The Joint Commission

Sentinel Event Alert

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Preventing accidents and injuries in the MRI suite

Magnetic resonance imaging (MRI) was applied to health care in the late 1970s to provide never-before-seen two- and three-dimensional views of body tissue and structure. Today, more than 10 million MRI, or MR, scans are done in the United States each year. (1) While the capabilities of the MRI scanner are well-recognized, its inherent dangers may not be as well known. The following types of injury can and have occurred during the MRI scanning process:

1. "Missile effect" or "projectile" injury in which ferromagnetic objects (those having magnetic properties) such as ink pens, wheelchairs, and oxygen canisters are pulled into the MRI scanner at rapid velocity.
2. Injury related to dislodged ferromagnetic implants such as aneurysm clips, pins in joints, and drug infusion devices.
3. Burns from objects that may heat during the MRI process, such as wires (including lead wires for both implants and external devices) and surgical staples, or from the patient's body touching the inside walls (the bore) of the MRI scanner during the scan. (2)
4. Injury or complication related to equipment or device malfunction or failure caused by the magnetic field. For example, battery-powered devices (laryngoscopes, microinfusion pumps, monitors, etc.) can suddenly fail to operate; some programmable infusion pumps may perform erratically; (3) and pacemakers and implantable defibrillators may not behave as programmed.
5. Injury or complication due to failure to attend to patient support systems during the MRI. This is especially true for patient sedation or anesthesia in MRI arenas. For example, oxygen canisters or infusion pumps run out and staff must either leave the MRI area to retrieve a replacement or move the patient to an area where a replacement can be found.
6. Acoustic injury from the loud knocking noise that the MRI scanner makes.
7. Adverse events related to the administration of MRI contrast agents.
8. Adverse events related to cryogen handling, storage, or inadvertent release in superconducting MR imaging system sites.

Five MRI-related cases in the Joint Commission's Sentinel Event database resulted in four deaths and affected four adults and one child. One case was caused by a projectile; three were cardiac events, and one was a misread MRI scan that resulted in delayed treatment.

In 2005, Jason Launders, MSc, a medical physicist with the ECRI Institute, conducted an independent analysis of the FDA's MAUDE (Manufacturer and User Facility Device Experience Database) reporting database over a 10-year time span, which revealed 389 reports of MRI-related events, including nine deaths: three related to pacemaker failure; two to insulin pump failure; and the remaining four events related to implant disturbance, a projectile, and asphyxiation from a cryogenic mishap during installation of an MR imaging system. More than 70 percent of the 389 reports were burns; 10 percent were projectile-related; another 10 percent were "other events, including implant disturbance; 4 percent were acoustic injuries; 4 percent were fire-related; and 2 percent were internal heating-related.

The most common patient injuries in the MRI suite are burns and the most common objects to undergo significant heating are wires and leads. Other objects associated with burns are pulse oximeter sensors and cables, cardiorespiratory monitor cables, safety pins, metal clamps, drug delivery patches (which may contain metallic foil), and tattoos (which may contain iron oxide pigment). Less common injuries involve pacemakers. The American College of Radiology (2) recommends that implanted cardiac pacemakers and implantable cardioverter/defibrillators should be considered a relative contraindication for MRI. Any exception should be considered on a case-by-case basis and only if the site is staffed with individuals with the appropriate radiology and cardiology knowledge and expertise. (2)

While only one missile-effect case has been reported to the Joint Commission, they are more common than is generally recognized. Many people—including health care workers—are unaware that the magnets in the MRI scanner are always "on" and that turning them "off" (quenching) is an expensive and potentially dangerous undertaking, involving the controlled release of cryogenic gases that can be deadly if released into a contained area. As a result of the magnets, many of the objects pulled into the MRI scanner are cleaning equipment or tools taken into the MRI suite by housekeeping staff or maintenance workers.

Risk reduction strategies

Conventional metal detectors have been used to help identify metal objects in and on patients, but they are not 100 percent accurate and can give false-positives and false-negatives.(4) Furthermore, metal detectors cannot alert personnel to all objects that are subject to heating, malfunction or failure during an MRI scan. (5) However, the recent availability of ferromagnetic detectors may help in screening patients for objects left on their person, according to Dr. Emanuel Kanal, chair of the ACR's Magnetic Resonance Safety Committee. A recent study concludes that ferromagnetic detectors have 99 percent sensitivity. (6)

A report on projectile cylinder accidents in the American Journal of Radiology (7) recommends strategies to prevent missile-effect accidents, including implementing protocols that allow maintenance and housekeeping personnel to enter the MRI suite only after proper safety education and when no patient is in the suite. A number of preventive measures for hazards in the MRI-environment are recommended by Dr. Kanal (8) and are supported by the ECRI Institute (9), including:

- Appoint a safety officer who is responsible for implementing and enforcing safety procedures in the MRI suite.
- Implement systems to support safe MRI practice such as written protocols and checklists and periodically review, and assess compliance with your organization's MRI policies, procedures and protocols.
- In general, do not bring any device or equipment into the MRI environment unless it is proven to be MR Safe or MR Conditional. MR Safe items pose no known hazard in all MRI environments, and MR Conditional items have been demonstrated to pose no known hazards in a specified MRI environment with specified conditions of use. (10) The Safety of "MR conditional" items must be verified with the specific scanner and MR environment in which they will be used.

Joint Commission recommendations

The Joint Commission offers the following recommendations and strategies to health care organizations for reducing MRI accidents and injuries:

1. Restrict access to all MRI sites by implementing the four zone concept as defined in the ACR Guidance Document for Safe MR Practices: 2007. (2) The four zone concept provides for progressive restrictions in access to the MRI scanner:
   - Zone I: General public
   - Zone II: Unscreened MRI patients
   - Zone III: Screened MRI patients and personnel
   - Zone IV: Screened MRI patients under constant direct supervision of trained MR personnel
2. Use trained personnel to screen all non-emergent patients twice, providing two separate opportunities for them to answer questions about any metal objects they may have on them, any implanted devices, drug delivery patches, tattoos, and any electrically, magnetically, or mechanically activated devices they may have. If the patient is unconscious or unable to answer questions, question the patient's family member or surrogate decision maker. If this person is unsure, use other means to determine if the patient has implants or other devices that could be negatively affected by the MRI scan (e.g., look for scars or deformities, scrutinize the patient's history, use plain-film radiography, use ferromagnetic detectors to assist in the screening process, etc.). (2), (8)
3. Ensure that the MRI technologist has the patient's complete and accurate medical history to ensure that the patient can be safely scanned. All implants should be checked against product labeling or manufacturer literature specific to that implant, or peer-reviewed published data regarding the device or implant in question. Technologists should be provided with ready access to this information.
4. Have a specially trained staff person who is knowledgeable about the MRI environment accompany any patients, visitors and other staff who are not familiar with the MRI environment inside the MRI suite at all times. (2), (8)
5. Annually, provide all medical and ancillary staff who may be expected to accompany patients to the MRI suite with safety education about the MRI environment and provide all staff and patients and their families with appropriate materials (e.g., guidelines, brochure, poster) that explain the potential for accidents and adverse events in the MRI environment.
6. Take precautions to prevent patient burns during scanning, including:
   - Ensure that no items (such as leads) are formed into a loop, since magnetic induction can occur and cause burns. (4)
   - If the patient's body touches the bore of the MRI scanner, use non-conductive foam padding to insulate the patient's skin and tissues. (2)
   - Place a cold compress or ice pack on EKG leads, surgical staples, and tattoos that will be exposed to radiofrequency irradiation during the MR imaging process. (2)
7. Only use equipment (e.g., fire extinguishers, oxygen tanks, physiologic monitors, and aneurysm clips) that has been tested and approved for use during MRI scans. (2)
8. Proactively plan for managing critically ill patients who require physiologic monitoring and continuous infusion of life sustaining drugs while in the MRI suite.
9. Provide all MRI patients with hearing protection (i.e., ear plugs).
10. Never attempt to run a cardio-pulmonary arrest code or resuscitation within the MR magnet room itself.

Ferromagnetic Objects

buffing machines
chest tube stands
clipboards (patient charts)
gurneys
hairpins
hearing aids
identification badges
insulin pumps
keys
medical gas cylinders
mops
nail clippers and nail files
oxygen cylinders
pulse oximeters
pacemakers
pagers
paper clips
pens and pencils
IV poles
prosthetic limbs
shrapnel
sandbags (with metal filings)
steel shoes
stethoscopes
scissors
staples
tools
vacuum cleaners
watches
wheelchairs

References

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2 ACR Guidance Document for Safe MR Practices: 2007, AJR:188, June 2007, http://www.acr.org/SecondaryMainMenuCategories/quality_safety/MRSafety/safe_mr07.aspx

3 "Ensuring Safety for Infants Undergoing Magnetic Resonance Imaging," *Medscape*, http://www.medscape.com/viewarticle/499273

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7 “Projectile Cylinder Accidents Resulting from the Presence of Ferromagnetic Nitrous Oxide or Oxygen Tanks in the MR Suite,” AJR:177, July 2001

8 Emanuel Kanal MD, Magnetic Resonance Safe Practice Guidelines of the University of Pittsburgh Medical Center, 2001.

9 “Hazard Report: Patient Death Illustrates the Importance of Adhering to Safety Precautions in Magnetic Resonance Environments,” *Health Devices* (30) 8, August 2001, ECRI

10 American Society of Testing and Materials F 2503-05, *Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment*

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For additional MRI Safety Resources, visit the Joint Commission Resources website.