BS"D

Planning an MR Suite: What Can Be Done To Ensure MR Safety?

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Who will benefit from the information presented in this lecture?
MR site administrators, Radiologists, Technologists, MR site architects/designers, and all who are interested in prospectively designing for safety in MR site planning.

How was a problem determined?
Historical review of hundreds of MR safety incidents and accidents.

Examples of how this issue has been addressed:
Signage, physical restriction to inadvertent MR site access, prospective siting of non-ferrous fire extinguishers, nonferrous oxygen cylinders, installation of resuscitative gases and suction in sites prospectively identified to manage emergencies in the MR arena.

What will attendees be able to do differently because of this information?
Anticipate some of the more common causes of accidents and incidents in magnetic resonance sites and incorporate into their MR site designs and plans steps to mitigate these risks.

In the process of creating the American College of Radiology's Guidance Document for MR Safe Practices (starting with its earliest version in 2002; it has since been updated in 2004, 2007, and most recently in 2013), a retrospective review was performed of hundreds of adverse events, incidents, and accidents that had transpired in magnetic resonance sites across the globe. The intent was to investigate whether there were common grounds underlying these incidents, and whether such a root cause analysis could uncover a "weak link", as it were, that, were it to be identified and corrected, could help prevent such MR safety incidents from recurring.

In fact, two such "weak links" were not only identified, but were found to be connected with in excess of 90% of all reported MR safety incidents studied at that time. The two common factors that seemed to accompany the vast majority of MR safety accidents and incidents were:

1) Insufficient MR site access restriction on the part of those uninitiated in the potential hazards of the MR imaging environment.

2) Insufficient knowledge and education regarding MR safety concerns (and how to diminish them) on the part of those charged with supervising and running clinical and research MR installations.

It rapidly became clear that if we, as an industry, could successfully address these two major perceived deficiencies in our installed base of magnetic resonance scanners and sites, we could decrease the incidence of the vast majority of MR safety accidents and adverse events being reported to the various watchdog databases each year.

Addressing the MR safety knowledge and education of all MR practitioners is beyond the scope of this presentation. However, adequate MR site access restriction is indeed one of the main focal points of this lecture.

Before we address *how* adequate site access restriction can be accomplished, it is important to understand *why* it is indicated. After all, there are many objects that are dangerous or potentially dangerous. For example, everyone recognizes the potential danger of a raging fire – and people ensure that they take whatever steps are required to ensure that they do not get too close. Why, then, is there a need to restrict access to the magnetic resonance environment?

The answer is actually quite straightforward. As noted above, the dangers inherent in a raging fire are obvious to all. We see it, hear it, feel it – the response is automatic. In contrast, the powerful static and time varying magnetic fields of the magnetic resonance environment are, essentially, invisible and undetectable. They cannot be seen, touched, felt, smelled, heard – in fact, one may not even know that a powerful static magnetic field may be present, even if one is standing in the middle of such a field. Further, for at least the static magnetic field components of the MR scanner, the forces exerted by the magnetic field increase with very roughly the third power of the distance from the field. In other words, with relatively small amounts of motion towards the MR imaging system there can be massive increases in the attractive and rotational forces exerted by that magnetic field on ferromagnetic objects. This is especially true for magnetically shielded systems and for higher field, stronger magnetic resonant scanners. Thus, the effects and impact of a strong magnetic field on a ferrous object inadvertently brought into the MR imaging environment may not be detected until it is too late to correct it, or to reverse the steps that had been taken and remove the offending objet from the field. By the time that the anesthesiologist was aware that the oxygen tank was overtly ferromagnetic and was being strongly attracted to the MR imaging magnet in which 6 year old Michael Columbini was positioned, it was far too late to try to stop the ferrous oxygen cylinder from flying into the magnet bore – with fatal results.

Therefore, if one is not able to directly detect these strong magnetic fields, efforts should be made to restrict accidental access to these fields by a) those unfamiliar with them and the forces associated with them, and b) ferromagnetic objects that do not need to be in the vicinity of the MR imaging environment.

How does one restrict access to the MR scanner while at the same time enable it to be freely used for patient care?

To answer this question we looked to our colleagues in nuclear medicine. Once again we find a potentially dangerous power source – radioactivity - that cannot be directly detected or sensed, yet inadvertent exposure can have disastrous results. Over the decades our society has ensured that several safety practices are in place associated with any and all radioactive sources. The presence of signage that is a) readily recognized and universally understood warning of the existence of powerful magnetic fields, and b) positioned where it will be seen by all approaching this environment in time for them to respond accordingly. This includes floor mats and/or lighted signs for fire response teams.

However, by far the most reliable way to ensure that the lay public does not inadvertently become exposed to ionizing radiation is by ensuring that they cannot accidentally find themselves in an environment where they can be exposed to the radioactive material and its forces in the first place. Physical site access restriction remains by far the key element in successfully preventing accidental exposure to undetectable dangerous energy sources.

To this end, the American College of Radiology MR Safety Committee created what it defined as four Zones around the MR imaging magnet and its associated magnetic fields. While Zones 1 and 2 are essentially organizational in nature, Zones 3 and finally Zone 4 (the latter representing the confines of the room itself in which the MR scanner is found) are accompanied by physical restriction to inadvertent access. Even the type of physical restriction should receive some attention on the part of those implementing such restrictions. Clearly a thin plastic chain on a movable pedestal is, for all practical purposes, not a barrier at all. Further, combination locks in hospital settings notoriously find their combinations readily transferred from person to person – including to those who might not be aware of the potential dangers that lie on the other side of that locked door. Thus, the usage of combination locks is not recommended, but rather true physical restrictions that would serve to prevent inadvertent access of the “magnetically uninformed” to the potentially dangerous environment of the MR imaging system.

In addition to site access restriction, safety in MR site installations can be designed into the site layout. For example, in case of emergency such as a patient arrest during scanning, locations outside of the MR scan room itself in which one can run a code/arrest/emergency or at least in which the patient can be managed until help arrives can be prospectively designated. If the intent is to run full resuscitative codes in this location, it should also ideally have all required gases, suction, etc. already in place with sufficient access to first responders and those handling and manning the emergency.

Another way in which the site layout can increase safety for the MR arena is to ensure that ferromagnetic screening devices are situated in locations that provide for site throughput while at the same time provide sufficient warning that if potential offending materials and objects are discovered they can be safely removed before they present a potential hazard to the patient, research subject, or health care worker.

Additionally, by prospectively positioning MR conditional fire extinguishing equipment (appropriate for electrical as well as paper types of fire) in planned convenient locations around the MR installation, rapid response with safe equipment is potentiated. A similar approach should be taken to ensure that nonferrous oxygen cylinders are readily available to be brought in to Zone 4 regions if/as needed. This will prevent the inevitable search for oxygen when it might be urgently needed, and hopefully preclude the mistake of finding and introducing ferrous cylinders into Zone 4 regions.

By prospectively planning site access restriction as well as efficient site signage and equipment layout, it is possible to markedly increase the safety of all who practice in and around the powerful magnetic fields intrinsic to all MR imaging installations.