WASHINGTON UNIVERSITY ST. LOUIS
MALLINCKRODT INSTITUTE OF
RADIOLOGY

MRI SAFETY TRAINING
EAST BUILDING
This training document was prepared for the MR Steering Committee by Lisa Augustine and Glenn Foster – MRI Research Technologists. To ensure a safe and knowledgeable working environment, all potential MRI operators must complete formal training as outlined below. Upon satisfactory completion of this orientation\training program, approval to operate the MRI scanners in the East Building will be given. This training manual was revised in 2010 by Linda Hood, R.T.

Each researcher\staff will complete the following:

1. View Siemens MRI Safety video: [http://www.medical.siemens.com/webapp/wcs/stores/servlet/PSGenericDisplay~q_catalogId~e_11~a_catTree~e_100010,1007660,12754,1022566,1018426~a_langId~e_-11~a_pageId~e_101242~a_storeId~e_10001.htm](http://www.medical.siemens.com/webapp/wcs/stores/servlet/PSGenericDisplay~q_catalogId~e_11~a_catTree~e_100010,1007660,12754,1022566,1018426~a_langId~e_-11~a_pageId~e_101242~a_storeId~e_10001.htm)
2. Review MRI Safety Guide
3. Complete and successfully answer the MRI Exam questions in the Exam Part III section
4. Complete the MR Facility orientation\walk through

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MRI SAFETY TRAINING

Part I

General Information
General Information

1. Before anyone (staff, subject, visitor) may enter the magnet room, a screening form must be completed and reviewed by the investigator who will be performing the MRI exam.

2. Before entering the magnet room, all pockets are to be emptied of; watches, pagers, wallets, pens, pencils, hair clips, jewelry, keys, and any other possible projectiles.

3. It is recommended that the person being scanned change into MR compatible clothing. Scrub bottoms and gowns are provided for this purpose.

4. The magnet room door should be kept closed at all times except when entering or exiting the room.

5. All persons scanned must wear ear protection. If they decline the exam must be canceled.

6. Never scan with an unplugged surface coil in the bore of the magnet.

7. Use of any research equipment, coils, or supplies not supplied by the MRI Research Facility must be approved by the MR Steering Committee.

8. All investigators must clean up after themselves. Return all equipment to its proper place. The room should be kept neat and tidy. Do not lay coils and phantoms on the floors.

9. Please report all malfunctioning or damaged equipment to the research technologists immediately. If the technologists are absent, call the technologist pager 314-672-0230. Do not call Siemens service directly to request service.

10. All studies should be archived immediately after the exam is complete. Data may remain on the systems for up to seven days unless disk space becomes critical, in which case the oldest studies will be removed first.

11. A physician must be available to cover MR research exams where patients are being scanned or contrast is being administered. For normal volunteers, no medical coverage is necessary, however, the researcher must be familiar with code procedures and calling security services at 2-HELP (2-4357) if a medical emergency should arise. Campus EMS will notify 911 if necessary.

12. Researchers should never leave their subjects unattended in the magnet. If the researcher must leave the area then he/she must get another qualified researcher to cover for him/her during the absence.

13. Subjects should never be left lying on the scan table outside of the magnet. Due to the lack of side rails on the table there is a risk of the subject falling off of the table.
Section I: The Magnetic Environment

1. The Magnetic Field

It is important to remember when working around a superconducting magnet that the magnetic field is always on. Under normal working conditions the field is never turned off. Therefore, it is important to be aware of safety issues regarding ferrous projectiles and patients who may have contraindicated devices implanted in their bodies.

There are two units used to describe magnetic field strength. They are the Tesla and the Gauss. One Tesla equals 10,000 Gauss. The strength of the magnetic fields of our magnets on the first floor is currently 1.5 Tesla or 15,000 Gauss and 3 Tesla or 30,000 Gauss. Our magnets are approximately 30,000 - 60,000 times stronger than the earth's magnetic field. The five gauss line is the area at which the magnetic field becomes dangerous. For our 1.5T and 3T systems the five gauss line is located at the foot end of each scan table.

2. Keep Doors Closed!

The doors leading to the magnet room should be closed at all times except when entering or exiting the room. This will prevent people who do not belong in the room from mistakenly wandering into the room.

3. MRI Compatible Equipment:

Do not assume that all the equipment in and around the MRI environment is MRI compatible. Be sure that what you take into the MRI suite is safe to enter the room. There are two aluminum stretchers located in the hall that are completely safe to go in the scanner rooms. This facility does NOT have MRI compatible wheel chairs. You will need to transfer any subjects who cannot walk into the room onto the aluminum stretcher and then transfer them to the table. Be very careful of walkers and canes, not all of them are made of aluminum.

Section II: Screening/Consent Forms

1. Consent Forms:

Because we are a research facility we have several researchers who perform non-FDA approved MRI sequences on patients and volunteers. These sequences are important to the advancement of the science of MRI. We must, however, inform the patients and volunteers that we are performing these non-approved sequences on them and they must give us their informed consent to do so. We have copies of the consent forms for patients and volunteers to sign EVERY TIME THEY HAVE AN EXAM. In addition, the consent form must be signed by the Principal Investigator or their designee. Only one consent form is needed per exam, but the patient must sign a new consent form every time they return for another exam.

Screening Forms

As stated earlier, the magnets have a very strong magnetic field surrounding them which has the potential to attract certain types of metal. The magnetic field can also
interfere with the normal operation of electronic devices. For these reasons, we must have a
detailed health history for every person that enters the magnet room. This includes all
staff members, investigators, patients, and volunteers. The repercussions associated with
a patient, volunteer, or staff member being injured because of negligence on the part of the
scanning investigator could be severe and could cause research to be halted at this facility.
Screening forms have been designed and must be completed by every person entering the
magnet room. For persons who are employed by this facility, the form only needs to be
completed once. In the event that a staff member has an accident or surgery where a
metallic foreign object or electronic device is implanted into their body, the staff member
would be restricted from going into the magnet room until the metallic/electronic object
can be cleared for safety purposes. It is up to the staff member to be aware of such
circumstances and to report any such events to their direct supervisor.

**From this point on patients and volunteers will be referred to as "subjects".
However, it should be noted that the word "patient" refers to any person scanned in
the research facility who is under a physician's care; that physician being one who is
an investigator in the research study.

Subjects who return for another MRI exam must fill out a new screening form each time
they visit. If it has been less than six months since their last scan, and they haven't had
any metal enter their body by accident or surgery, you may have them fill out the top
portion of the screening form and document, for example, NO CHANGES SINCE SCAN
DONE ON 8/21/2010. The subject must sign the new screening form so we have
documentation stating that they do not have any new metal in their body since the last
scan. In order to complete the screening form in this manner, you must have the screening
form from the previous exam to insure the subject was originally cleared to be scanned.
Every screening form must be signed by the subject and the investigator or technologist
who is performing the scan.

Keep in mind that all subjects who are giving information regarding their health history
must be conscious and coherent. Any gaps in memory or lack of information about a
surgical procedure are grounds for canceling the subject, unless a family member can
provide a detailed history. If there is ever any question about a subject's past health
history regarding metal in their body, it is required that the MRI exam be put on hold until
the question can be investigated thoroughly.

An in depth explanation of contraindications to MRI will follow in the next section.

**Section III: Contraindications for MRI**

There are several types of contraindications that would prevent a subject from having an
MRI scan. Metallic implants and foreign bodies as well as the subject's physical condition
will be discussed in this section. All subjects are required to remove any clothing that has
metal on it. Gowns and pajama bottoms are provided for the subject to change into. All
subjects and staff members must empty their pockets of any loose metallic objects (hair
pins, safety pins, coins, keys, ID badges, wallets, credit cards, banking cards, lighters,
pocket knives, scissors, stethoscopes, hemostats, etc.) before entering the magnet room.

1. Surgical Implants
There are hundreds of metallic implants that can be surgically placed into a person's body for various reasons. Some of these implants are ferrous and may be attracted to the magnetic field. Some may be electronic in nature, in which case, the magnetic field can interrupt the device's normal operations. Worse, by placing an electronic device in the magnetic field, a current may be induced in the conducting wires of the device which could possibly burn the patient. There are many metallic implants that are non-ferrous and may be compatible for MRI such as orthopedic screws, rods, and plates. It is suggested that a waiting period of at least two weeks after surgery is necessary for the tissues around the implant to take hold of it to prevent any potential movement of the implant. Although the two week period is generally observed, in some more emergent instances a subject with a non-ferrous implant may be scanned as soon as a day after the implant is in place. There are also some ferrous implants (e.g., heart valves, venous blood clot filters) that are compatible for MRI. Typically the waiting period for these implants is between two and six weeks. The bottom line is that the waiting period decision should be left to a Radiologist who is familiar with the implant and its magnetic properties. To prevent injury to the subject, it is extremely important that the scanning investigator be familiar with the difference between compatible and contraindicated implants and devices.

2. Accidental Metallic Foreign Bodies

Occasionally an investigator may have a subject tell them they have been injured by a piece of metal which punctured their body in some way, shape, or form. Common causes of this type of injury are people being shot with bullets, buckshot, pellets, or BB’s. Other frequent causes are people who work with grinding, sanding, or cutting metal frequently are exposed to metal slivers flying off of the metal piece they are working with. These metal slivers often fly into the eyes, hands, or face. People who have been involved in wartime activity may have pieces of shrapnel or other metal fragments in their body. Any of these circumstances must be investigated thoroughly to prevent injury to the subject.

3. Checklist of Tested Implants, Devices, and Metallic Foreign Bodies

Refer to www.mrisafety.com for a complete list of surgical implants and metallic foreign bodies which have been tested by leading MRI safety authorities in magnetic environments for evidence of deflection and torquing of the metallic objects. This web site should be used to investigate any questionable implant or foreign body.
4. Procedure to Clear Metallic Implants and Foreign Bodies

The subject should list all of their surgical or accident history on the screening form. In addition to this, the investigator should re-question the subject about their history even if the subject has written that they have not had any surgery. It is not uncommon for a subject to conceal or forget about a procedure or accident which may have happened long ago. They also may be uncomfortable about writing it down for the world to see. Further questioning the subject and explaining to them the importance of their honesty can sometimes provide additional information to the investigator.

If you discover the subject has had a surgical implant or an accident involving metal you must find out the following:

1. What was the procedure? What was the nature of the accident?
2. What kind of implant is it? What does it do? What is it used for?
3. When was the procedure done? What year?
4. Do you know for sure that it is metal?
5. Who was the doctor/surgeon who performed the procedure? Is he or she still in practice?
6. At what hospital was the procedure performed?
7. If it was an accident, did you have any x-rays done at the time and was the metal removed?

Once you have all of the answers to these questions, proceed with the following:

1. Take the information to one of the MRI technologists. The technologists have been educated as to what may or may not be scanned and in many instances will be able to assist you.

2. If the technologist does not know of the implant or thinks the subject may have to be canceled, the PI and a radiologist must be involved at this time for more information. If the subject doesn't know if the implant is metal, the radiologist may suggest x-rays be done to rule out metal. X-rays may not be performed without the permission of the Principal Investigator.

3. If the radiologist does not know of the implant, you must contact the surgeon who placed the implant and request a copy of the operating room report which should describe the model and name of the implant. This report will be attached to the subject's screening questionnaire for permanent documentation.

4. The final responsibility of canceling or proceeding with the exam lies with the Principal Investigator who should make an informed decision based on the information provided by the MRI technologists and radiologists.

5. If the subject is cleared, a written permission signed by the Principal Investigator for the subject to undergo the MRI exam must be provided to the MRI research staff. This permission form will be attached to the subject's screening questionnaire for permanent documentation.
Any person (subject or staff) who has a history of working with metal as an occupation or hobby should have x-rays of their orbits to rule out metallic foreign body before they enter the magnet room. The only case of a patient being blinded by a metal sliver piercing their optic nerve was a former metal worker who did not know that he had a piece of metal in his eye. Typically if metal workers get a sliver of metal in their eye, it is removed in an emergency room by a physician. However, without x-rays, there is no way of knowing if the entire piece of metal was removed. Usually x-rays will be ordered at the time the metal is taken out. If we can obtain a copy of the report from those x-rays, and the subject has not gotten any more metal in their eyes since the x-rays were taken, then we may use the original x-ray report to clear the subject for the MRI exam.

5. Pregnant Subjects

It is the policy of the MRI research department to not scan any pregnant subjects for research purposes. In the clinical environment, pregnant patients are only scanned in emergency situations. With this in mind, and realizing that research is not done on an emergency basis, pregnant subjects must wait until after they give birth to participate in a research project. If a subject believes she may be pregnant, it is up to the Principal Investigator to decide if the subject should undergo a pregnancy test. If the PI deems the pregnancy test necessary, all arrangements and financial responsibility will be taken care of by the PI or their designee.

If the pregnancy test is negative and the subject is to undergo the MRI, a copy of the pregnancy test report will be needed by the MRI staff to attach to the subject’s screening questionnaire for permanent documentation.

6. Contrast Agents used in Subjects who are Breastfeeding

In the case where a research subject is breastfeeding her child, the mother must be informed that her milk must be expressed with a breast pump and thrown away for 48 hours following the injection of gadolinium contrast agent. It is important that she be aware of this in order that she may, ahead of time, store enough milk to feed the child during the 48 hours after the contrast injection.

7. Pregnant Staff

It is the policy of the MRI research department that all pregnant staff members be restricted from the magnet room and during the first trimester when radiofrequency pulses are on. Any pregnant ancillary staff member (nurses, coordinators, secretaries) who does not need to be in the magnet room should stay out of the room unless there is an emergency with a subject. Pregnant staff members, such as MRI technologists, who must enter the room on a regular basis, should only stay in the room as long as necessary i.e., positioning subjects, emergencies, etc. The goal is to keep the pregnant staff member out of the magnet room as much as possible unless it is part of their job description to be in the room, or if there is an emergency with the subject. If an MRI staff member is pregnant she should inform her supervisor immediately. Ancillary staff members should let the MRI technologists know if they are pregnant.

8. Radiofrequency and Specific Absorption Rate

MRI employs radiofrequency (RF) pulses to disturb the alignment of protons in the nucleus of hydrogen molecules in the body. These RF pulses deposit heat into the tissues of the body. This heat deposition is termed Specific Absorption Rate or SAR. SAR is measured in watts per kilogram and is a function of several variables, including: (1) the
The type of RF pulse used (90 or 180 degrees); (2) the number of RF pulses in a sequence; (3) the pulse width; (4) the TR; (5) the weight of the patient; and (6) the type of coil used. The FDA has developed guidelines to regulate the amount of deposited heat that are within acceptable limits. Currently all manufacturers of MRI equipment are permitted to submit their pulsing sequences to the FDA for SAR review. Therefore, the FDA has issued different guidelines for different manufacturers.

**Conditions in the examination room**

Ambient temperature: 21°C, ±3 oC  
Relative Humidity: 50% - 70%

**Specific Absorption Rates**
Levels insufficient to produce a core temperature increase in excess of 1°C and localized heating to greater than 38°C in the head, 39°C in the trunk, and 40°C in the extremities.

< 3.2 W/kg averaged over the mass of the head  
< 1.5 W/kg whole body average for all subjects  
< 3.0 W/kg whole body average for subjects with normal functioning thermoregulatory systems  
< 8.0 W/kg spatial peak in any one gram of tissue

** It should be noted that subjects with thermoregulatory illnesses such as fever, or diseases in which the patient is unable to sweat, may be compromised by heat deposition in MRI. Extreme care should be taken with these subjects to keep them cool during the exam. You should investigate choosing sequences that do not result in high amounts of heat deposition. Also, the eyes are particularly susceptible to heat deposition.

**Section IV: Emergency Procedures**

1. **Emergency Removal of the Subject from the MRI Scanner**

If the investigator has placed a subject in the scanner and upon looking at the first set of images notices a metallic artifact present, the investigator must follow the proper procedure for removing the subject from the scanner and the magnet room.

1. Tell the subject you are going to remove them from the magnet. Instruct them to remain perfectly still and to not sit up at any time.
2. Pull the table out of the scanner very slowly.
3. Move a gurney into the magnet room and place it next to the table.
4. Have the subject slide, without sitting up, onto the gurney.
5. Slowly pull the gurney straight away from the magnet without turning the gurney.
6. Once you reach the doorway slowly turn the gurney and move it out through the doorway.
7. Once the subject is safely outside of the room, they may sit up.

** This procedure should also be used if the subject tells you of a contraindicated metallic implant in their body after they have already been placed in the magnet.

2. **Calling 2-HELP (2-4357)**

The East building in which our magnets are located is not serviced by the Barnes Hospital code team. In order to get emergency help you must call **2-HELP (2-4357)** and
follow the instructions of the dispatcher. You will need to tell them the address right away. It is 4525 Scott Avenue.

3. The Crash Cart

There is one crash cart located in the MRI research area on the first floor of the East building. You will find it either in front of Bay 1 or in front of Bay 3. We move it from scanner to scanner depending on where we are performing clinical research exams on humans.

4. Code Procedures

In order to know the status of the subject at all times, it is strongly recommended that the pulse oximeter be placed on the finger of every subject that goes into the magnet. This will provide you with a heart rate and oxygen saturation for the subject while they are in the scanner. If the subject should become unresponsive begin the code procedure as listed below.

1. Immediately remove the subject from the bore of the magnet.
2. Try to arouse the subject by shaking them gently.
3. If no response, feel for a pulse at the carotid artery in the neck. At the same time, put your ear near their mouth and nose while looking at their chest to determine if they are breathing.
4. If the subject is not breathing or does not have a pulse call 2-HELP (2-4357) immediately.
5. Return to the subject immediately and begin rescue breathing and or CPR (if certified) appropriate to the subject's condition.
6. If more than one investigator is present have them call 2-HELP (2-4357) for help and then round up as many medical personnel as possible. During the day you may call Dr. Raichle's secretary, Shari Macke, at 362-7116 who will send any physicians located on the second floor down to help.
7. The second person should also bring the stretcher into the magnet room to enable transport of the subject out of the room.
8. **DO NOT BRING THE CRASH CART INTO THE MAGNET ROOM.**
9. If you have been able to transport the subject outside of the magnet room, proceed to the holding area and bring the crash cart. The crash cart is equipped with an ambu bag which you may now use to breathe the patient if you have been trained to do so.
10. Once emergency personnel arrive, **DO NOT LET THEM INTO THE MAGNET ROOM.** You must get the subject out of the magnet room without endangering any personnel who have not been cleared to enter the room. Among other items, paramedics always have stethoscopes, scissors, and hemostats on them which will turn into deadly projectiles if brought near the magnet. In addition, you do not know their health history and whether or not they may have a contraindicated implant in them.
11. Inform the emergency personnel of the incident and stay close by to assist them with any questions they may have or items they may need.
12. After the subject is taken away by the paramedics, an incident report will need to be filled out.

5. Quench

The term "quench" is used to describe the rapid boil off of the cryogens that keep the magnet cooled and in a superconducting state. Cryogens are super cooled liquid gases. Our Siemens' systems require liquid helium to keep them cool. Without cryogens, the magnet loses its magnetic field. Usually a quench is undesirable and is due to a malfunction within the system. In rare instances a quench may be necessary to free someone from the magnet if they have been accidentally struck by a projectile
ferrous object and pinned to the magnet. In each control room there are boxes on the wall that enclose quench buttons that should be pushed in the event that the magnetic field must be manually run down. When a quench occurs, either spontaneously or manually, you must evacuate from the magnet room immediately to avoid being overcome by the helium gasses should they not vent properly out of the room. If you are going to manually quench the magnet, make sure the door to the scan room is left open to avoid a vacuum forming which may seal the door shut. If the magnet quenches spontaneously, and you are unable to open the door, you must break the window between the control room and the magnet room in order to get the subject out of the room.

6. Projectile Injury

If a subject or staff member becomes pinned to the magnet by a ferromagnetic object, you must evaluate the situation quickly before taking any action. If the person is unconscious, bleeding profusely, at risk of losing a limb or extremity, or in severe pain, you must manually quench the magnet to bring down the field in order to release the object and the person. If the person is responsive and able to tell you they feel O.K., you may be able to leave them in the position until a service engineer can respond and ramp the magnet down slowly to avoid a full quench. If you choose the latter, and the person then loses consciousness, or their condition worsens, immediately quench the magnet manually. Keep in mind that the cryogens are expensive to replace so evaluate the situation carefully but never put cost above the life or well being of the person.

Once the person is released, get them out of the room and call 2-HELP (2-4357) for emergency medical help.

7. Responsible Parties

Any time a patient is scanned, or any contrast agent is administered to a human in the MRI research area a physician must be available to cover in the event of a medical emergency. If the PI is not a medical doctor, arrangements must be made to have a medical doctor available to respond for emergency purposes. If a designee of the PI is present with the subject, the designee must know how to reach the PI, or a medically responsible party, immediately in the case of emergency. This also means when a subject is scanned, the responsible physician may not be out of town without arranging for medical coverage in the event of an emergency. The MRI technologists will assume these arrangements have been made before the subject is scanned and will not be responsible for medical treatment of the patient other than proper emergency procedures, in the event of an emergency or adverse event.

Section V: The Scanner and Related Equipment

1. System log on\off procedure

In order to use the scanners, you must have been approved by the research committee for scan time on the research magnets. If you have been approved, you will be given a protocol number in which to generate an access code (for billing).

Every user will be given a RIIS username\password which will be used to generate access codes and to log onto the scanner.
Upon arriving at the MRI suite you will need to log onto the RIIS system to start your billing time. The scanner itself is always left on but the video feed to the monitor will only come on if someone is logged in. There is a dual boot system that controls the RIIS computer and the Bay 3 PC. Select the RIIS system button on the switch box.

Once you have logged onto the RIIS system, the computer will monitor who is using the scanner and how much time they use.

If you should arrive at your MRI session and the previous user mistakenly left the system logged on, you can use your RIIS user name and password to log them off and then continue with your log in. **THE PERSON WHO IS LOGGED IN DOES NOT HAVE TO BE THE PERSON TO LOG OFF.**

FYI: When logging off, after you enter your user name/password in the log off screen you must click **CONTINUE** in order for the log off process to be complete. The video feed to the scanner monitor will turn off if this procedure was successful.

### 2. Table Controls & Table Stop Buttons

**TRIO:** There is a red “stop” button on the gantry that if pressed will stop the table movement and also stop a scan that is running. If this button is pressed the in\out buttons will start blinking and to reset the table you will need to press each in\out button alternately a few times to reset the table.

There is a release latch on the right side of the table towards the foot. Pull the latch up and you will be able to manually move the table.

**SONATA & ALLEGRO** have a table stop\release button located on the gantry. Press the red stop button and you will be able to manually push\pull the table.

### 3. Stereo/Headphones/Earplugs

All subjects are required to wear ear protection while undergoing an MRI exam. Headphones are provided which hook into the stereo system so the subject may enjoy music during the exam. The headphones are also part of the noise cancellation system which helps to drown out the knocking noise of the gradients. If the subject chooses not to wear headphones, earplugs will be provided. If the subject refuses all hearing protection, the scan cannot be performed.

### 4. Communicating with the Subject While They are in the Scanner

It is important to maintain voice contact with the subject throughout the exam. The researcher should routinely establish contact between each sequence. If the subject is wearing the stereo headphones, and the RIT system is being used, you must speak to them through the black microphone. If they are not wearing the headphones, and you are using the Siemens intercom system you must speak to them while depressing the talk
button on the intercom. In order to hear the subject, you must have the hearing level turned up on the intercom.

5. The Patient Alarm

Every subject should be given the patient alarm ball to hold in their hand during the exam. The subject should be instructed to squeeze the ball if...

They need to speak with the investigator in between sequences.
They want to come out of the scanner immediately.
Something is hurting them.

Because the scanner cannot be put in a pause mode, if you stop a scan to speak to the subject, you will have to start the scan all over again from the beginning. For this reason, it is wise to advise the subject to squeeze the ball only in situations of pain, injury, or claustrophobia. If the investigator is communicating with the subject routinely between sequences, the subject will be less likely to squeeze the ball in the middle of a sequence to ask a non-emergent question.

6. The Invivo Monitoring System

The MRI research department has purchased an excellent MRI compatible monitoring system for use during MRI exams. With this system we are able to do the following:

1. Obtain an EKG trace from the subject.
2. Obtain blood oxygen saturation percentages from the subject.
3. Obtain blood pressures from the subject.

EKG & Cardiac Gating

Currently there are several types of studies where cardiac gating is desirable. Cardiac gating functions to allow imaging in areas of the body where there is considerable motion. For example, when imaging the heart, cardiac gating is used to tell the computer to image all of the slices at the same point in the heart cycle every time the heart beats. This gives the appearance that the heart motion is frozen resulting in images with the appearance of little or no motion artifact.

Special attention must be given when attaching the electrode and leads to the subject's chest. Because you are placing the lead wires in a magnetic field, it is possible to induce an undesirable current in those wires which may burn the subject. It is imperative that the lead wires and the main EKG cable have no loops in them when placed on the subject. The main cable should not touch the sides of the magnet or the subject's skin as it is run out of the magnet bore. The cable should be run straight out of the bore with no loops and should not cross over the subject's body at any point. If you must get the cable from the subject's left side to the plug-in port on the right side of the table, run the cable down the left side of the subject, and then across the foot of the table. A washcloth, sheet or towel must be placed between the subject's skin and any wire that makes contact with the skin.

Blood Pressure Monitor

The blood pressure monitor is able to measure the subject's blood pressure non-invasively at prescribed intervals throughout the exam. The researcher may set a time interval at which the monitor will automatically inflate the cuff on the subject's arm while the subject is in the scanner. An updated BP reading is displayed with each interval's measurement.

The blood pressure cuff may be placed on either arm but care should be taken not to place it on an arm which has an IV placed in it. Also, it is not uncommon for women
who have undergone a mastectomy to have poor lymph circulation in the arm on the side of the mastectomy. Because of this, these subjects cannot usually withstand pressure placed on the arm of the same side as the mastectomy. For example, if the woman has had her right breast removed, you will want to put the BP cuff on her left arm. If she has had both breasts removed, ask her on which arm she prefers to have the cuff placed.

**Blood Oxygen Saturation Monitor (Pulse Oximeter)**

The pulse oximeter when placed on the fingertip of the subject will display the subject's heart rate and percentage of oxygen in the blood. The pulse oximeter may be placed on any finger; however, we have found that it works best on the index or middle finger. You may place a piece of adhesive tape around the clip when it is on the finger to hold it securely in place.

The corrugated cable running from the finger clip to the pulse ox monitor contains fragile fiber optic wires. It is important that this cable is not stepped on or crushed. Please be careful with it. Damage to the fiber optics or a break in the corrugated cover could cause the pulse ox to malfunction or produce RF artifacts.

**NOTE:** For safety purposes, it is strongly recommended that the pulse oximeter be placed on all subjects who are having an MRI exam. If the subject should fall asleep in the scanner and become unresponsive when the investigator attempts to speak to them, the investigator will know whether or not the subject is O.K. or in distress based on the readouts from the pulse oximeter. This will save the investigator from having to stop the experiment to go into the magnet room to check on the subject. Also, if the subject should have heart failure or a breathing difficulty, the investigator will know immediately based on the readout from the pulse oximeter.

8. Removing Subjects from the MRI Scanner

If a subject requests to be removed from the magnet at any time, the investigator should do so promptly. Whether it be because of pain, illness, or claustrophobia, the investigator must never keep the subject in the MRI scanner against their will. If a subject asks to be brought out, communicate with them to determine the problem. You may ask the subject if they can continue. If not, remove the subject immediately.

9. Starting a Scan/Stopping a Scan in Progress

To start a scan simply “apply” the sequence. On the TRIO another message regarding the table position will appear, press “continue”. If the sequence has been programmed to “wait for user to start” another message window will appear, press “continue” to start the scan. To stop a scan click on the stop button on the control screen.

10. Oxygen/Suction/Room Air Supplies

All three Bays in the MRI research facility are equipped with oxygen, suction, and room air channels. In Bay 1, they are mounted to the wall to the left of the scanner. In Bays 2 & 3, they hang from the ceiling to the left of the scanner. Oxygen is marked by the
green hose or regulator, suction is white, and room air is yellow.

11. **Shutting Down the System** (not the magnetic field)

The System computers for the scanners in the East Building are never shut down. It may be necessary for the operator to reboot the scanner or shut the system down and bring it back up if applications are not functioning properly. The MRI Technologists will shut the system down if the building utilities are going to be off and if the system will not be in use for an extended period of time.

**Section VI: Data Acquisition and Management**

1. **Responsibility for Acquired Data, Archiving, & Deletion of Data**

All investigators are responsible for the data they acquire. Data must be transferred and archived immediately after the exam is complete in order to prevent loss of data by removal from the MRI system disks.

Data may stay on the MRI local data base for up to seven to 10 days. If the drives become full and deletion is necessary, the oldest studies will be removed first. If an investigator needs their data to stay on the local data base, advise the technologist that you would like it to remain temporarily on the system.

If studies are returned to the system, please delete them as soon as you are finished working with them.

Investigators may only remove their own data. All other MRI data may only be removed from the system disks by the MRI research technologists.
1. Mr. Jones is feeling a little claustrophobic during his exam and would like his wife to sit with him during his MRI exam. Mrs. Jones had a pacemaker implanted five years ago therefore it is permissible to allow her into the room now as long as she stays at least 10 feet from the front of the magnet.

a. True  
b. False

2. For subject safety purposes, which of the following items are contraindicated for an MRI scan.

a. orthodontic braces.  
b. orthopedic screws in the ankle placed 6 months ago  
c. aneurysm clips  
d. pacer wires (no pacemaker) left in the chest after open heart surgery 3 years ago.  
e. c & d only  
f. all of the above

3. You walk into the scan room and find a maintenance employee pinned to the magnet by a floor buffer. He is unresponsive but has a weak pulse. You immediately...

a. throw cold water on him.  
b. use smelling salts to try to rouse him.  
c. call his supervisor and tell him that the maintenance employee is sleeping on the job.  
d. call for help then attempt to free the employee. If unsuccessful, press the quench button to eliminate the magnetic field

4. While scanning a subject for a heart study, he suddenly complains of a stinging, burning sensation at the location of one of the electrodes placed on his chest for cardiac gating. You....

a. tell him to remain quiet until the sequence has finished.  
b. turn the radio up louder so you can't hear his complaint.  
c. tell him the stinging will subside in a few hours.  
d. immediately remove him from the magnet and inspect the area of the leads for loose or crossed wires.

5. When positioning the EKG monitoring cable on a subject for a heart study, it is OK to run the cable across the subject's body to plug it into the connector box.

a. True  
b. False
6. You have just positioned a subject inside of the magnet for a knee scan when she suddenly remembers she had a brain aneurysm repaired ten years ago. You...

a. rapidly pull the table out of the scanner, immediately lower it, and rush her out of the room as fast as possible.
b. continue with the exam because you are not scanning her head.
c. call 2-HELP
d. very slowly pull the table out of the scanner and then have the subject slowly slide onto a stretcher so that you can slowly cross her through the magnetic field lines and out of the room.

7. Which of the following is the current FDA recommendations regarding specific absorption rates for the Siemen's MR scanner?

a. not to exceed 1.5 W/kg(whole body)
b. not to exceed 3.2 W/kg(head imaging)
c. not to exceed 8 W/kg in any single gram of tissue
d. not to exceed an increase of 1°C core temperature or 38°C in the head, 39°C in the trunk, and 40°C in the extremities.
e. all of the above.

8. If a subject is unresponsive when you try to communicate with him in between scanning sequences, you should...

a. continue with the scan and assume that he is sleeping.
b. call 2-HELP.
c. defibrillate him.
d. pull him out of the scanner or at the very least go into the room to see if he is O.K.

9. To avoid the confusion that may be caused by the scenario in the previous question, it is a good idea to use the pulse oximeter on everyone that is placed into the magnet.

a. True
b. False

10. Your subject has informed you that he has worked as a metal grinder for ten years but he has never had any metal shavings fly into his eyes.

a. proceed with the scan since he has never gotten any metallic foreign bodies in his eyes.
b. do not proceed with the scan and at the discretion of the Principle Investigator, send the subject for x-rays of his orbital area to rule out possible metallic foreign bodies.

11. Your subject has informed you that she had a metal sliver enter her eye 10 years ago but that the doctor got it all out. You...

a. proceed with the scan since the metal sliver was removed.
b. do not proceed with the scan and at the discretion of the Principle Investigator, send the subject for x-rays of the orbital area to rule out possible metallic foreign body.
12. While performing a brain MRI on a twenty-four year old woman, she begins to complain of some stinging around her eyelids. Upon examining her you find out that she has permanent tattoo eyeliner. You...

a. terminate the exam, apply cold compresses to her eyes, and seek the proper medical attention.
b. apply ice-cold compresses to her eyes to lower the temperature in the area and then continue with the scan if she feels up to it.
c. tell the subject to shut her eyes and the pain will go away.

13. Your subject has had a heart attack while undergoing an MRI exam. You ...

a. call 2-HELP and immediately bring the crash cart into the magnet room to begin resuscitation measures.
b. call 2-HELP and bring the subject out of the room on a stretcher to begin resuscitation measures.
c. call Barnes hospital code team and bring the subject out of the room on a stretcher to begin resuscitation measures.
d. call 911 and bring the subject out of the room on a stretcher to begin resuscitation measures.

14. The table latch located on the TRIO bed when released will...

a. stop the table from moving.
b. set off an alarm that tells you the patient is moving around on the table during the scan.
c. release the table for manual removal of the patient during emergencies.
d. quench the magnet.

15. The red stop button on the Sonata and the Allegra’s gantry when pressed will:

a. allow the table to be moved manually
b. stop the table from moving

16. During the middle of a measurement, you hear the subject attempting to speak to you but you cannot hear her clearly. You...

a. ignore her and continue the measurement.
b. stop the measurement and speak to her.
c. stop the measurement and yell at her for interrupting.
d. terminate the entire exam.

17. Your subject tells you she had surgery twenty years ago on her brain but she can't remember exactly what it was for. You...

a. proceed with the scan because she seems credible.
b. cancel the scan for today until further investigation into the matter can occur.
c. tell the subject of the risks involved due to her lack of history and allow her to decide if she wants to have the MRI.
d. proceed with the test only after having the subject sign a waiver that releases us from responsibility of injury because after all it’s not our fault she can't remember her surgery.
18. Which of the following are contraindicated for an MRI exam?

a. cardiac pacemaker
b. Swan-Ganz catheter
c. aneurysm clips
d. all of the above

19. It is acceptable to loop an insulated surface coil cable around a subject's arm or leg to help keep the cable from getting caught in the table.

a. True
b. False

20. Cryogens are...

a. industrial strength cleaners.
b. sedatives.
c. liquefied gases used to cool a superconducting magnet and are deadly to breathe.
d. sewer gases.

21. A quench is...

a. a relief of thirst for a hardworking technologist.
b. a rain cloud that occurs inside of the magnet room due to overuse of the magnet by physicists.
c. a rapid, usually undesired, release of the cryogens which causes a rapid decline of the magnetic field.
d. the German word for magnet.

22. The first thing that you should do if a quench occurs is...

a. call 911.
b. call the service engineers.
c. immediately remove the subject from the scanner.
d. call the EPA

23. If during a quench the cryogens do not vent out of the room properly a vacuum may form making it difficult to open the door to the magnet room to get the subject out. If you are unable to open the door, you should...

a. sit and wait..
b. use a blow torch to burn through the door.
c. break the window between the control room and the magnet room.
d. panic.

24. If your subject becomes short of breath while in the MR scanner you should immediately grab the oxygen tank off of the crash cart and administer oxygen.

a. True
b. False
25. It is O.K. to let someone go into the magnet without emptying their pockets of metal objects if they are only going to be in there for less than a half hour.

a. True
b. False

26. Which of the following objects are approved for entry into the MR scanner room.

a. stethoscope
b. hemostats
c. employee I.D. badges
d. small paper clips and coins
e. none of the above

27. All Investigators are responsible for the data they acquire. Data is typically left on the scanners for how long?

a. indefinitely
b. 7-10 days
c. 3 months
d. it is deleted the next day

28. Upon arriving for your MRI session you notice that the previous user did not log out, what do you do?

a. use your own RIIS username\password to log the previous user out
b. track down the previous user and have them log out
c. cancel your session and notify the RIIS system manager
d. start scanning

29. If the subject sets off the patient alarm during the scan you should...

a. page the MRI technologists
b. tell the patient to be patient.
c. communicate with the subject to check on their status.
d. turn off the alarm and keep scanning.

30. Which of the following are contraindications for MRI?

a. cochlear implants
b. neurostimulators
c. patient controlled anesthesia devices
d. all of the above

31. Pregnant women should never be scanned in our research facility.

a. True
b. False

32. Pregnant research staff members are not permitted to enter the magnet room during the first trimester.

a. True
33. Which of the following is the correct method of investigating a metallic implant in a subject?

a. take the subject's word that their implant is non-ferrous.
b. call the surgeon responsible for placing the implant and get a detailed written operating room dictation explaining where the implant was placed, what it is, what it is made of, the manufacturer, and the model name and number.
c. ask the subject's family member.
d. call a physician referral service.

34. Any time a patient is scanned for research purposes, a medical doctor or other qualified medical personnel associated with the study must be present or in the near vicinity, and available at all times.

a. True
b. False

35. The MR compatible monitoring system that we have available to us is capable of measuring which of the following?

a. EKG and heart rate
b. blood pressure
c. blood oxygen saturation
d. all of the above

36. It is O.K. to leave a subject lying on the table outside of the magnet bore while you leave the room.

a. True
b. False

37. All subjects undergoing an MRI should be given ear protection in the form of earplugs or the noise cancellation headphones.

a. True
b. False

38. Every person that enters the magnet room should have completed a screening questionnaire regarding metal in the body.

a. True
b. False

39. It is mandatory that research subjects remove all metal, metal jewelry, clothing with metal on it, and pocket contents before having an MRI scan.

a. True
b. False

40. Metallic objects in the body will produce an artifact on the images that looks like...

a. a black signal void with bright edges.
b. a green streak.
c. a line through the image.
d. pink swirls.
41. If caught in the magnet room during a quench where should you place your body to avoid inhalation of the cryogens?

a. on top of the scan table.
b. perpendicular to the main magnetic field.
c. as close to the floor as possible.
d. pressed up against the window between the scan room and the control room.

42. The simplest way to stop a measurement is to...

a. click the left mouse on the stop button in the lower left hand corner of the scan console.
b. quench the magnet.
c. turn the key off.
d. speak the word "stop" into the microphone.

43. Which of the following is the correct reason to shut the MRI system down (not the magnetic field).

a. building utilities are to be shut off.
b. the scanner applications have locked up.
c. the system will not be use for an extended period.
d. all of the above.

44. When should the doors to the magnet rooms be shut?

a. when measurements are running.
b. whenever the system is not in use.
c. whenever there is the potential that someone not associated with the study will wander into the room.
d. all of the above

45. If an acquaintance of yours asks you to take them into the magnet room to look at it, what do you do.

a. take them right in.
b. insist that they empty their pockets and then take them in.
c. tell them absolutely not, under any circumstances will you let them in.
d. screen them for metal in their body as if they were a patient and if they are cleared, have them remove all loose metal from hair, pockets, and clothing, and then take them in the room.

46. All subjects must complete a consent form of some type before having an MRI scan in the research facility.

a. True 
b. False

47. A volunteer had an MRI scan six months ago and they are now participating again. What documents do they need to complete?

a. none, the ones they completed before are still good.
b. screening form only.
c. consent form only.
d. consent and screening forms.

48. Under normal circumstances when the MRI scan is not an emergency, subjects who have had non-ferrous metal e.g., orthopedic screws or plates, surgically implanted must wait how long before they can undergo an MRI scan?

a. 2-6 weeks
b. 5 years
c. 1 year
d. forever

49. Subjects who have had ferrous metal devices which are not contraindicated for MRI i.e., heart valves, venous blood clot filters, surgically implanted must wait how long before they can undergo an MRI scan?

a. 2-6 weeks
b. 5 years
c. 1 year
d. forever

50. After completing an experiment, you should...

a. leave the room clean and tidy.
b. leave the room as you found it.
c. leave the phantoms on the floor.
d. call the technologists to clean up the room.

51. Ferromagnetic objects are dangerous to take near the magnet because...

a. they can become projectiles and harm the subject.
b. they will burn the subject.
c. they become very heavy.
d. there are too many north poles and the subject gets dizzy.

52. The leads for cardiac gating must be handled as follows.

a. wound together and routed down the center of the magnet.
b. run in parallel across the subject's chest.
c. placed on the shin of the subject.
d. coiled in a loop and placed across the subject's chest.
e. none of the above.

53. Echo-planar imaging and other sequences can be quite loud. You should...

a. tell the subject to grin and bear it.
b. have the subject cup his hands over his ears.
c. use ear plugs or ear phones to dampen the sound.
d. have the subject sing during the scan to dampen the sound.

54. Consent forms must be signed by all subjects when non-FDA sequences are used.

a. True
b. False
55. While scanning a subject for a heart study, he suddenly complains of chest pain. You...

a. tell him to remain quiet until the sequence is finished.
b. ignore his complaints.
c. immediately remove him from the scanner, get him out of the room, and call 911.
d. give him a drink of water and put him back in the scanner to continue the exam.

56. All ferrous devices and devices containing motors or questionable ferrous parts should be secured when brought into the magnet room.

a. True
b. False

57. The five gauss line is...

a. a pixel line in the matrix.
b. the magnetic field line territory at which the magnetic field can become harmful.
c. a catheter inserted into the femoral artery.
d. a geometric theorem.

58. Where is the five gauss line located in our MR research facility?

a. at the front door of the building.
b. in the street in front of the building.
c. at the foot of the table.
d. at the opening of the magnet bore.
e. at the RF window/screen between the control room and the magnet room.

59. When a subject is in the bore of the magnet it is O.K. for the researcher to leave the control room ...

a. to check the weather outside.
b. whenever he feels like it.
c. when he wants to get himself a soda.
d. if, and only if, he gets someone else to monitor the subject for him while he is gone.

60. Potential subjects who have magnetically controlled artificial body parts or prostheses such as artificial limbs or eyes cannot undergo an MRI exam.

a. True
b. False
WASHINGTON UNIVERSITY, ST. LOUIS
MALLINCKRODT INSTITUTE OF RADIOLOGY
MRI SAFETY TRAINING
PART IV
COMPLETION DOCUMENTATION

_________ Siemens MRI safety video viewed

_________ MRI Safety Training Study Guide reviewed

_________ MRI Safety Exam completed\questions successfully answered

_________ MR Facility East Building, walk through completed

________________________________________________________________________ has completed the MRI Safety
(Research Staff\Investigator’s name)

28
Training\Orientation Program and has been approved to operate the MRI scanners on the first floor of the East Building.

Approval given by

_______________________________________________

Date: ____________________