Magnetic Resonance Imaging Safety

2.0 Contact Hours

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Magnetic Resonance Imaging Safety

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Objectives:

After completing this course, the student will be able to:

1. List four injuries that can, or have, occurred in the MRI scanning process.
2. Describe the four MRI safety zones.
3. Discuss four considerations that ensure scans are performed only on patients for whom the procedure is not contraindicated.
4. Name and discuss the levels of MR personnel

Introduction

Magnetic Resonance Imaging, or MRI, is a non-invasive painless test that takes pictures of various parts of the body without the use of x-rays. The MR scanner is a large cylinder-shaped tube with a very powerful magnet. A radio wave antenna is used to send signals to the body and then receive signals back. These signals are converted into detailed pictures of almost all internal body structures by a computer attached to the scanner.

An MRI scan helps physicians evaluate parts of the body in order to diagnose and treat medical conditions. The patient is given specific guidelines about what to do before an exam, but much of the time the patient can follow his or her daily routine with regard to medications, and eating or drinking. Depending on the type of MR exam, and the body part to be scanned, the patient may be required to ingest contrast material or receive an intravenous injection of contrast. The likelihood of contrast allergy is extremely small, as the contrast material used in MR scans – gadolinium - does not contain iodine and rarely causes an allergic reaction. Adverse effects have occurred more commonly in those patients who had previous reactions to MR contrast, and those with asthma. Before the scan, the technologist will take a brief patient history and ascertain what accessories must be removed from the patient, as certain metal and electronic objects cannot go into the scanning room.

MRI is considered safe for patients in general. Some patients with certain implants can't be scanned and the technologist will determine that during the pre-scan interview. However, there are certain dangers that are not well-known, and injury can occur during the scanning process.

The American College of Radiology (ACR) recommends that all clinical MR sites maintain MR safety policies and procedures that are reviewed and updated periodically, especially with any significant regulation changes in safety practices. In addition, MR technologists should be ARRT (American Registry of Radiologic Technologists)

registered, and trained as level 2 MR personnel. They should also maintain current certification in American Heart Association basic life support at the health care provider level.

On February 14, 2008, the Joint Commission (JC) issued a Sentinel Event Alert entitled, "*Preventing Accidents and Injuries in the MRI Suite.*" The alert states that although more than 10 million MRI scans are performed in the U.S. each year, injuries can, and have occurred during the scanning process. Some of those injuries include:

- Projectile injury – objects that have magnetic properties can be pulled into the scanner at an extremely high speed.
- Dislodged implants – those that have magnetic properties, such as aneurysm clips and joint pins.
- Burns – from objects that may heat during the scan, such as lead wires for implants and surgical staples.
- Equipment malfunction – pacemakers and implantable defibrillators not functioning as they were programmed.
- Failure to support the patient after sedation or anesthesia resulting in injury or complication – for instance if an oxygen pump is emptied and staff must leave the MR scan room for a replacement.
- Acoustic injury from the scanner noise.
- Injury related to contrast agents.
- Adverse events related to cryogen handling and storing.

Five MR-related cases have been reported to the Joint Commission that resulted in four deaths, affecting four adults and one child. An independent study by the ECRI Institute revealed 389 reports of MR-related events and nine deaths over a 10-year time span. Burns are the most common patient injuries. The ACR recommends that implantable cardioverter/defibrillators and cardiac pacemakers be considered a contraindication for MRI.

General Safety

To provide a safe environment for staff and personnel, the MR technologist should be the only person authorized to grant access and control the door to the scanner room. The door should be closed at all times except when a patient enters or exits the room. The technologist should direct the staff to ensure safety within the environment.

The MR technologist is also responsible for screening persons entering the magnet room according to facility policy and procedures. All persons entering the magnet room must be screened with no exceptions; and no one should be allowed access to the area until he or she is appropriately screened for items on their person or in their body, which may be hazardous to their safety and that of others.

Warning signs should be posted outside the magnet room to warn individuals of the magnetic field and the signs should indicate the presence of a high magnetic field to those with pacemakers and defibrillators.

Cautious handling of magnetic objects:

- Information on magnetic carriers, such as floppy disks, disks, tape and magnetic strips on credit cards will be erased by the magnetic field.
- Non-ferrous objects including jewelry, hairpins, prosthetics, can not be brought into the scan room. These metallic objects may disturb the radio frequency (RF) signal and reduce image quality.
- Oxygen tanks, IV poles, monitors, carts, tables, and procedure trays can not be brought into the scan room without potential for injury to patients and personnel.
- No one is to enter the scan room without screening and direction from the MR technologist.
- No iron or magnetic object will be brought into the scan room unless the magnetic field has been removed and the MR technologist has given permission to enter to scan room. Magnetic objects can cause serious injury to individuals within the room.
- Police or security personnel should not be permitted inside the scan room with firearms.

Screening of Patients

Screening is to ensure that scans are performed only on patients for whom the procedure is not contraindicated:

- Patients should be screened through the use of a MR questionnaire. This questionnaire identifies patients with implants, previous surgery, metal fragments from war, gunshots, or injury, pregnancy and sickle cell anemia, and chest tubes with an attached pleura-vac.
- When the patient is not capable of responding to the questionnaire, a family member must be contacted.
- When a family member can not be contacted, the technologists must review the patient's chart, use the metal detecting wand, check the patient for surgical scars, and/or request the radiologist to order x-rays for questionable sites.
- Patients will be instructed to remove mascara.
- X-ray procedures will be performed when additional screening is necessary to clarify questions related to possible metal fragments or implants.
- The technologist will re-verify the patient's answers to the MR questionnaire. The completed questionnaire will be forwarded to medical records for retention.
- The MR technologist, using the procedure described above, will determine the safety of the patient and other people entering the restricted magnetic field area or scan room. If the technologist has any concerns, the radiologist should be consulted.

- Medical conditions which may result in the patient's inability to successfully complete a procedure include: persistent tremor or movement disorder and inability to maintain a supine or prone position.

Contraindicated Implantable Devices

- Electrically, magnetically, or mechanically activated implants (pacemakers, neurostimulator or other biostimulation device).
- To determine whether a particular device is contraindicated the technologist should use *Reference Manual for Magnetic Resonance Safety, Implants, and Devices* (current edition should be maintained).
- Intracranial aneurysm clips are contraindicated unless the patient has a device card demonstrating that an MR-compatible clip was used.

MR-compatible Implantable Devices

- Certain devices can be safely scanned with high magnetic fields.
- Many implantable device manufacturers provide patients with MR-compatible device cards. If a patient produces the compatible device card, the patient may be scanned.
- When a device card in not provided, the technologist will refer to the *Reference Manual for Magnetic Resonance Safety, Implants, and Devices* (current edition should be maintained).
- In the event the technologist still has a question, a statement from the device manufacturer that the device is MR-compatible will be required before the patient will be scanned.

Equipment that should not be permitted in the Scan Room:

- I.V. pumps
- ventilators
- oxygen tanks
- unapproved stretchers or wheelchairs
- crash carts
- procedure tables
- regular patient monitoring equipment

Equipment Permitted in the Scan Room:

- When appropriate patients must be monitored with MR-compatible monitoring equipment, using recommended cables, leads, and following the safety protocol described in the monitoring device operator manual.
- MR-compatible stretchers, wheelchairs, and other patient care equipment. All should be approved by the MR technologist.

Female Patients

Patients 50 years and younger should be evaluated for pregnancy to minimize the risk of fetal exposure. Only after a negative result of a pregnancy test, should the procedure be performed for emergency room patients, unless delaying the procedure compromises the patient's condition. Outpatients should be questioned regarding the last menstrual period (LMP) and, if a concern exists, a pregnancy test should be performed. If a scan must be performed on a pregnant patient, maximum shielding must be used.

Noise

- During a scan, the machine makes a banging noise, which can become quite loud. The stronger the gradients used, the louder it may be - for instance, fast scan techniques.

- The patient should be instructed ahead of time that there will be a lot of noise. It can be very disconcerting if they are not expecting it.

- Even though the system standards are within FDA guidelines of acceptable noise levels, all patients should receive hearing protection. Medical Imaging departments should supply each patient with foam earplugs that will help in noise reduction. All patients should be encouraged to wear the plugs, even if the patient initially refuses.

Emergencies

In the event of an emergency related to the magnet and its mechanical operation, proper response will avoid further injury to patients and personnel who are in proximity to the magnetic field or its operation in the scanner room.

In a mechanical emergency:

- Care must be taken to ensure that no part of the patient's body, hair or clothing can be trapped or injured by any part of the equipment.
- In the event an item becomes lodged in the table top: press one of the emergency stop buttons - this will disable table movement.
- The tabletop can be moved manually and the article can be dislodged.
- If the MR operator visually or audibly detects a change in motor drive speed, excessive noise, or vibration, switch the system to the off position.

In a magnetic emergency:

- The magnet emergency stop button should be used:
    - When forces from the magnetic field are causing injury to personnel or patients.
    - When fire or other unexpected occurrence demands immediate action and entry to the examination room by emergency personnel.

In a fire:

- When smoke/fire or burning smells eminent from the magnet room the patient will be immediately removed, so that staff may further investigate.
- The patient will be walked out of the room, or the MR table will be disengaged from the gantry and removed from the room.
- Facilities personnel should be called to investigate.
- If fire is determined, follow the facility policy and provide the operator with location of fire.
- The MR technologist should be solely responsible for directing and screening all staff, including firefighter staff, in and around the magnet to ensure that no personnel enter the magnet room with ferrous equipment, or any implantable devices which would preclude their entry.
- The MR electrical power should be shut down by pressing the *Emergency Run Down* button.
- If needed, use only a non-magnetic fire extinguisher, which should be located in the MR control area.
- If the fire has not been extinguished once the MR-compatible extinguisher is exhausted, the magnetic field must be removed before further steps to extinguish the fire are taken.
- All staff must exit the magnet room and remain outside the closed scan room door.
- The magnetic field must be removed by pressing the “quench” button on the *Emergency Rundown Unit*.
- A quench pipe in installed in the system for the purpose of exhausting dangerous helium and nitrogen gases. However, the quench cycle poses it own dangers and staff must be outside the room in the event of failure to the quench pipe.
- Following a quench, even without fire to the MR, the MR service engineer must be contacted to evaluate damages and return the magnet to operating condition.

ACR recommends that all staff at any facility with an MR scanner should be required to have annual mandatory education in MR safety. There are levels of staff:

Non-MR Personnel

These are patients and visitors who do not meet the criteria of level 1 or level 2 MR personnel. Specifically, non-MR personnel should be the terminology used to refer to any

individual or group who has not within the previous 12 months undergone the designated formal training in MR safety issues defined by the MR safety director.
General hospital staff should also be considered non-MR personnel except that basic annual MRI safety training must be mandatory.

Level I MR Personnel

Individuals who have passed minimal safety education to ensure their own safety as they work in Zone III will be referred to as level 1 MR personnel. This will include department transportation. Level 1 personnel will not be responsible for screening individuals or taking patients into the MR suite Zone III without approval or direct supervision of MR Level II personnel.

Level II Personnel

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 or burns and direct neuromuscular excitation from rapidly changing gradients, will be referred to as level 2 MR personnel. These individuals include MR technologists, radiologists, and medical imaging nursing staff.

In addition, the ACR has established safety zones for safe screening and restricting access to the scanner:

ZONE 1 - This region includes all areas that are freely accessible to the general public. Typically, this zone is outside the MR environment itself, but the area in which everyone accesses the MR environment.

ZONE II – This area is between the publicly accessible uncontrolled Zone I and the strictly controlled ZONE III. Patients are not free to move throughout Zone II at will, but rather under the supervision of Medical Imaging staff. In Zone II, answers to screening questions and patient histories are obtained.

ZONE III - All access to Zone III is to be strictly restricted, with access to regions within it - including Zone IV - controlled by, and entirely under the supervision of, MR personnel.

ZONE IV – This area contains the MR magnet and its associated magnetic field. Non-MR personnel will be accompanied by or under visual supervision of level 2 MR personell for the entirety of their duration within Zone III or Zone IV. This zone should be clearly marked as being potentially hazardous due to the presence of very strong magnetic fields.

Level 1 and 2 MR personnel may move freely about all zones.

Many factors must be considered to ensure the facility is sufficiently and suitably prepared to handle MR emergencies.

Resources:

Kanal, E., et al., ACR Guidance Document for Safe MR Practices: 2007. *American Journal of Radiology*, 2007;188:1-27.

The Joint Commission, "Preventing Accidents and Injuries in the MRI Suite," Sentinel Event Alert, Issue 38, Feb. 14, 2008. Available: http://www.jointcommission.org/SentinelEvents/SentinelEventAlert/sea_38.htm