PSNet
PATIENT SAFETY NETWORK

The Magnetic Deflection

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The Case

A 68-year-old woman with a prior history of cerebrovascular accident and hypertension presented to the hospital with new left-sided weakness and hypertensive urgency. The duration of her symptoms was unclear, and she was not a candidate for thrombolytic therapy. She was admitted to the stroke unit and received aggressive treatment to control her blood pressure. A neurologist was consulted and ordered an urgent magnetic resonance image (MRI) of the brain.

The MRI staff informed the bedside nurse that the patient could be brought down for the study. At that time, the patient's blood pressure was still elevated, requiring pushes of intravenous antihypertensives. Nevertheless, the physician told the nurse that the study was urgent and the patient should be taken down for it.

After the patient was brought to the radiology department, she was identified and situated inside the MRI machine. The technician left the room and went back to his work station. The nurse decided to check the patient's blood pressure one more time before leaving her and found that it was improving. Reassured, she also left the room but forgot to notify the MRI technician that the blood pressure cuff was still attached to the patient.

Within a few seconds after starting the scan, there was a loud noise in the MRI room and the technician stopped the scan immediately. He entered the room and realized that the blood pressure cuff had a metal bar (around which the Velcro looped) that had been brought into the magnetic fields of the MRI scanner, which caused it (and the patient's arm) to be drawn to the MRI scanner wall with considerable force. The technician removed the offending piece of equipment and the scan was completed without further incident; luckily, the patient was not injured.

The Commentary

by Emanuel Kanal, MD

Various energies are used to generate magnetic resonance images (MRIs), but the most notorious of them all is the powerful magnetic field that is used in the MRI process.(1-4) The magnetic fields found in and around MRI scanners are far more powerful than those typically encountered in our normal day-to-day activities—in fact, they are typically tens of thousands of times stronger than the earth's magnetic field. Not only are they strong enough to pull ferromagnetic objects toward the scanner, but the forces increase when moving even a few centimeters closer to the MRI scanner. This powerful attractive force can result in injury to a patient or health care worker from any of various mechanisms. These include, among others:

i. Direct trauma from the accelerating ferromagnetic object striking the patient or health care worker once the object is exposed to the MRI-associated magnetic fields.
ii. Tearing of and/or damage to vascular, neurological, or other delicate tissues; organs; or structures from motion of an embedded ferromagnetic object, device, implant, or foreign body exposed to the MRI scanner magnetic fields. Note that these might be implanted within the patient or within health care workers.
iii. Incapacitation or modification of the function of an active implanted device upon whose normal operation and function the patient may be dependent.

We are used to the idea of lead "shielding" to prevent X-rays from reaching the shielded parts of a patient or health care worker, etc. But for all intents and purposes, the entire patient will be exposed to the powerful magnetic fields of the MRI scanner—as will family members and health care personnel who may accompany the patient into the room in which the MRI scanner is sited. To make matters worse, these strong magnetic fields associated with these MRI scanners are entirely invisible, so there is potential for serious harm with every MRI unless robust systems are in place and staff remain extremely vigilant.(5)

To continue the X-ray analogy, we are used to the potentially harmful energy of regular X-rays only being "on" during imaging; the X-rays are not produced while the machine is at rest. This is not the case for MRI scanners. At all times, 24 hours a day, the powerful magnetic field of the MRI scanner is present and at full force, even when the machine is not being actively used for imaging, there is no patient in the scanner, or the room is sealed off at night and no staff are present.

This relatively unusual status—a powerful and potentially harmful invisible force being present associated with a diagnostic imaging tool that may be entirely unoccupied and not used at the time—has been the cause of innumerable incidents and accidents in and around MRI scanners ever since the field was first introduced into the medical diagnostic imaging armamentarium in the early 1980s. To this day, injuries continue to occur in MRI scanners around the globe from ferromagnetic objects being inadvertently brought into MRI scanning environments by those who are unfamiliar with this imaging modality—at times with serious, and even fatal, consequences.(6-10)

The only way to avoid such events and injuries is to redouble our efforts to always be aware of the constant nature of this powerful force and to prospectively screen all who approach the MRI scanner to ensure that no ferromagnetic objects are on or in them or are being inadvertently introduced into the MRI environment. Typically the patient completes a pre-MRI screening questionnaire that helps clarify if the patient has any object on or in them that may be dangerous in MRI environments. The MRI technologist then reviews these responses and gathers further information if/as indicated. Today ferromagnetic detectors also have been

developed that can specifically scan and screen for the presence of the types of metals that would be attracted to such powerful magnetic fields. These ferromagnetic detectors are increasingly being used in diagnostic MRI installations throughout the world today to assist in the MRI prescreening process before permitting anyone access to the room in which the MRI scanner is sited.

Perhaps most importantly, in November 2016 the Journal of Magnetic Resonance (11) published a consensus of eight different international MRI organizations and societies that defines the organizational structure of those who are to oversee safety in all clinical or research MRI sites and calls for the creation of three positions: a magnetic resonance medical director, a magnetic resonance safety officer, and a magnetic resonance safety expert. Together these oversee all aspects of safety relating to the MRI center, personnel, and scanning. In a nutshell, the magnetic resonance medical director is responsible for all safety issues of the MRI site, the magnetic resonance safety officer oversees the execution of the directives of the magnetic resonance medical director, and the magnetic resonance safety expert is available to assist and educate the others in MRI safety–related issues and questions that might require such levels of expertise.

The MRI technologist is typically charged with executing the directives of the magnetic resonance medical director and thus ensuring safety in the MRI environment. Technologists may stop patients or clinicians prior to their entering the MRI room and insist on prescreening before anyone is granted access to the MRI room. Essentially functioning as a "red rule," similar to how operating room nurses ensure that all are properly attired prior to entering the surgical suites, the MRI technologist is thus the front—and often the last—line of MRI safety, protecting all who enter the MRI arena. To the clinician the message is simple: Even though it is your patient in that MRI scanner, be sure to cooperate with this prescreening process. Remember, this prescreening not only protects the patient, but the life you help save may be your own.

Take-Home Points

- All MRI scanners utilize a powerful magnetic field in the magnetic resonance imaging process.
- This powerful magnetic field is *ALWAYS ON*, whether a patient is in the scanner or not, whether the MRI scanner is being used for imaging at the time or not, whether the MRI suite is even occupied or not, and even if there is a power outage. The safety hazard therefore is always present whether or not a scan is being performed, unlike other types of imaging technology.
- The magnetic field of the MRI scanner is sufficiently strong to create significant safety hazards for anyone in the vicinity if a ferromagnetic object is inadvertently brought into the room in which the MRI scanner is housed. Even if that object is inside the patient or health care worker, the magnetic field will interact with it and there is a potential for harm to the exposed individual.
- For the safety of patients and any attendant health care workers, it is critically important to cooperate with the MRI technologist's prescreening process prior to accessing the room in which the MRI scanner is housed.

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