.

YOUR PERSONAL SAFETY

MRI Systems do NOT use ionizing radiation (X-Rays)

To date, most studies into possible adverse effects have concluded that static magnetic fields, at field strengths used in clinical settings, produce no substantial harmful bioeffects.

Auditory Noise

Should you have to be in the MRI Scan Room during the scan, you will be exposed to the loud banging noises produced by the magnet. This noise can be loud enough to cause temporary hearing loss. Every person in the scan room during a scan is **required to wear hearing protection**. Disposable ear plugs or noise attenuated headphones will be provided.

Pregnancy

According to the safety guidelines, pregnant MRI technologists and healthcare workers are allowed to perform MRI procedures. The MR Technologist can enter the MR system room and attend to the patient during pregnancy, regardless of the trimester. However, it should be noted that pregnant technologists and healthcare workers should not remain within the MR system room or magnet bore during the actual operation of the scanner.

EMERGENCIES IN MRI

Metal Object in the Magnet

The most common emergency will be some metal object stuck in the magnet.

The usual scenario is that late at night, while working in the MRI Department, a metal object is inadvertently introduced into the MRI scan room. In the blink of an eye the metal object is jammed in the middle of the scanner.

WELL, WHAT WOULD YOU DO?

DO NOT DO ANYTHING!

DO NOT TRY TO FIX THE PROBLEM YOURSELF

Provided no-one is injured:

- Close the door
- Call the MRI Supervisor
- Call the MRI Engineer
- Wait for instructions

If there are injuries:

- Immediately notify the Radiologist in charge of Imaging Services
- Notify the MRI Supervisor
- Notify the MRI Engineer

MRI Contact Numbers are posted on the notice board in the Operators Room of both magnets. The name and phone number of the MRI Supervisor, the Manager and the MRI Engineer are listed.

MAGNET STOP or MAGNET QUENCH

This button very quickly dissipates the magnet field. (30 secs) However this button should never be used unless authorized by the Radiologist in charge of MRI. This is only used for life threatening emergencies - someone injured and pinned to the magnet. This is used only by MRI personnel and under the direction of the physician in charge of MRI.

If there are no injuries, you would never even think of quenching the magnet as it requires at least a week to get the system back up and running.

Fire

Regular fire extinguishers located throughout the hospital are **not** MR safe.

Outside each MR Room mounted on the wall is an MR Safe fire extinguisher. It is labeled "MR SAFE". These are the only extinguishers which are safe to be taken into the MRI Scan Room. In addition, the rooms are equipped with sprinkler systems.

IF YOU FORGET

If you enter the magnetic field with a ferromagnetic item, there are several ways to avoid injury:-

If the object is in your pocket, place your hand over the item and leave the scan room.

Remove the object, then re-enter the scan room.

If you are holding a large ferrous object that is being pulled toward the magnet, let go of it immediately. It is virtually impossible to stop the attraction of large objects.

If an object flies into the magnet opening, do not reach for it until it stops moving.

SUMMARY

MRI Safety is everyone's responsibility. Each and every time that you are about to enter the MRI Scan Room, pause for a couple of seconds and verify that you are "safe" to enter and that your equipment is "safe". Five seconds spent double checking could save someone's life.

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