UC San Diego Health

Department: **Imaging Services**
Modality: **MRI**
Guidelines: **MRI Safety**
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Contents

I. Objective

This policy is intended to guide the provision of a safe environment for patients, visitors, and employees within the Magnetic Resonance Imaging (MRI) suite. Education and proper screening procedures are detailed to ensure safe patient care and conduct of MRI studies.

II. Audience

This policy applies to anyone working or visiting any MRI suite within the UC San Diego Health system. These include MRI suites at the Hillcrest, Thornton, Jacobs, and East Campus hospitals (including the Jacobs Medical Center IMRIS suite). Outpatient MRI suites within the UCSD Health system, UCSD School of Medicine, and MRI suites performing clinical research at Altman Clinical and Translational Research Institute (ACTRI) and the Center for Translational Imaging and Precision Medicine (CTIPM) are included.

III. Definitions

Code Blue/Rapid Response	Declaration of or a state of medical emergency and call for medical personnel and equipment to attempt to resuscitate a patient especially when in cardiac arrest or respiratory distress or failure.
Ferromagnetic	A few elemental solids and alloys, especially those containing iron, nickel, and cobalt, exhibit extremely large positive susceptibilities and are termed ferromagnetic. Metals possessing ferromagnetism are strongly attracted to a static magnetic field and present the greatest danger to patients and staff in the MRI environment.
Ferromagnetic Detection System (FMDS)	Devices that can only detect ferromagnetic objects, which pose a missile-related hazard in the MRI environments.
Gadolinium-based Contrast Media (GBCM)	An intravenous contrast agent used in MRI to produce high quality images when the patient is scanned.
Magnetic Resonance Imaging (MRI)	Noninvasive imagine tool using a powerful magnetic field, radio waves, and a computer to produce detailed images of the human body.
Missile Effect	Capability of the fringe field components of the static magnetic field to attract ferromagnetic objects, drawing them rapidly into the scanner with considerable force.

MRI Training	Level I: Those who have passed minimal safety educational efforts to ensure their own safety as they work within Zone III. Level II: Those who have been more extensively trained and educated in the broader aspects of MR safety issues, including, for example, issues related to the potential for thermal loading or burns and direct neuromuscular excitation from rapidly changing gradients.
MRI Zones	The American College of Radiology (ACR) has defined four safety zones within the MRI facilities. These are denoted Zone I through IV and correspond to levels of increasing magnetic field exposure (and hence potential safety concerns).
MRI Safe 	Any object, device, implant, or equipment that poses no known hazards in the MRI environment., meaning they have no magnetic pull and are perfectly safe to enter the MRI scan room without any worries.
MRI Conditional 	Any object, device, implant, or equipment that has been demonstrated to pose no known hazards in a specified MR environment with specified conditions of use. These conditions of use must be followed at all times.
MRI Unsafe 	Any item that is known to pose hazards in all MRI environments. These are objects, devices, implants, and equipment that are not under any circumstances able to enter the MRI scan room. These are items that are highly magnetic, or devices/implants that are documented to be unsafe to receive an MRI.
MRMD	Magnetic Resonance Medical Director
MRSO	Magnetic Resonance Safety Officer
MRSE	Magnetic Resonance Safety Expert
Missile Effect	The capability of the fringe field component of the static magnetic field of an MR system to attract a ferromagnetic object, drawing it rapidly into the scanner by considerable force.
MR Safety Screening Questionnaire	A comprehensive list of questions that must be answered by patients, family members/guardians, or

	visitors to determine if they are deemed safe to enter the scan room (Zone IV).
Radiofrequency (RF) Coils	An essential MRI hardware component. They directly impact the spatial and temporal resolution, sensitivity, and uniformity in MRI. RF coils are the "antennas" of the MRI system and have two functions: first, to excite the magnetization by broadcasting the RF power (Tx-Coil) and second to receive the signal from the excited spins (Rx-Coil).
Quenching	The process of turning off the magnetic field of an MRI machine by releasing the liquid helium that cools the superconducting coils. The result is the loss of the superconductivity of the MRI unit.

IV. MRI Safety Roles

MR Medical Director

The MR Medical Director (MRMD) responsibility will be assumed by a licensed physician/radiologist with appropriate training in MR safety level 2. The MRMD is responsible for overseeing overall MR facility operational safety. The MRMD responsibility is to ensure policies and procedures are in place for the safe performance of MR procedures. These include:

1. Collaboration with the MR Safety Officer (MRSO) and the MR Safety Expert (MRSE) for MRI safety workflows.
2. The development, implementation, and maintenance of specific policies and procedures pertaining to the safe operation of MR services.
3. The implementation and maintenance of appropriate MR safety and quality assurance programs.
4. Appropriate ongoing assessment of risk for the facility.
5. Appropriate system for record keeping and analysis of adverse events (with the MRSO and MRSE as needed).
6. Appropriate investigation and recording of all reported MR safety adverse events.
7. Site-specific MR Safety training requirements for MR Personnel and others accessing the MR environment.

MR Safety Officer

MRSO should be identified as responsible and should oversee safety practices within a defined component of the MRI practice. The MRSO responsibilities include:

1. Ensuring accessibility if the MR facility is in use to the operators of MR scanners. Ensuring that policies and procedures of the MRMD are always implemented and enforced. Development, documentation, and execution, in conjunction with and under the authority of the MRMD, of safe working procedures for the MR environment.
2. Ensuring that adequate written safety procedures, emergency procedures, and operating instructions are issued, in consultation with the MRMD and MRSE, as needed.
3. Ensuring the implementation and monitoring of appropriate measures for minimizing risks to staff and patients in cooperation with the MRMD.
4. Managing hazards posed by the MR equipment and monitoring the measures taken to protect against such hazards.
5. Ensuring, in cooperation with the MRMD, that medical, technical, nursing, emergency, and all other relevant staff groups (including ancillary workers) who may be exposed to the MR environment are educated appropriately and updated as necessary as to MR safety requirements.
6. Providing and/or ensuring the provision of MR safety education and training in cooperation with and as per the policies of the MRMD and maintaining records of personnel education.
7. Consulting the MRMD and/or MRSE when further advice is required regarding MR safety.
8. Reporting back to the MRMD promptly on all MR safety–related issues.
9. Ensuring that there is a clear policy for purchasing, testing, and clear markings of all equipment that will be taken into Zones III and IV.
10. Providing safety advice on the modification of MR protocols (in cooperation with the MRMD and/or MRSE) if/as needed.
11. Maintaining regular contact with other relevant groups or committees responsible for the safety and welfare of personnel on-site.
12. Providing expertise in root cause analyses, solutions meetings, etc., related to MR adverse event

MR Safety Expert

Serves as a resource for the MRMD and MRSO for technical and physics-related MR safety issues (i.e., issues other than contrast agents, anxiolytics, and other pharmaceuticals). It is expected that the MRSE will serve in an advisory role for one or several MR facilities and thereby does not need to be physically present at the MR facility, although a prospectively and clearly defined means to contact this individual is expected. The MRSE responsibilities include:

1. Providing advice on the engineering, scientific, and administrative aspects of the safe use of MR equipment, which includes quantification assistance for energy, force, and risk exposures.

Providing advice on the development and continuing evaluation of a safety framework for the MR environment.

2. Providing advice for the development of local rules and procedures to ensure the safe use of MR equipment.
3. Providing safety advice regarding non-routine MR procedures, which includes advice regarding safety related to implanted devices and other similar issues.
4. Providing advice on MR Safety and MR quality assurance programs, evaluations, and audits. Providing safety advice regarding equipment acceptance testing.
5. Establishing and maintaining links with appropriate regional and professional bodies and reporting back to the MRMD and MRSO on safety-related issues.
6. Providing expertise in root cause analyses, solutions meetings, etc., related to MRI adverse events

V. MR Safety Committee

The MR Safety Committee is centered on MRMD, MRSO, and MRSE organizational structure with the inclusion of MRI Leadership and pertinent stakeholders (i.e., Radiologists, MRI Technologists, advanced practice providers, nurses, anesthesia personnel, clinical assistants, MR technical maintenance personnel, desk operations, administrative personnel, facility management personnel, among others) as needed. The committee is designed to discuss MRI safety issues and infrastructure on continual improvement. The committee is also responsible for vetting of updates to any MRI policy/guideline.

VI. Reporting MRI-related Adverse Events and Incidents

Injuries related to the magnetic field and noise are rare if proper precautions are followed. In the event of a patient complaint or injury it is important to report and investigate the incident.

1. After an incident or complaint, file an *iReport*:

    - Thermal injuries/burns or complaints that the equipment feels warm
    - Complaints of hearing loss following MRI
    - Injuries due to projectiles
    - Near miss projectile incidents

2. The iReport will be investigated by the MRI Supervisor, MRI Manager, and MR Medical Director to ensure all guidelines and policies are followed if re-education or disciplinary notices are needed.

3. Information will be forwarded to the MR Safety Expert to advise on the incident.
4. The vendor is notified in all instances of heating or excessive noise, and the equipment is tested for proper functioning.
5. Follow up with patient.
6. An MRI related event will be referred to the Risk Management Team to assess.
7. Data is reviewed in MRI Safety Committee meeting and Patient Safety Committee meeting for education issues or guideline changes. All incidents will be logged.

VII. MRI Safety Zones

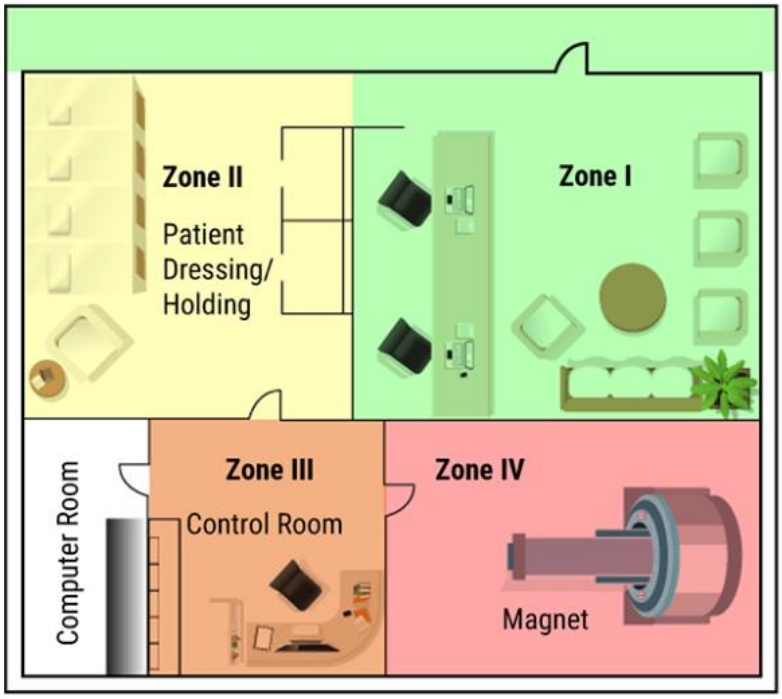
The MR facility may be conceptually divided into four zones for MR safety purposes (please see example diagram below).

Zone IV - Zone IV is synonymous with the MR scanner room and is comprised of the physical walled confines where the scanner is located. It includes the MR projectile zone where there is definite, potentially lethal, projectile risk (located on signage of scan room door). Zone IV, by definition, will be located within a surrounding controlled access Zone III. Zone IV is labelled as potentially hazardous because of a strong magnet. The entry door to Zone IV (i.e., the MR scanner room) should be closed except when it must remain open for patient care or room/MR system maintenance. During the times that the door to the MR system room must remain open, a "caution" barrier should be positioned in the entry to Zone IV to inhibit unintended passage of personnel and/or materials from Zone III to IV.

Zone III - Zone III comprises the "MR controlled access area," and entrance should be restricted by reliable key locks, locking systems controlled by access control cards/badges or similar technology, or any method to ensure appropriate access by designated personnel.

Zone II - This area is the interface between the publicly accessible, uncontrolled Zone I and the strictly controlled areas of Zones III and IV. This area typically contains a patient waiting area, patient prep areas, locker rooms etc. Screening and ferromagnetic detection is often performed in Zone II.

Zone I - This region includes all areas that are freely accessible to the public. This area is typically outside the MR environment itself and is the area through which patients, health care personnel, and other employees of the MR facility access the MR environment.



VIII. MRI Personnel and Non-MRI Personnel

All individuals working within at least Zone III of the MR environment should be documented as having successfully completed at least one of the MR safety live lectures or prerecorded presentations approved by the MR Medical Director. Attendance should be repeated at least annually, and appropriate documentation should be provided to confirm these ongoing educational efforts.

There are 2 levels of MR Safety Training:

Level I: Those who have passed minimal safety educational efforts to ensure their own safety as they work within Zone III.

> **Requirements:** Level I MRI Safety program with assessment on UC Learning Center. MRI personnel will discuss screening, orientation to MRI spaces (zones), MRI safe equipment and emergency procedures (fire, code blue, quench) as part of the Level 1 Safety program. MRI leadership will issue a sticker for the employee's badge to indicate completing the requirement for Level 1 MRI Safety. MR Safety training is to be renewed annually.

Level II: Those who have been more extensively trained and educated in the broader aspects of MR safety issues, including, for example, issues related to the potential for thermal loading or burns and direct neuromuscular excitation from rapidly changing gradients.

> **Requirements:** Level II MRI safety training on initial hire date and annually thereafter. Badge stickers are issued to MRI staff following review of emergency procedures (fire, code blue,

quench), review of burn and missile projection prevention, review hearing protection guidelines, identify zones. Renewed annually.

Non-MR Personnel: All those not having successfully complied with these MR safety instruction guidelines shall be referred to henceforth as non-MR personnel. Specifically, non-MR personnel will be the terminology used to refer to any individual or group who has not within the previous 12 months undergone the designated formal training in MR safety issues defined by the MR Safety Expert (MRSE) and/or the MR Medical Director (MRMD).

Management of MR safety roles: MRMD, MR Safety Officer, MR Safety Expert

It is understood that those serving in the MRMD, MR Safety Officer (MRSO), or MR Safety Expert (MRSE) role will have the necessary education and experience in MR safety to qualify as Level 2 MR Personnel and should also undergo MR safety–specific education on an annual basis.

IX. MRI Screening

Due to the inherent dangers in the MR environment, screening tools are essential to ensure all who are entering Zone IV are safe to do so. Thorough and accurate communication among all involved stakeholders is essential at all levels of the MR screening process.

- During the ordering process for an MRI procedure, MRI screening questions are presented to ensure the MRI is routed to correct personnel and ensure that the patient is safe for the MRI exam.
- During the scheduling process for an MRI procedure, detailed set of questions are presented to the patient (via the scheduling team or when the patient self-schedules on *MyChart*) to ensure that the patient is safe for MRI. Any unsafe or unclear answers will be flagged and investigated further to ensure MRI safety is achieved. Anything deemed unsafe or unknown is considered a contraindication for MRI, thus resulting in a cancellation of the MRI appointment.

Conscious nonemergent patients, research participants, and volunteer participants

Conscious nonemergent patients, research participants, and volunteer participants are to complete an MR safety screening questionnaire (written or electronic) prior to their introduction to Zone III. A healthcare proxy may be indicated for a patient in a nonemergent setting if there is concern for lack of response accuracy due to the patient's condition (for example, in the setting of mild or more advanced cognitive impairment). Conscious nonemergent patients and research or volunteer participants must be MR safety screened at least twice prior to being granted access to Zone IV. At least 1 of these screens must be performed by Level 2 MR Personnel verbally and/or interactively. For example, after completing the screening form, a Level 2 MR Personnel (typically the MRI Technologist) verbally reviews the form's responses and contents with the patient. If safety concerns are identified, entrance into Zone IV is not permitted until the concern is rectified.

Pediatric/minor patients

Children may not be reliable historians. If possible, children, especially teenagers, should be screened twice by Level 2 MR Personnel: once in the presence of parents or guardians and once separately to maximize the possibility that all potential dangers are disclosed. As with all patients, pediatric patients are recommended to change into MR Safe pocketless garments to help ensure that no metallic objects, toys, or other unsafe items enter Zone IV. Pillows, stuffed animals, and other comfort items brought from home represent potential risks and should be discouraged from entering Zone IV. These items should be permitted only on a case-by-case basis if thorough screening has ensured their safety in the MR Zone IV. It is common for properly screened parents or guardians to accompany pediatric/minor patients into Zone IV to help ensure the success of the imaging exam. The use of a Ferromagnetic Detection System (hand-held or stationary) is also required as an additional layer of MRI safety.

Screening of the adult accompanying the minor into Zone IV will be on a paper MRI screening form, noting the relationship of the adult on the bottom of the form. It will then be scanned into the patient's electronic medical records (EMR). Refer to the ***Screening of Non-MR Personnel*** section for proper workflow prior to entering Zone IV.

Unconscious, unresponsive, altered-level-of-consciousness, mentally impaired, unable to communicate patients

As these patients cannot provide their own reliable histories regarding possible prior surgery, trauma, or injury by a metallic foreign body, a multifaceted approach to obtaining reliable information is recommended prior to proceeding with the MR examination:

1. Consultation of the electronic health record (including surgical records and any available implanted devices module) and an evaluation of prior imaging can provide additional important safety screening information.
2. Available family members or guardians with appropriate knowledge of such patients should complete a written MR safety screening questionnaire prior to the patient's introduction to Zone III.
3. If no reliable patient history can be obtained, and if the requested MR examination cannot wait until a reliable history might be obtained, it is recommended that:
    a. Visual inspection for scars, sites of trauma and/or obvious implants by MR Personnel designated by the MRMD be performed.
    b. If recently obtained radiographs, computed tomography [CT] studies, or MR studies of core anatomic regions are not available, patients undergo plain radiography to exclude potentially harmful embedded or implanted metallic foreign bodies, implants, or devices. Plain-film radiography should include the head, chest, and abdomen/pelvis. If there are obvious post-traumatic changes to the distal extremities, radiographs of those regions should be performed prior to MR exposure.
4. Consultation and involvement from the Radiologists are required to clear the patient and ensure it is safe to enter Zone IV.

Screening of Non-MR Personnel

All non-MR Personnel wishing to enter Zone III must first pass an MR safety screening process. Only MR personnel are authorized to perform an MR safety screen prior to permitting non-MR personnel into Zone III. Non-MR Personnel will be under the constant supervision of level II MRI Safety Trained MRI personnel while in the MRI Department. The following workflow will be followed:

- Visitor or ancillary staff member checks in at front desk of MRI
- MRI personnel will screen the visitor/staff
- Visitor or staff will be asked to empty pockets of all metallic objects if possibility of entering Zone IV
- Non-MRI personnel will undergo processes of screening with a ferromagnetic detection system (FMDS), wall mounted and/or hand-held, to ensure that no ferrous objects exist, should they need to enter Zone IV
- Lockers are available for any valuables (watch, wallet) that would need to be locked up safely
- MRI level II trained team member to accompany visitor or ancillary staff member at all times
- If a visitor needs to accompany a patient into Zone IV for comfort due to anxiety or claustrophobia, earplugs will be provided.

Accompanying MRI patients in Zone IV

At times it is beneficial for a family member/friend to remain in the MRI scan room (Zone IV) to help a patient during their MRI exam. This is normally due to claustrophobia. Knowing that someone is present with them, reduces the patient's anxiety. If this is requested by a patient:

- A paper MRI screening form will be filled out by the individual entering Zone IV, noting the name of the person, date filled out, and relationship to the patient
- The MRI screening form will be carefully reviewed by the MRI Technologist to ensure the patient is safe to enter Zone IV
- Individual will be informed to empty pockets and remove any ferrous objects from body. Refusal to do so will prevent them from entering Zone IV
- MRI Technologist will use the Ferromagnetic Detection System to ensure that individual is safe to enter Zone IV. Any alert from detection system will be questioned and investigated
- Screening form will be uploaded in the electronic medical records (EMR) of the patient via the Media Tab, noting that it is the screening form of person accompanying the patient
- Any uncertainty, based on the answers to that screening form, will be considered a "hard stop" and that individual will not be permitted to entering Zone IV
- No more than 1 person is allowed to accompany a patient into Zone IV and it must be an adult
- Earplugs will be provided to protect their hearing
- The individual entering to assist the patient will not be allowed to participate in any of the workflow of the MRI exam; They will only be there as a support system for the patient

Dress Attire for MRI Staff

The strong magnetic field of the MRI can pull metallic objects into the bore of the scanner at a high rate of speed making it dangerous to anyone in the room. Special precautions must be taken to ensure that MRI staff are properly screened and not bring metallic objects into the magnet room

- It is the responsibility of MRI staff to ensure their work attire (including undergarments) is metal free. Exceptions are made for underwire bras and clothing with zippers
- Scrubs attire is required
- Any loose items and items in pockets, (i.e., watches, wallets, cell phones, etc.) must be removed and stored, ensuring they do not enter into the MRI scan room (Zone IV)
- Badge holders must be non-ferrous at all times
- The use of ferromagnetic detection systems is required at beginning of shift by fellow MRI Technologists, ensuring that MRI staff are metal-free and can safely enter the room
- Any detection of metal must be addressed immediately and removed

Screening with Ferromagnetic Detection System

Screening for ferromagnetic materials by direct inspection and use of a ferromagnetic detection system (FMDS) is required before entering Zone III and Zone IV. Implanted and on-planted medical devices, both MR Conditional and MR Unsafe, may include ferromagnetic material (including batteries). The use of conventional metal detectors that do not specifically differentiate between ferromagnetic and nonferromagnetic materials is not recommended. Using an FMDS is recommended as an adjunct and not replacement for thorough and conscientious screening of persons and devices before being permitted into Zone III and/or IV. It serves as another required measure in our workflow to ensure MRI safety of patients, MRI personnel, and non-MRI personnel. FMDS screening may help detect ferromagnetic objects and some medical implants missed during the standard screening. Screening with FMDS must be performed by the MRI Technologist for people who are entering Zone III and Zone IV.

Clearing Retained Metallic Foreign Bodies

Caution should be exercised with MR imaging in the presence of metallic foreign bodies, particularly if they are located near vital neural, vascular, or soft-tissue structures. The relative risk of injury is dependent on the ferromagnetic properties of the foreign body, the geometry and dimensions of the object, the strength of the static magnetic field, and the strength of the spatial gradient of the MR system.

Bullets/Shrapnel

- Plain film radiography is the technique of choice recommended to detect metallic foreign bodies for patients before admission to the MR environment. The inherent sensitivity of plain film radiography is sufficient to identify a metal with a mass large enough to present a hazard to a patient in the MR environment. Findings will then be documented in the patient's electronic medical records (EMR) for future reference. Consultation and involvement of the Radiologists is required to clear prior to MR exposure.

Orbital Foreign Body

- If a patient has a known orbital region injury with a metallic object, or the patient has worked with metal and has potential of metal shavings in his/her eyes, then the individual must have x-rays to confirm that there are not any retained metallic objects in the orbits. The MRI scan must be postponed until documentation has been received indicating that there are not any metallic objects in the orbits. Findings will then be documented in the patient's electronic medical records (EMR) for future reference. Consultation and involvement of the Radiologists must be clear prior to MR exposure.
- Similarly, if a family member or staff member has a known history of metallic foreign body in the orbital region, they CANNOT enter Zone IV without orbital x-rays.

Full Stop/Final Check

A full stop and final check performed by the MR Technologist is recommended to review and confirm the satisfactory completion of MR safety screening for all patients before entering Zone IV. Elements of this include verification of the following:

- Patient identification (2 patient identifiers) and visual inspection
- The examination to be performed includes potential use of contrast and completion of associated contrast risk assessment (including laterality if applicable)
- Appropriately performed screening
- Proper preparation, programming, or removal of implanted/on-planted devices
- Performing sweep with appropriate use of a ferromagnetic detection system (FMDS)
- Performing the Final Stop/Final Check will be acknowledged by the MRI Technologist in the patient's EMR.

X. Medical Implants and Devices in the MRI Environment

The classification of materials/objects in the MR environment falls into 2 major categories:

1. Patient support equipment and portable items such as ventilators, physiological monitors, anesthesia machines, infusion pumps, intravenous poles, wheelchairs, step stools, and others
2. Medical devices directly related to the patient, including implanted devices (e.g., cardiac pacemakers, aneurysm clips, etc.) as well as on-planted devices (external insulin pumps, continuous glucose monitoring devices, etc.)
    - During the screening process (*Penguins*), full documentation of implants and their conditions, if any, in the patients' Electronic Health Records (EHR) by means of the

'Implant' section is required, in addition to the scanning of the implant information from the source into the patient's EHR media section.

- Reviewing implants and their conditions is essential to ensure patient safety and system compatibility in the MRI environment; therefore, review must take place before the scheduled date of service for the patient.
- **Lack of proper documentation for a medical implanted device is equivalent to being MRI unsafe. It will be contraindicated for an MRI until documented proof is obtained and reviewed for its conditionality.**

Patient Support Equipment

It is crucial to identify the manufacturer's MR safety labeling, as part of the Zone III site restriction and equipment testing and, to do so, all MRI locations must have a strong handheld magnet and a ferromagnetic detection system (FMDS). This will enable the site to test external, and even some superficial internal, devices or implants for the presence of grossly detectable ferromagnetic attractive forces.

Using the MRI labeling classification system to clearly identify *Safe*, *Unsafe*, and *Conditional* equipment within the MRI environment. All equipment will be tested by the MRI staff to determine if it is safe to enter the magnetic field. Any equipment not labeled will be considered unsafe until appropriate testing has been completed:

- **MR Safe.** 

A designation indicating that the object or device is safe in all MR environments, without conditions. The term "MR Safe" is reserved for items that are composed of materials that are nonmetallic, nonconducting, and nonmagnetic; such objects pose no known hazards during or resulting from exposure to any MR environment.
- **MR Conditional.** 

A designation indicating that the object or device has been demonstrated to be safely used within the MR environment, provided the specified conditions for safe use (as provided by the manufacturer) are met. When making decisions based on published MR Conditional or safety claims, one should recognize that all such claims only apply to the tested precise model, make, and identification of the object/item as tested to be safe under the specified conditions within the MR environment.
- **MR Unsafe.** 

An item which poses unacceptable risks to the patient, medical staff, or other persons within the MR environment.

Internal/External Medical Devices

Active Implanted Devices:

An active implanted device is a medical device that is powered by an external energy source, usually electronic. Examples of active implanted devices are, but not limited to, Pacemakers, Deep Brain Stimulators (DBS), Programmable Shunts, Cochlear Implant, Vagal Nerve Stimulators (VNS), *PillCams*/*Bravo Capsules*, and Neuromodulation Systems.

All elements of an MR Conditional system must be present for the system to be MR Conditional. For example, an MR Conditional neurostimulation system is comprised of a MR Conditional pulse generator and MR Conditional leads. If any element of the system is not MR Conditional, the entire system is not MR Conditional.

Cardiac Implantable Electronic Devices. Cardiac implantable electronic devices (CIEDs) include cardiac pacemakers, implantable cardioverter defibrillators (ICDs), cardiac resynchronization therapy (CRT) devices, cardiac contractility modulation therapy devices, implantable cardiovascular monitors (ICMs), and implantable loop recorders (ILRs). Manufacturer guidelines for these devices must be carefully reviewed and researched. Specific scanning parameters and requirements need to be followed to ensure MRI safety is achieved.

- Refer to the ***Conditional MRI Policy*** and the ***Non-Conditional MRI Policy*** for requirements of performing MRIs on patients with Pacemakers.

Neuromodulation Systems. Neuromodulation Systems include Deep Brain Stimulators (DBS), Responsive Neurostimulation Systems, Cochlear Implants, Spinal Cord Stimulator Systems, Vagus Nerve Stimulator Systems (VNS), hypoglossal nerve stimulator systems, Sacral Nerve Stimulator Systems, and Peripheral Nerve Stimulator Systems.

Careful attention to the accurate identification of the precise make, model, and manufacturer as well as location of implantation of the leads and IPG for the Neuromodulation System is mandatory to ensure patient safety. Subtle differences in model numbers within a particular class of neurostimulation systems or a modification in how or where it is or was implanted can markedly change the scanning conditions, including a device changing from being MR Conditional to being MR Unsafe and posing a serious risk to the patient.

Implantable and external insulin pumps. Insulin pumps can either be implanted or worn externally. Presently, these devices are considered MR Unsafe due to the presence of ferrous materials and/or electronics that can be adversely impacted by the electromagnetic field used for MR. Importantly, if

exposed to the MR environment, sensing and insulin delivery circuits may be temporarily or permanently damaged such that there may be dangerous physiologically unsafe insulin delivery.

- If a patient has an implanted insulin pump, **the MRI is contraindicated**, until removed.
- External insulin pumps may be associated with continuous glucose monitoring devices, some are unsafe for MRI, therefore require removal from the patient prior to entering Zone IV.

Cochlear Implants. A cochlear implant is a medical device designed to provide a sense of sound to individuals with severe to profound hearing loss who do not benefit from conventional hearing aids. It is important to research the manufacturer's guidelines for cochlear implants.

- Some cochlear implants require an MRI kit to prepare the patient for MRI. An MRI kit that wraps around the head and ears of the patient and is intended to reduce the likelihood of the implant magnet moving during the MRI. This needs a pre-scheduled visit for the Ear/Nose/Throat (ENT) Department to use the kit to prepare the patient to undergo the MRI procedure.

- The MRI will follow, same day. The patient will return back to the ENT Department to remove the MRI kit.

Passive Implanted Devices:

A passive implant device is a medical device that does not have any active power source or electronic components. Examples of passive implanted devices are, but not limited to, intercranial aneurysm clips, inner ear implants, endovascular coils, stents, and filters, non-programmable shunts, and orthopedic implants.

If the passive device is implanted in the United States of America can be imaged immediately (not waiting 6 weeks) after implantation at either 1.5 or 3T if they meet the guidelines below:

- FDA approved for use

- The IFU of the implant does not specify a period of time that the implant can't undergo an MRI. If IFU states a period of time to wait, we will abide by that requirement and perform MRI accordingly

- Tested with ASTM standards with a rating of MR Safe or MR Conditional on a 1.5T or higher. Many devices are not tested at 3T, but we will allow them to be performed at 3T if imaging at 1.5T is not possible or an exam on 3T is preferred; please refer to the IFU of that particular implanted device

- Minimum SAR for diagnostic clinical images will be used. MRI Technologist has flexibility to edit scanner parameters. If needed, image quality can be reviewed with radiologist to ensure diagnostic quality

- A patient with any device with a rating of MR Unsafe will not undergo MRI scan
- Radiologists have the ability to alter any care plans in the best interest of the patient after a risk versus benefit decision
- Conditional MRI devices must be utilized according to manufacturer's guidelines for use

Intracranial aneurysm clips. If it is unclear whether a patient has an implanted intracranial aneurysm clip, recent cranial radiographs, CT, or MR examinations should be reviewed to identify a possible intracranial aneurysm clip. If prior studies are unavailable, radiographs or CT should be obtained.

In the event that a patient has an intracranial aneurysm clip, the MR examination should not be performed until the specific manufacturer, model, and type of aneurysm clip within that patient is identified. Next, it should be determined if the aneurysm clip is MR Unsafe or MR Conditional.

- All documentation of types of implanted clips, dates, etc., must be in writing and signed by/attributable to a licensed physician. Electronic copies of operative reports, physician statements, etc., are acceptable as long as a legible physician signature or other electronic attestation accompanies the requisite documentation
- Blanket letters and verbal confirmation of make/model will not be accepted

XI. Abandoned and/or Fractured Leads in MRI

We must use caution when considering whether to scan patients with any known abandoned or fractured leads from implanted devices. Documentation of the implanted device/leads will be required, uploaded in the patient's electronic medical records (EMR) and reviewed by the MRMD (with possible assistance of the MRSO), to assess whether the patient is safe to undergo an MRI procedure. Plain radiograph films might also be required in order to assess the placement of leads and any leads that may be fractured. Below are some considerations for different types of leads and wires:

Temporary Epicardial Pacing Wires. Patients who require temporary cardiac pacing, sometimes in the context of recent cardiac surgery, may have epicardial pacing wires that extend percutaneously. These wires are not permanently implanted epicardial leads for the purposes of permanent pacing. There is a theoretical risk that MRI examinations in patients with retained temporary epicardial wires (which consist of electrically conductive materials) could lead to cardiac excitation or thermal injury. However, such retained temporary epicardial wires, which are relatively short in length and do not form large conducting loops, have not been found to pose a substantial hazard to patients during MRI procedures.

Permanent Intracardiac/Epicardial Pacing Leads. It should be noted that, retained temporary epicardial cardiac pacing leads (commonly found post cardiac surgery) are not the same as epicardially implanted

permanent cardiac pacing leads. Because of the inherent qualities (i.e., materials, length of leads, etc.) of these pacing leads, it is advisable to exercise caution for patients with abandoned permanent epicardial cardiac pacing leads similar to how patients with abandoned intracardiac pacing leads are managed with respect to MRI issues. Risks of abandoned/fractured leads include lead tip heating with potential for induced cardiac arrhythmias or changes in device sensing parameters.

Abandoned/Fractured Leads from Other Active Devices. The presence of abandoned or fractured leads associated with another device such as a neurostimulator will require review by the MRSO and MRMD. Device and lead documentation in the electronic health record (EMR) will be required, and radiographs demonstrating the lead should be available for review. Often, the presence of abandoned or fractured leads increases risk for heating significantly and may preclude safe performance of an MRI scan. Some devices, such as Liva Nova Vagal Nerve Stimulator (VNS) have MR conditions allowing a safe MRI scan with a small retained lead fragment. Each instance must be reviewed on an individual basis.

XII. MRI Operating Modes

There are three recognized Modes of MRI scanner operation based on perceived risk of patient and volunteers:

1. **Normal operating mode.** This is the "routine" level at which being considered safe for all patients, regardless of their condition.
2. **First level controlled operating mode.** This level is defined as one where certain imaging parameters may cause physiologic stress (such as peripheral nerve stimulation or tissue heating). Active medical supervision is required to use this mode to ensure that a careful assessment of benefits vs risks has been assessed. The MR scan operator must acknowledge this at the console before being allowed to proceed with the scan.
3. **Second level controlled operating mode.** Also called "research" or experimental" mode, this level is reached when such operation may produce significant risks to patients. Second level mode may only be used under an appropriate ethics/human studies protocol. Special security measures (such as software password lock) must be used to prevent unauthorized operation in this mode.

UCSD performs MRIs in first level controlled operating mode, but does convert to normal operating mode for specific circumstances of the patient:

- Requirements of specific implants and devices (i.e., staying at a SAR of <=2 W/kg, restricting the duration of any sequence to a specified maximum duration, or recommended rest periods between scanning sequences)
- Moderately (or larger) obese patients (BMI >=35)
- Pregnant patients
- Patients who are insulated (i.e., body cast)

- Decompensated cardiac patients and febrile patients
- Patients in or on whom there is any metal (device, implant, or foreign body) which is either in or near the volume that will be undergoing direct RF irradiation for the required MRI exam
- Patients with retained lead or wire within their body
- Patients with impaired ability to perspire
- Unconscious, sedated, confused, and/or locally anesthetized patients that may not be able to communicate heating sensations
- ICU/CCU/NICU, etc. In-Patient populations

XIII. Missile Effect Accident Prevention

The "*missile effect*" refers to the capability of the fringe field component of the static magnetic field of an MR system to attract a ferromagnetic object, drawing it rapidly into the scanner by considerable force. The missile effect can pose a significant risk to the patient inside the MR system and/or anyone who is in the path of the projectile. Furthermore, considerable damage to the MR system may result due to the impact of ferromagnetic objects.

For patients preparing to undergo MR procedures, all metallic personal belongings (i.e., hearing aids, analog watches, jewelry, etc.) and devices must be removed prior to entering Zone IV. All patients will be changed into a gown as some clothing items that have metallic fasteners or other metallic components (e.g., clothing with metallic threads) could cause burns. The change into gowns must occur no matter what MRI procedure is performed.

Non-ambulatory patients must only be allowed to enter the MR system using a non-ferromagnetic wheelchair or non-ferromagnetic gurney. Wheelchairs and gurneys should also be inspected for the presence of a ferromagnetic oxygen tank or other similar components or accessories before allowing the patient into the MR setting.

Any individual accompanying the patient must be required to remove all metallic objects before entering the MR area and should undergo a careful and thorough screening procedure. All hospital and outside personnel who may need to enter the MR environment periodically or in response to an emergency (e.g., EVS staff, Facilities, Biomed, nurses, security officers, fire fighters etc.) should be educated about the potential hazards associated with the magnetic fringe field of the MR system. These individuals should, likewise, be instructed to remove metal objects before entering the MR environment, especially the MR system room, to prevent missile-related accidents.

1. Appoint an MRI safety officer (MRSO) or other person responsible for ensuring that proper procedures are in effect, enforced, and updated to ensure safety in the MR environment.
2. Establish and routinely review MRI safety policies and procedures and assess the level of compliance by all staff members.

3. Provide all MRI staff, along with other personnel who would have an opportunity or need to enter the MR environment with formal training on MRI safety. This will be done for new employees and repeated annually.
4. Understand and emphasize to all personnel that the static magnetic field of the MR system is always ON and treat the MR environment accordingly.
5. Do not allow equipment and devices containing ferromagnetic components into the MR environment unless they have been tested and labeled MR safe. Adhere to any restrictions.
6. Adhere to any restrictions provided by suppliers regarding the use of MR-safe and/or MR-conditional equipment and devices in your MR environment.
7. Maintain a list of MR-safe and MR-compatible equipment, including restrictions for use.
8. Bring non-ambulatory patients into the MR environment using a nonmagnetic wheelchair or gurney. Ensure that no oxygen tanks, sandbags with metal shot, or other ferromagnetic objects are concealed under blankets or sheets or stowed away on the transport equipment.
9. Even if an oxygen tank is MRI safe, it should be noted that we still do not bring in these oxygen tanks into Zone IV. In-wall oxygen will be used for patients requiring this oxygen. MRI safe oxygen tanks must be labeled as such. The MRI department must routinely check to ensure all oxygen tanks within the department remain MRI safe.
10. Ensure that IV poles accompanying the patient into the MR environment are non-ferromagnetic.
11. Use the MRI labeling classification system to clearly identify Safe, Unsafe, and Conditional equipment within the MRI environment. All equipment will be tested by the MRI staff to determine if it is safe to enter the magnetic field. Any equipment not labeled will be considered unsafe until appropriate testing has been completed.

12. Carefully screen all individuals and patients entering the MR environment for magnetic objects in their bodies (e.g., implants, bullets, shrapnel), on their bodies (e.g., hair pins, brassieres, buttons, zippers, jewelry), or attached to their bodies (e.g., body piercing jewelry). Magnetic objects on or attached to the bodies of patients, family members, or staff members should be removed, if feasible, before the individuals enter the MR environment.
13. Have patients wear hospital gowns or scrubs with neither pockets nor metallic fasteners for MR procedures. Patients' regular clothing can contain magnetic objects or metallic threads that may pose a hazard in the MR environment.
14. Patients will be changed into a hospital gown, regardless of the type of MRI exam being performed.
15. A ferromagnetic detection system (FMDS), stationary and/or portable, must be used on patients before entering Zone IV. Any alert signal would mean a “hard stop” to review potential ferrous objects/implants.

XIV. Preventing Excessive Heating and Burns Associated with MRI

MRI Safety Guideline

Magnetic resonance (MR) imaging is a safe diagnostic modality. However, damaged radiofrequency (RF) coils, physiologic monitors, electronically activated devices, and external accessories or objects made from conductive materials have caused excessive heating, resulting in burn injuries to patients undergoing MR procedures. Heating of implants and similar devices may also occur, but this tends to be problematic primarily for objects made from conductive materials that have elongated shapes or that form loops of a certain diameter.

To prevent excessive heating and burns in association with MR procedures, the following guidelines should be followed:

1. The patient should change into a gown or other appropriate attire that does not contain metallic material.
2. Prepare the patient for the MR procedure by ensuring there are no unnecessary metallic objects contacting the patient's skin (e.g., drug delivery patches with metallic component).
3. Prepare the patient for the MR procedure by using insulation material (i.e., appropriate padding) to prevent skin-to-skin contact points and the formation of "closed-loops" from touching body parts. Appropriate padding should be used to prevent direct contact between the patient's skin and the transmit RF body coil of the MR system. This is especially important for MR examinations that use the transmit RF body coil or other large RF coils for transmission of RF energy.
4. Use only electrically conductive devices, equipment, accessories (e.g., ECG leads, electrodes, etc.), and materials that have been thoroughly tested and determined to be safe or otherwise acceptable for MR procedures.
5. Carefully follow specific MR safety or MR conditional criteria and recommendations for implants and devices made from electrically conductive materials (e.g., bone fusion stimulators, neurostimulation systems, cardiac pacemakers, cochlear implants, intracranial pressure monitoring catheters, etc.).
6. Before using electrical equipment, check the integrity of the insulation and/or housing of all components including surface RF coils, monitoring leads, cables, and wires. Preventive maintenance should be practiced routinely for such equipment.
7. Keep electrically conductive materials that must remain in the MR system from directly contacting the patient by placing thermal and/or electrical insulation between the conductive material and the patient.
8. Keep electrically conductive materials that must remain within the transmit body RF coil or other transmit RF coil of the MR system from forming conductive loops. Note: The patient's tissue is conductive and, therefore, may be involved in the formation of a conductive loop, which can be circular, U-shaped, or S-shaped.
9. Position electrically conductive materials to prevent "cross points." A cross point is the point where a cable crosses another cable, where a cable loops across itself, or where a cable touches either the patient or sides of the transmit RF coil more than once
10. Position electrically conductive materials (e.g., cables, wires, etc.) to exit down the center of the MR system, not along the side of the MR system or close to the transmit RF body coil or other transmit RF coil.

11. Do not position electrically conductive materials across an external metallic prosthesis (e.g., external fixation device, cervical fixation device, etc.) or similar device that is in direct contact with the patient.
12. Allow only properly trained individuals to operate devices (e.g., monitoring equipment) in the MR environment.
13. Follow all manufacturer instructions for the proper operation and maintenance of physiologic monitoring or other similar electronic equipment intended for use during MR procedures.
14. Closely monitor the patient during the MR procedure (using open communication between sequences and providing patient an alert ball). If the patient reports sensations of heating or other unusual sensation, discontinue the MR procedure immediately and perform a thorough assessment of the situation.
15. RF surface coil decoupling failures can cause localized RF power deposition levels to reach excessive levels. The MR system operator will recognize such a failure as a set of concentric semicircles in the tissue on the associated MR image or as an unusual amount of image non-uniformity related to the position of the transmit RF coil components, jewelry, necklaces, bracelets, key chains, etc.).

XV. MRI Contrast Agents

No patient is to be administered prescription MR contrast agents, typically gadolinium-based contrast media (GBCM), without orders from a licensed physician or advanced practice provider practicing under a supervising physician. Research study participants may receive MR contrast agents as directed by the study protocol after they agree to enroll in the study that has undergone ethics committee (i.e., institutional review board) approval and sign the appropriate informed consent (and assent, as appropriate). Qualified MR Personnel may establish and attend peripheral intravenous (IV) access lines if they have undergone the requisite site-specified training in peripheral IV access and have demonstrated and documented appropriate proficiency in this area. IV injection–qualified MR Personnel may administer MR GBCMs via peripheral IV routes as a bolus or slow or continuous injection as directed by the orders of a licensed site physician or advanced practice provider. For details regarding MRI contrast agents and workflows, please refer to ***Intravenous Contrast Media Guidelines-Adult***.

XVI. Patient Management During MRI Procedure

We will maintain constant communication with the patient throughout the MRI exam to make sure the patient is comfortable.

- After final screening and allowing the patient to use the restroom, the MRI Technologist will explain the exam to the patient in the language they are comfortable with, using interpretation services, if required. The patient should be allowed time to ask any questions.
- If a language barrier exists, a translation device is required to ensure screening, directives for MRI and questions are answered and understood.

- When positioning the patient on the table, padding is used to ensure the patient's comfort. Examples include knee wedge under legs, padding of arms or lower back.
- The MRI Technologist will give the squeeze ball to all patients and make sure they know how to use it if the patient may need attention. The MRI Technologist will also explain the intercom system and remain in verbal contact with the patient throughout the exam using the intercom. If the patient does not respond to the verbal communication, the technologist will go into the scan room at determined times during the exam, pulling the patient out of the scanner and checking on the patient.
- To prevent overheating, especially in the 3T MRI scanners, place insulated padding between the bore and patient. Do not cross patient arms or legs. Ensure all cables are not looped and positioned straight down bore. Avoid excess blankets on patients.
- Insulated padding should be placed between patient and the bore, regardless of body habitus.
- Family members or friends of the patient may stay in the scan room with the patient to provide comfort and support after being properly screened and provided with hearing protection.
- Patients who are anxious may require a break. Pull the table out of the scanner and allow them to relax for a few minutes before resuming.
- If the patient requires medication, we will refer them to their physician to discuss. Options to include alternative imaging, oral medications, or general anesthesia.
- Patients taking oral medication should receive instructions from the physician regarding dosage and when to take the medication.

Hearing Protection During MRI:

The main source of acoustic noise associated with an MR procedure is caused by rapid alterations of currents within the gradient coils.

These currents, in the presence of the strong static magnetic field of the MR system, produce significant (Lorentz) forces that act upon the gradient coils. Acoustic noise, manifested as loud tapping, knocking, chirping, or other sounds are produced when the forces cause motion or vibration of the gradient coils as they impact against their mountings which, in turn, flex and vibrate.

Prior to scanning:

- Patients must be supplied with hearing protection to meet the OSHA guidelines: either foam earplugs and/or head set system.
- Any patient or individual who remains in the scanner room during data acquisition must wear hearing protection.
- The intercom and auditory stimulus equipment must be adjusted to avoid exceeding safe dB levels for the patient.

XVII. Special Patient and Personnel Considerations

Pregnant Healthcare Workers in the MRI Environment:

Below recommendations are not based on indications of known adverse effects of the MRI environment on pregnancy or pregnant healthcare workers. The recommendations reflect a conservative approach, recognizing there is insufficient data pertaining to the effects of the electromagnetic fields of the MR system to support or allow unnecessary exposures. Pregnant technologists and health care workers are expected to follow the recommendations of the ACR and the MRI department regarding pregnant health care workers as outlined in the ACR White Paper on Magnetic Resonance (MR) Safety.

Pregnant MRI Technologists and Healthcare workers are permitted to work in and around the MR environment throughout all stages of their pregnancy.
Acceptable activities include, but are not limited to:

- Positioning patients
- Scanning
- Archiving
- Injecting contrast
- Entering the MR scan room in response to an emergency

Although permitted to work in and around the MR environment, pregnant MRI Technologists are requested not to remain within the MR scanner bore or Zone IV during actual data acquisition or scanning.

Pregnant Patients in MRI:

The current guidelines of the FDA require labeling of MRI devices to indicate that the safety of MRI with respect to the fetus "has not been established". Safety concerns arise with respect to both mother and fetus. Maternal safety concerns are the same as for a non-pregnant patient and are addressed by pre-scan screening. Fetal concerns are twofold; first, the possibility of teratogenic effects, and second, the possibility of acoustic damage. In general, it should be noted that most studies evaluating MRI safety during pregnancy show no ill effects.

The American College of Gynecology and Obstetrics recommends that orders for MRI examinations on pregnant patients should be reviewed on a case-to-case basis, and the risk-benefit ratio needs to be made by the physicians involved. There are no known biological effects of MRI on fetuses. Gadolinium should be avoided when examining a pregnant patient. It is suggested that pregnant patients undergoing an MRI examination discuss with the referring or supervising physician about potential risks versus benefits of performing a fetal MRI. At this stage, the preponderance of research studies has failed to discover any reproducible harmful effects of exposure of the mother or developing fetus to the 3T or weaker magnetic fields used in the routine clinical MR imaging process. However, far less is known about the potential effects, if any, of the time varying gradient and/or radiofrequency magnetic fields used during actual scanning to potentiate image generation. Furthermore, most of our data to date comes from research involving magnetic fields of 1.5T or less. Thus, we have less information regarding the potential safety issues that may exist at higher field strength systems. These theoretical risks should be carefully balanced against the potential benefits to the patient undergoing an MR examination. A decision as to whether to proceed with the requested MRI study will need to be based on a thorough

and thoughtful evaluation of the potential and at times unknown risks of the MR examination versus the potential benefits to the patient, as well as the risks associated with declining to do so.

1. Pregnant patients can undergo MRI scans at either 1.5T or 3T field strength during any trimester if the following conditions are satisfied:

    a. The responsible Radiologist determines that MRI is appropriate after careful consideration of risk–benefit tradeoffs.

    b. The responsible Radiologist confers with the referring physician and then documents the information below in the radiology report:

    - The diagnostic information needed from the MR study cannot be acquired safely by alternative means (e.g., ultrasonography).
    - The diagnostic information from the MRI will be used to treat the patient and/or the fetus, or alter the current treatment, during the pregnancy.
    - The referring physician believes it would be imprudent to wait until after pregnancy to obtain this information.

2. **Gadolinium should be avoided during pregnancy.** If essential, consultation with radiology faculty and referring clinician is required, and patient must give informed consent after discussing risks and benefits.

Large Body Habitus

Exceptionally large patient body habitus is an MR safety concern primarily due to inherent risk of RF burns. Contact or excessive proximity to the bore of the magnet can result in near field RF burns, and appropriate insulating pad thickness and positioning about the patient/subject is essential to prevent burns. Ensuring adequate appropriately placed padding can be difficult with exceptionally large patients/subjects, and particularly while under general anesthesia or while sedated, padding must be scrupulously assessed to prevent burns. Another consideration in exceptionally large patients/subjects is the possibility of forming closed-loop tissue proximities and contacts, such that skin-to-skin contacts become more likely (e.g., between thighs, between abdominal panniculus and thigh, etc.). Thus, properly applied padding that serves as insulation is vital in this patient population. Strategies to reduce patient heating include using a detachable transmit-receive RF coil, choosing lower SAR, and reducing scan time to minimize overall energy deposition in the patient. Large-bore magnets are also recommended to provide adequate space for large body habitus (after clearing of any implants or conditions for that magnet).

Prisoners/Detainees

These patients may present wearing metallic or ferromagnetic handcuffs, ankle cuffs, or shackles. Accompanying correctional officers may be carrying ferromagnetic objects including guns or other weapons. Prior to the patient arriving at the MR department, notification to the corrections department for an alternative nonferromagnetic restraining option should be requested. MR screening of the patient and the accompanying correctional officer(s) should occur before entering Zone III. The accompanying officer(s) should be educated as to the static magnetic field–related safety issues and, if they agree following screening, should accompany the technologist into Zone IV for patient positioning and removal. Firearms with ferromagnetic components pose a potential serious threat in Zone IV and can become dangerous projectiles and may discharge, resulting in a death.

XVIII. Emergency Procedures in Zone IV/MRI Suite

The strong magnetic field of the MRI can pull metallic objects into the bore of the scanner at a high rate of speed making it dangerous to anyone in the room. Special precautions must be taken to ensure that emergency responders are properly screened and not bring metallic objects into the magnet room.

Code Blue/Rapid Response in Magnet Room (Zone IV)

- Activate Code Blue or Rapid Response by following appropriate workflow at respected MRI location.
- Remove patient from Zone IV by detaching MRI table and move to Zone III or Zone II
    - If table does not detach, and MRI safe gurney will be used to transfer patient and move to Zone III or Zone II
- Close the door to the magnet room (Zone IV) and assign an MRI staff member to guard the door, preventing anyone from entering
- Place stanchions across door threshold
- All responders will remain in Zone II or Zone III while providing patient care

Screening During an Emergency in MRI:

- Personnel responding during an emergency, for example Code Blue or Rapid Response, will be verbally screened as they enter Zone III by an assigned MRI staff member
- Responding personnel will be required to verbally respond to screening questions
- An additional MRI staff member will be stationed at the door to Zone IV to prevent anyone from entering

Code Red in Magnet Room (Zone IV)

R.A.C.E. can be a useful mnemonic for MR staff response to fire:

- ✓ **R**escue persons in danger IF SAFE TO DO SO.
- ✓ **A**ctivate the nearest **A**larm, and call, when possible, to provide specific information.
- ✓ **C**ontain the fire by closing ALL doors of the room/area, including fire doors. An MR conditional fire extinguisher may be used to control the fire IF SAFE TO DO SO.

- ✓ **E**vacuate if instructed to do so by the fire department.

- Assign an MRI staff member to direct responders to the location of fire
- If the fire was successfully contained, assign an MRI staff member to ensure responders do not take metallic objects into Zone IV – properly screening them to ensure MRI safety (refer to ***Screening of Non-MR Personnel*** section)
- When a fire is in the magnet room (Zone IV) and cannot be contained by the in-room sprinkler system or by the safe use of an MR Conditional fire extinguisher and the fire department will require access to the room, the Emergency Magnet Off (*quench*) should be engaged to avoid potential severe injury to the fire department staff or damage to MRI equipment (refer to ***Quenching the MRI Magnet*** section)

Emergency Procedures Outside of Magnet Room

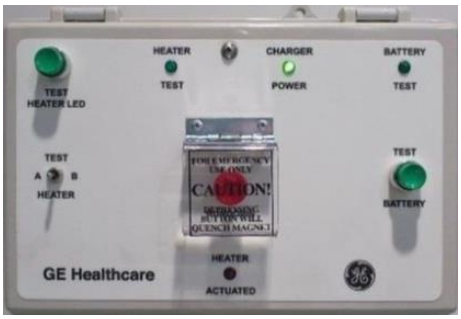
- Follow medical center guidelines for appropriate emergency response
- Assign an MRI staff member to ensure responders do not enter Zone IV
- Ensure MRI safe fire extinguishers are located throughout the MRI department

XIX. Emergency Table Stop and Emergency Power Off (EPO)

The Emergency Power Off (EPO) button is generally used to stop electrical power to the entire suite and computer room, including an uninterrupted power supply if present. Use of the EPO may require an electrician and access to the main breaker to reset and so should be used with caution and only in emergent situations only. The EPO button is generally present in the MR control room or on the wall inside Zone IV. In some cases, it may be covered with a plastic guard to avoid accidental activation. The EPO may be used in cases of fire, flooding, or voltage accidents. Example scenarios for deploying an EPO could include detecting smoke or having an uncontrolled water pipe burst in the MR environment.

In the case of Emergency Table Stop or Power Off, if a patient needs to be quickly removed from the scanner. Fast and safe patient removal from the room is often a key component in any emergency response scenario.

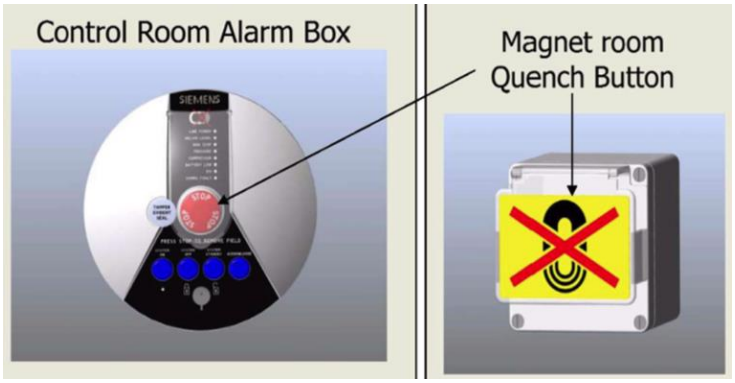
The MRI team is responsible for knowing how to safely and quickly remove the table from the scanner by using the Emergency Table Stop or Power Off options, as well as the location of the EPO button for each MRI unit within UCSD.



Example of EPO

XX. Quenching the MRI Magnet (Emergency Magnet Off)

The quench button is to be used only in the case of an emergency in which a person is injured and the only safe way to avoid further injury is to decrease the magnetic field strength of the magnet, or if a fire is within Zone IV and uncontainable with the use of an MRI safe fire extinguisher. Pushing the quench button will cause the liquid helium that cools the magnet to rapidly boil off. The quench pipe above the magnet is designed to allow the helium to vent outside of the building. If the quench pipe fails, there is a danger that the magnet room will be filled with helium and that the oxygen in the room will be displaced, which could cause injury or death for anybody in the magnet room or the console room during a quench.



Example of Quench Button

Quenching the magnet can be dangerous due to the rapid boiling off helium which creates dangerously high pressures and could displace oxygen from the room. A quenching could cause permanent, irreparable damage to the magnet. If the magnet survives the quench it will have to be recharged which is very costly and time consuming.

Intentional quenching is performed in an extreme emergency to rapidly run the magnetic field to zero. A quench of the magnet should only be performed when:

- A person is pinned to the magnet and is unable to be removed from the scanner without harm
- There is a fire in the MRI scanner, equipment, or console room that cannot be contained

The quench button is on the quench box which is mounted on the side wall inside each magnet room or mounted by the tech workstation of that magnet. Lift the spring-loaded plastic cover to access the button.

What should you do if the magnet quenches?

- Stop the scan, if not already done so
- If a patient is currently in the scanner and is ambulatory, advise the patient to leave Zone IV as soon as possible, walking as low to the floor as possible to maintain their head below the potential accumulation of cryogen gas to minimize the risk of asphyxia
- Open the scan room door to ventilate Zone IV
- Consider opening the door to other zones to help ventilate Zone III
- If entering Zone IV to rescue the patient or personnel, stay as low to the ground as possible. If a gurney or wheelchair is needed, assume the magnet is still on and at field and use MR Conditional equipment
- Notify emergency response personnel
- Notify MRI leadership, who will alert the engineer of the magnet's manufacturer

References

American College of Radiology. ACR Manual on MR Safety 2024. Available at *https://www.acr.org/Clinical-Resources/Radiology-Safety/MR-Safety*. Accessed 10/20/2024.

https://pulse.ucsd.edu Imaging Department Guidelines. Available at *Intravenous Contrast Media Guidelines-Adult*

Appendix

MRI Standard Operating Procedures	***Click Here***
MRI Policies and Guidelines	***Click Here***