MRSO Exam Prep Course

Module 13

Implant Safety Considerations

As technology, experience, and education increase in the medical industry, so do we see the increase in medical implants in patients. Implants are classified by MRI into two types: passive implants and active implants. There are no electrical components in passive implants. Screws, joint replacement, staples, and sternal wires are examples of passive implants. Active implants may cause interference with the scanner and artifacts in our picture. The MR unit may potentially induce implant failure. An electrical component circuit in active implants might interfere with your MRI.

Patients may also have foreign bodies or unknown shards of metallic components put into them, either purposefully or accidentally. These can include shrapnel, bullets, and other projectiles. These sorts of implants can endanger a patient. As a result, it's critical to understand what we're working with before scanning our patients.

Body expression is another sort of hazard to the MR environment. These include jewelry, tattoos, and so on.

To determine if an implant or foreign body poses a risk to the MR environment, we must first establish where these dangers originate, where they are positioned, where they will be after the acquisition, and whether we can acquire manufacturer instructions. We can make educated judgments about the danger of an MR operation on our patients by understanding the regions of MRI that potentially affect them.

Patients with ferromagnetic and/or electrically conductive implants or foreign substances are at risk from the static magnetic field. We should know by now that the static magnetic field poses a translational and rotational force threat to ferromagnetic materials that enter the MR environment. This is due to the magnetic spatial gradient. This approach explains the magnetic flux line concentrations in the vicinity of our MR device. The amount of magnetic force applied to an item may be calculated using flux line densities and the position of ferrous objects in the MR environment. The maximum spatial gradient specifies the entire force that an item will exert on the MR unit. This takes into account the MR unit's field strength. As they pass over the magnetic spatial gradient, electrically conductive objects can produce current within them. This can result in opposing magnetic fields, as stated by Lenz's law.

During the MR scan, our patient is additionally at risk from the time-varying radiofrequency magnetic field. During radiofrequency transmission, the time-varying radiofrequency system will deposit energy into our patient. This might cause electrical fields to form on implants or items, potentially burning our patients. Wire loops can also generate electrical fields that might injure our patients. Electrical fields in an implant or foreign body might concentrate at sharp edges or corners. These become places where heat may be generated.

Section 13.1 Body Expression

Individuals can express themselves in a variety of ways, including via the use of jewelry, dermal anchors, and tattoos. Each of these can provide difficulties for an MRI technician. It is critical to recognize the dangers and challenges connected with these implants in order to adjust for them.

13.1.1 Jewelry

First, we'll go through any static magnetic field dangers related to jewelry. This is determined by the material's magnetic susceptibility. In the presence of a magnetic spatial gradient, ferrous objects can translate or rotate. This may or may not pose a concern to our patients, but having these things removed is an excellent practice. Artifacts have the greatest influence on picture quality depending on where the patient's jewelry is located. It is not unusual to observe an artifact in our image if the jewelry is in the field of vision. When executing sequences that are very vulnerable to field homogeneity, jewelry outside of our field of view can also have an impact on image quality.

Magnetic fields that change over time can also have an effect on jewelry. Some jewelry can become heated as a result of radiofrequency radiation. This is determined by the material's conductivity, the size of the jewelry, and its placement inside the radiofrequency field. To reduce contact with the skin, some institutions wrap unremovable jewelry with tape. The idea is that doing so will reduce the likelihood of burns occurring.

The gradient fields also show patient concerns. This concern, for the most part, will not hurt our patients, but it may create discomfort. Lorentz force can arise as a result of shifting magnetic fields, creating vibrations inside certain jewelry that is oriented in the presence of time-varying gradient fields. Overall, it is best practice to remove jewelry from patients whenever feasible, and if this is not possible, to limit contact between the jewelry and the patient's skin.

13.1.2 Dermal Anchors

Dermal anchors are becoming increasingly popular. Because these items are fixed within a patient's tissue, the static magnetic field presents no risk to them. However, these implants should be explored further for ferromagnetic components. Nonferrous materials are used in the majority of dermal anchors and piercings. Artifacts, like other types of jewelry, might be present in our image and diminish the quality of our image.

The magnetic fields that change over time are remarkably similar to those mentioned with jewelry. Because of the small size of each individual dermal anchor, the RF field provides only a little heating risk to our patient. These are usually modest and do not generate enough electrical fields to cause a burn.

The time-varying gradient fields can also generate vibrations in our patient's external implants, causing pain. Throughout the test, the patient should be talked with, and if the concern of a burn persists, a heat sink, such as an icepack, can be utilized on top of the dermal implant to lessen the risk of a burn.

Section 13.2 Passive Implants

Passive implants are those that do not contain any electrical components. Dental work, breast implants, tissue expanders, ocular implants, wires/leads/sutures, IUDs, staples, status and filters, foil-backed medicine patches, screws, and foreign bodies are all examples of passive implants.

13.2.1 Dental Implant

Many of our patients have dental treatment that includes everything from braces and fillings to bridges and dentures. Magnetic components may be found in some dental implants. Due to the fact that many dental implants are ferrous, the static magnetic field may interact with them. These implants are usually secured and will not move throughout the MRI scan. However, we can observe extensive dental work evidence. These should be considered while assessing image quality. Because of the size and placement of dental implants, heating concerns from time-varying RF fields are negligible. Our patient will not be harmed by the time-varying gradient fields. Overall, dental implants that do not contain magnetic components pose a little risk during an MRI treatment.

13.2.2 Breast Implants

Breast implants are comprised of saline or silicone and are wrapped in a plastic shell. They will not represent a hazard to the static magnetic field, time-variable magnetic field, or generate any artifacts in our image because they do not include any magnetic, electrically conductive, or metallic components.

Tissue Expanders

Tissue expanders are used to prepare a patient's tissue for a breast implant. These implants may incorporate metallic or magnetic components. These implants should be inspected for any ferrous components that might endanger our patients. The static magnetic field has the potential to interact with the magnetically activated components included in many of the tissue expanders used in patients, causing the implant to migrate. Another difficulty with tissue expanders is that they might cause big artifacts in the breast region. The dangers connected with the time-varying magnetic field, which includes the radiofrequency transmitter and the gradient fields, will not offer a significant risk to the patient who is wearing tissue expanders. We could see a big artifact that interferes with image quality.

13.2.3 Ocular Implants

Lens implants and devices are examples of ocular implants. Lens implants with no metallic elements represent no risk in the MRI setting. Ferrous components may be found in implants such as retinal tacks and eyelid springs. This might interact with the static magnetic field and potentially injure our patients. There have never been any reports of their causing damage to a patient receiving an MRI test.

Contact lenses are mostly made of plastic. Contact lenses containing iron oxide or other metals that are used to modify a patient's eye color may cause injury during an MRI test. It is advised that they be removed before their test.

When it comes to glaucoma drainage implants, the majority of them are made of nonmetal materials and are safe for MRI inspection. There is one that is made of nonferrous 316 L stainless steel. However, while inspecting the optic nerve, this implant may generate artifacts.

The scleral buckle is another ocular implant that should be explored. This is used to heal retinal separation by wrapping the material around the eyeball like a ring. These are typically formed of nonmetallic clips, however, Tantalum clips have been utilized. These are nonferrous metals that are suitable for MRI operations.

13.2.4 Wires/Leads/Sutures

In MRI, many types of cables and leads are employed. Generally, any linear item larger than 2 cm in length can cause some level of warmth. Heating peaks as we approach the half wavelength size of this implant. Leads can be discovered in the chests of patients who have had cardiac surgeries, near the bone for bone growth stimulators, or in the brains of patients who have had neurological treatments. If this becomes a threat to the patient, the length, orientation, size, placement, position, and substance all play a part. When dealing with cables or leads, the static magnetic field is usually unimportant.

The time-varying magnetic field may raise concerns about our patient's safety if he or she has cables or leads. Gradient fields with variable duration can create an electrical current and activate tissues at the ends of any leads. If the stimulation interferes with the cardiac, neurological, or respiratory systems, our patient may suffer injury.

The time-varying radiofrequency fields provide the greatest danger. This can generate a lot of heat at the ends of any leads or cables.

It is quite difficult to discover a suture with ferromagnetic characteristics when discussing sutures. Nonetheless, this impact is minor and has not been demonstrated to damage patients. Sutures are thus not contraindicated for scanning at 1.5 or 3 Tesla.

In the MRI setting, guidewires have been found to cause problems. This risk, like that of other lines, is related to time-varying radiofrequency fields. These have been demonstrated to generate high heat in the MR environment and should be risk-assessed.

13.2.5 Staples

Following surgery, staples are utilized as a closure device. Staples are generally little bits of nonferrous metal. This indicates that patients with staples should be safe from the static magnetic field. However, they should be checked before scanning, and if any ferrous material is detected, a compress can be used to keep the staples in place.

Because of their tiny size, staples represents no thermal danger when characterizing risks generated by a time-varying RF system. This may alter when many staples come into contact, generating a single electrically conducting item. In this case, this might constitute a heat hazard. However, this may be prevented by utilizing a heat sink. The time-varying gradient field presented no harm to staples.

13.2.6 Stents/Filters

Stents are utilized to open up vessels throughout the body. When put in a static magnetic field, they often include metallic material and can exhibit some deflection. When compared to the strain imposed on a stent by the beating of the heart, the danger associated with cardiac stents, for example, is negligible. This suggests that cardiac stents represent no risk to our patients in terms of the static magnetic field. Because of the modest size of the implant, a single heart stent provides no thermal danger to our patient. Multiple stents overlapping are regarded to provide a major heating risk in our patients. Yet, no reports have been found to support this notion. New evidence suggests that as long as a patient with a heart stent is scanned in normal mode, an MRI at any field strength is not contraindicated. Stents in other parts of our patient's body may be a different scenario. On the safety of any stent placed outside the heart, the manufacturer should be consulted. Some stents have not been evaluated and would be considered MR dangerous.

We must also consider radiofrequency fields that change over time. Because of the greater size of the implants, many of these metal-containing stents may cause warmth. The manufacturer's advice should be followed.

Filters are used to keep blood clots from entering the lungs. A filter is commonly placed in the inferior vena cava, which is located under the kidneys. Some manufacturers recommend waiting 6 to 8 weeks before inserting any stents or filters. This is because scar tissue is supposed to go around the implant and retain it in place. This guideline is not required for all stents, and any stent made of nonferrous materials would not require this time. Manufacturers should be informed regarding any suggestions regarding time-varying magnetic fields and magnetic spatial gradient restrictions.

13.2.7 Foil Backed Medication Patches

The foil-backed medicine patch's function is to provide medication to a patient via their skin. In terms of the static magnetic field, the foil-backed pharmaceutical patch poses no risk to the patient. However, radiofrequency heating might occur in the patch's foil. As a result, they should be removed before subjecting a patient to an MRI exam.

13.2.8 Copper 7/Copper T

A contraceptive device is the Copper 7 or Copper T. This intrauterine device (IUD) is unusual in that it has a coil of thin copper wire wrapped around the implant. Copper is nonferrous in the static magnetic field and so should not create any deflection when put in the magnetic spatial gradient. In vitro testing of these IUDs revealed no evidence of deflection or substantial artifact.

Thermal heating was theoretically achievable when exposed to the time-varying RF system due to the coil of copper wire (which is electrically conductive). There have been no instances of this happening in people receiving 3 Tesla or less MRI.

13.2.9 Foreign Body

A foreign body can enter a patient in a variety of ways. It might be connected to a job, an injury, or other circumstances. It is difficult to determine the makeup of a foreign body. Many times, a patient is unaware that they have it inside them. This might be difficult for the MRI technician. It is considered that the foreign body is ferrous and may produce deflection when put in a static magnetic field. Threats from the static magnetic field are negligible if these things are not positioned near essential locations (eyes, arteries, nerves, etc.).

In terms of induced warmth, these items are frequently tiny (2 cm). This indicates that there will be very little heating.

Section 13.3 Active Implants

Active implants are electrically charged items that require a generator. Pacemakers, implanted cardioverter defibrillators (ICDs), neurostimulators, and bone growth stimulators are examples of these devices. Active implants necessitate greater vigilance in assessing the hazards associated with these implants. When possible, follow the manufacturer's directions.

13.3.1 Pacemakers

The pacemaker's goal is to control the cardiac rhythm. These can be constructed for patients with non-dependent pacemakers or patients with patient-dependent pacemakers. We shall look at two types of pacemakers: traditional pacemakers and leadless pacemakers. We shall go through these implants rationally to assess their danger. The traditional pacemaker consists of a generator with leads and electrodes that are used to stimulate the heart. The static magnetic field may endanger the pacemaker setting. Because lead electrodes are typically nonferrous, they pose no harm to the static magnetic field. The generator, on the other hand, has components that may be sensitive to the static magnetic field. As a result, a static magnetic field might cause the implant to malfunction.

The time-varying radiofrequency field is the most dangerous to our patients. This is determined by the placement of the leads and generator, their position in our patient, whether or not the leads are connected to the generator, and other considerations. If the leads are present but the generator is not, the risk of burns from the time-varying RF electrical field is increased. Furthermore, if the leads are damaged, the heating at the ends of the leads may rise. If the leads are closer to the near-field or in an L- / U- shape, the quantity of heating may be different. Manufacturers may specify the usage of certain RF coils as well as SAR restrictions.

The time-varying gradient fields also endanger our patients. Arrhythmia may occur if the time-varying gradient fields excite the heart. Overall, while screening patients with pacemakers, the manufacturer's recommendations should be followed.

The new leadless pacemaker has the same hazards as the traditional pacemaker due to the static magnetic field.

We don't have to worry about leads or electrodes with time-varying radiofrequency fields, thus the risk of heating is reduced. This applies to the time-varying gradient fields as well as the stimulation heart. Overall, while scanning leadless pacemakers, follow the manufacturer's guidelines because they may malfunction during or after the MR treatment.

13.3.2 Implantable Cardioverter Defibrillator (ICD) and Neurostimulator

An implanted cardioverter defibrillator (ICD) monitors the cardiac rhythm and sends a shock if necessary. On the other hand, a neurostimulator's function is to activate brain regions. These are analogous to the pacemaker considerations. The static magnetic field may endanger the ICD, not because the lead electrodes are nonferrous, but because it can cause the implant to fail. Some manufacturers have labeled neurostimulators as safe at fields of 1.5 T or less.

The most dangerous hazard to our patients is the time-varying radiofrequency field. As with the pacemaker, if the leads are present, there is an increased risk of burns caused by an electrical field. Manufacturers may specify the usage of certain RF coils as well as SAR restrictions.

The time-varying gradient fields also endanger our patients. Arrhythmia may occur if the time-varying gradient fields excite the heart. Overall, while scanning patients with an ICD, the manufacturer's consideration should be followed.

13.3.3 Bone Growth Stimulator

The bone development stimulator's objective is to stimulate regions to speed up recovery. These devices have a generator as well as leads. They can either be external or internal, like in the case of spinal fusion surgery. If these units can be removed, they should be done so before entering the MR environment. If they are unable to do so, the manufacturer's recommendations should be followed.

The static magnetic field, like the other active implants, might cause these units to malfunction. The time-varying radiofrequency field, like any other active implant, induces electrical currents along the wires. We are concerned with the implant's size, position, and arrangement.

In terms of gradient fields, activation of the bone provides just a little risk to our patient. Overall, we are concerned about the implant malfunctioning and the induction of heat from the leads. When working with patients who have these implants, the manufacturer's guidelines should be followed.

13.3.4 Pain/Insulin Pump

Active implants include pain and insulin pumps. At field strengths of 3 Tesla or below, many of these are safe. To scan a pain or insulin pump safely, follow the manufacturer's instructions. Typically, they need patients to be scanned in normal mode, as well as a precise orientation of the pump for it to switch off when the MR unit is advanced. Because these implants do not include leads, the danger of burning is negligible. Because these units include electrically conductive materials, they may be subjected to Lenz's force when rapidly advanced in the MR unit. It is critical to speak with the patient during the examination.

13.3.5 Loop Recorders

Heart rhythms are recorded using loop recorders. These devices are implanted in patients and can be scanned if certain manufacturer requirements are met. Some on the market can be scanned at 3 Tesla or less under certain situations. When doing scans on patients with these implants, it is critical to contact the manufacturer for these recommendations.

Patients with specific types of implants, equipment, or materials may be in danger from the electromagnetic fields associated with the MR environment. Most injuries are caused by the movement or dislodgement of ferromagnetic objects caused by magnetic fields. However, induction of electrical currents, excessive heating, and/or misinterpretation of an imaging artifact as an abnormality can all pose dangers.

Ex vivo testing is often required for biomedical implants and materials to evaluate magnetic field interactions and heating in order to identify the relative safety of the objects in the MR environment. It is also desirable to determine induced electrical currents for equipment and items.