Ferromagnetic Detectors: The Challenges Associated with Providing Improved Patient Safety in MRI

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Summary

Purpose:

The American College of Radiology, in a 2007 guidance document for safe MR practices, recommended a standardized approach for protecting patients, accompanying family members and health-care professionals from the many MRI associated hazards. Our institution has actively implemented the recommendations of the ACR, but despite posted safety procedures, access control and employee and staff education, incidents or near-incidents still occurred. The conclusion was made that even best-intentioned and most-careful employees might still enter the scan room with ferrous objects while busily performing their duties. The 2008 Joint Commission sentinel-event alert suggests using ferromagnetic (FM) detectors as a tool to help mitigate ferrous objects being unintentionally brought into the MR scan-room. While the improved safety offered by FM detectors is appealing, many unforeseen challenges are associated with their implementation.

Methods:

With the intention of providing an additional check for individuals and equipment entering the MR scan-room, we installed Kopp FerrAlert® Entry FM detectors at the entrance of each of the scan rooms in our MRI department. The FM detectors were wall-mounted, directly outside the entrance doors to three 1.5 tesla MRI systems. A fourth detector was mounted, per manufacturer suggestion, approximately 6 feet from the entrance of a 3.0 tesla MRI system with an outward-opening door due to possible interference issues between the door and the detector.

Results:

Effective use of FM detectors in a MRI department providing 24/7 services to inpatients, outpatients and trauma patients is no easy task. Most of the difficulties encountered fall into two subgroups: false alarms and staff compliance issues.

False alarms take a significant amount of time to resolve. Our two largest sources of false alarms were from MRI conditional equipment and movement of the MRI scan-room door. By definition, MRI conditional objects contain some amount of conducting, metallic material and some may even contain ferrous materials. Detachable MRI scanner beds, MRI conditional stretchers, wheel chairs, infusion pumps, anesthesia machines, biopsy devices and ablative therapy equipment are all examples which, in all likelihood, will activate any FM detector. To our knowledge, no method is available to prevent these devices from setting off the alarm; therefore, additional checks are required when these using these items. It is critical that MRI conditional equipment is checked for loose ferromagnetic objects--for example, a pair of scissors left on an MRI conditional anesthesia machine would not be detected by the FM detectors since a false alarm would be anticipated. MRI staff must be aware that FM detectors may be rendered useless by most MRI conditional equipment.

False alarms caused by the scan-room door are challenging to eradicate. Ferromagnetic door hardware can result in a false alarm every time the door is opened, even with a 12" gap between the door and FM detector. Modern doors with non-ferromagnetic hardware may still set off the detector due to slight vibrations moving through the wall to the door-mounted FM detector when the door is opened or shut. Vibrations cause the FM detector to move ever so slightly with respect to the earth's magnetic field which can result in a false-alarm. From our experience, false alarms of this type can be removed by installing door switches which do not activate the FM detector until the door is fully opened or, if this is unavailable, mounting the FM detector directly to the floor a small distance from the wall can isolate vibrations and increase the distance between the detector and ferrous door hardware, mitigating this source of false alarms.

The final difficulty is staff compliance. Staff members entering the scan room must not wear clothing which activates the FM detectors or potentially dangerous objects brought into the scan room will not be detected since an alarm would be anticipated. The principle offenders at our institution were underwire bras and metal arch-supports in shoes. Neither item poses a danger in the MRI environment, but they do prevent the FM detectors from detecting objects which may be dangerous. Instituting a house-wide policy requiring those who work in MRI to dress free of ferromagnetic materials is an essential part of the proper use of FM detectors.

Conclusion:

Ferromagnetic detectors are a useful tool for providing increased safety in the MRI environment; however, a significant amount of time and effort is required by technical personnel to eliminate sources of false alarms combined with strong management efforts to implement staff protocol and dress-code compliance.

Goal:

Elimination of false alarms is the most critical aspect of successful implementation of ferromagnetic (FM) detectors in MRI. If FM detectors continually produce false alarms, they will be ignored by staff and will not be a useful safety improvement. False alarms can generally be broken down into two categories, preventable false alarms and non-preventable false alarms.

Preventable False Alarms: Location of the FM Detectors

I. False alarms triggered by vibration of the detector:

Any slight vibration of the detector may cause a false alarm due to movement with respect to the earth's magnetic field. If the detector is mounted directly to a wall and is not freestanding, vibrations from closing the scan room door may cause false alarms.

II. False alarms triggered by movement of ferromagnetic objects near the detector:

I. Ferrous hardware in scan room door will likely create false alarms. Ferrous door handles, deadbolts or trim can all be problematic.

II. Magnetized door switches are supplied by some MRI vendors and allow the scanner console to determine if the scan room door is opened or closed. Magnetized switches can result in a false alarm when the door is opened or closed.

III. Nearby storage cabinets with ferrous hinges, doors or door hardware can cause false alarms when the cabinet doors are opened or closed.

IV. Other moving doors or objects which are close to the detector can cause false alarms.

Solutions:

I. If detectors cannot be secured to a rigid wall (i,e., cinder block or brick) they should be free standing and bolted directly to the floor, isolating them from the source of the vibration (the closing scan room door). We have found that the top can still be secured to the wall as long as the detectors aren't directly mounted. **See Figure 1**.

II. While magnetized door switched can easily be replaced by mechanical ones, eliminating ferrous hardware can pose more of a challenge. Often, RF shielding manufacturers are unable to retro-fit older doors with non-ferrous hardware or simply don't offer a compatible solution. If the door cannot be replaced or retrofitted, the most robust solution is to move the detector away from the door, as shown in **Figures 1 and 2**. The distance required depends on the amount of ferrous material in the door. In most cases, one foot is sufficient and does not interfere with patient and staff movement in Zone 3 (**Figure 1**). Devices which deactivate the detectors when staff is not near them such as ultrasonic sensors , door switches or optical sensors are not useful for eliminating this type of false-alarm.

II. Devices which deactivate the detectors when staff are not near them is the best solution for false alarms coming from exterior movement of ferrous objects which are not passing through the detector. In our experience, ultrasonic sensors were not useful, because they activated the detectors when staff approached, even if they did not pass through. Door switches and optical sensors kept the detectors off unless a staff member physically entered the device and eliminated the majority of these false alarms (**Figure 3**). **Figure 4** shows the optical sensor available from one manufacturer.

Figure 1. Ferromagnetic detector offset from wall.

Figure 2. Another example of a detector offset from the wall.

Figure 3. Door switch which only activated the detector when the MRI door was open.

Figure 4. Arrow points at the optical sensor located at the base of the detector.

Preventable False Alarms: Dress Code Compliance

Enforcing staff dress code compliance is a challenging issue for management. However, if any garment worn by a staff member sets off the FM detectors, even if the ferromagnetic material in that garment does not pose a safety hazard, wearing of the garment renders the FM detectors ineffective. This is a difficult concept for some staff members to grasp since they may have been wearing these garments safely in MRI for years—however, if the detector alarms every time they pass through it will be useless at identifying potentially dangerous objects.

Common items which may set off the FM detectors:

I. Dress shoes and some sneakers that contain steel supports
II. All underwire bras
III. Lab coats and scrub jackets with metallic snaps
IV. Some glasses
V. Badge and ID card clips

Some of the above items may become a sensitive issue with staff members, however, for FM detectors to be a useful safety addition the policy must be:

"If the alarm sounds, you do not enter the scan room".

Staff members must dress appropriately for the safety culture you wish to promote at your institution.

Figure 5. Reproduced with the permission of GE

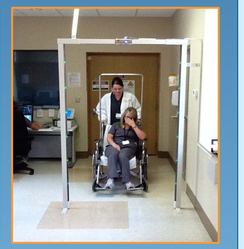

Figure 6. MRI conditional wheelchair, which could mask detection of potential small dangerous metallic items

Non-Preventable False Alarms: MRI Conditional Equipment

MRI conditional equipment may contain small amounts of ferromagnetic material or simply enough conducting material to set off FM detectors. Certainly, large items such as wheel chairs, stretchers (**Figure 5**), anesthesia machines, etc will set off almost any FM detector. In cases where equipment that is known to set off the FM detector is brought into the scan room, extra care must be taken.

Suggested protocol:

I. Check for loose ferromagnetic objects. If the MRI conditional item is large, such as a wheelchair or anesthesia machine, potentially dangerous ferrous items may be on or stored in the item and will not be identified by the FM detectors.
   I. Loose objects can be identified visually
   II. If handheld FM detectors are available, they should be used to help sweep for potentially dangerous objects
   III. If the MRI conditional item is a wheelchair or stretcher, a handheld FM detector should be used to check the patient for loose objects if they are not ambulatory. (**Figure 6**) If the patient is ambulatory, they should walk through the FM detector as a precautionary measure
II. Staff should walk through the FM detector without the MRI conditional equipment to first ensure that they are safe before bringing the equipment into the scan room.