

# Monash Biomedical Imaging

## Magnetic Resonance Imaging

### Safety Guide

MBI-REF-O001-V1

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## **EMERGENCY CONTACT NUMBERS:**

*In event of an emergency dial*

*333 from an internal phone, or*

*000 or 9905 3333 from an external phone.*

**Prof. Gary Egan** – Director, MBI

Mobile: 0419 556 695

e-mail: [gary.egan@monash.edu](mailto:gary.egan@monash.edu)

**Dr Nicholas Ferris** – Clinical Head, MBI:

Mobile: 0409 234 257

e-mail: [Nicholas.ferris@monash.edu](mailto:Nicholas.ferris@monash.edu)

**Richard McIntyre** – Chief radiographer.

Mobile: 0422 517 248

e-mail: [richard.mcintyre@monash.edu](mailto:richard.mcintyre@monash.edu)

Contact with other staff members via University switchboard or phone list next to MR console.

### **Siemens Service Centre**

Phone: 1800 310 300

Site Number: 110256

## 1. INTRODUCTION: MRI SAFETY POLICIES AND PROCEDURES

There are two MRI scanners located in the MRI laboratories at Monash Biomedical Imaging. Both magnets are superconducting magnets, and are on all the time. The MRI laboratories have specialised safety issues, most of which are unique to the MRI environment and others that are relevant to the clinical research setting. These are detailed below or on attached documents and staff should make themselves familiar with all safety issues.

All MBI radiology, radiography, scientific and other appropriate staff have been specifically trained in MRI safety and procedures as outlined in the training manual.

## 2. FIRE AND EVACUATION

Read the MBI safety manual. Internal Emergency Procedure Leaflets are positioned around the department and staff should be familiar with the different codes and procedures.

In an emergency there are four exits from the department. One is via the front north-west staff entrance, one is via the front northern general entrance, and the other two are via the eastern loading bay entrances. Each member of staff is required to undertake a fire and evacuation information session conducted by a security member annually.

## 3. SECURITY AND PERSONAL THREAT

**If a person becomes aggressive or violent towards a staff member or member of the public, security should be contacted immediately.** This can be done either by phone – ext. **333** on a Monash phone or **9905 3333** on an outside phone, or outside emergency operator – **000**. Please also refer to MBI safety manual.

## 4. MEDICAL EMERGENCY

All MRI clinical staff are medically trained. The first points of contact in event of emergency are the radiographer and radiologist.

### 4.1. Cardiac or respiratory arrest

If a subject has a cardiac or respiratory arrest in the unit...

1. Contact radiologist if in reporting room AND
2. Quickly remove patient from the Magnet Room.
3. Close the scan room door.
4. Call 000
5. Inform all relevant staff (Nurse if in attendance, First-Aiders) of the situation.
6. Certified first-aid staff should commence resuscitation.

### 4.2. Anaphylactic shock

Anaphylactic reactions are very rare in the MR environment. They are most likely to occur as a result of a contrast injection or an allergy to latex.

Signs of an anaphylactic reaction:

- Itch
  - Rash
  - Swelling
  - Shortness of Breath
  - Sweating
  - Vomiting
  - Nausea
  - Tachycardia
  - Respiratory Arrest
  - Cardiac Arrest
1. Remove the patient from the scan room and lock the scan door AND
  2. Contact the radiologist and member of nursing staff urgently to MRI
  3. Follow the guidelines for a medical emergency as explained above if situation require

## 5. PROCEDURE IN THE EVENT OF A MAGNET QUENCH

During a quench, the magnet loses its super-conductivity. The magnetic field ramps down in a matter of seconds - typically approximately 20 seconds. The magnet begins to warm up. Depending on the current helium fill level, liquid helium boils off at between 500 to 1500 litres within a few minutes and expands quickly. The exact amount depends on the helium fill level as well as the field strength of the magnet. One litre of liquid helium translates into approximately 700 litres of gaseous helium. During maximum conditions this means approximately 1000 m<sup>3</sup> gas. The purpose of the quench pipe is to securely exhaust gaseous helium to the outside. In rare instances, a spontaneous quench may be observed that cannot be explained by the presence of obvious external sources.

A quench is accompanied by hissing or whistling noises caused by the quickly escaping stream of cold helium gas. Plumes of white fog sink to the floor mainly from the upper part of the magnet and the vicinity of the quench line due to condensation of both water vapor and air. The stream of gas diminishes in a matter of minutes. Air near the non- insulated components of the magnet and the quench line condenses into liquid air and drips to the floor.

### 5.1. Risks associated with a failing quench pipe

The possibility of a quench was taken into careful consideration during the design of both the magnet and the helium quench line. As a result, a quench is completely harmless to personnel. Also, neither the magnet nor the MR installations are necessarily subject to damage during a quench.

Helium is lighter than air, non-poisonous and non-flammable. However, since it displaces oxygen, the risk of suffocation exists. Cryogenic helium escaping into the ambient air leads to white clouds caused by condensation. These clouds adversely affect visibility.

Persons may be rendered unconscious by the amount of helium entering their respiratory system. Depending on the helium concentration present, a few breaths suffice to result in unconsciousness.

In addition, escaping helium is extremely cold, causing hypothermia and frostbite. The latter results in injuries resembling burns (cryogenic burns) after the skin is exposed to normal temperature levels. Skin contact with cold parts or liquid air may also lead to frostbite.

In the case of failure of the quench pipe, the following may occur:

- Small leaks: Smaller amounts of helium gas are exhausted to the outside via the heating and air conditioning system and replaced by fresh air. This is not a critical situation as long as the heating and air conditioning systems function as required. Leakages are the result of errors during building construction and must be corrected.



- The quench pipe fails in part only: only part of the helium gas is exhausted to the outside via the integrated venting system. Larger amounts of helium may be present in the examination room. The heating and air conditioning may no longer ensure a quick air exchange. Large clouds may form that also impair visibility. Additionally, the pressure in the room increases. Depending on the size of the leakage, hazardous conditions may be present for the personnel involved.
- Total failure: the venting pipe fails completely, e.g. through blockage or breaks in the line. The entire amount of gas is blown into the examination room. Loss of life is imminent in the case of a complete failure. Up to 1000 m<sup>3</sup> gas are blown into the room, which frequently has a volume of less than 100 m<sup>3</sup>.

#### 5.1.1. Steps taken by the operator to minimize risks:

The planning as well as the installation of room venting and quench pipes must adhere to the planning requirements and be checked by trained personnel.

#### 5.1.2. Checking the exhaust system and room venting.

The helium boil-off system as well as the venting system must be visually inspected at regular intervals to determine possible changes.

### 5.2. Actions to take in the event of a quench:

- In the event of a quench, or other emergency, MRI scanner room staff will evacuate and seal off the MRI scanner room.
- An oxygen monitor will detect leakage of Helium and Nitrogen gas in the MRI scanner room. In the event of an alarm the staff will evacuate and seal off the area in question.
- If, in the opinion of the MRI scanner room staff or if present, the designated fire warden, the situation is sufficiently severe to warrant clearing the entire building, an evacuation protocol will be put into action.
- An elective manual quench should only take place where a member of staff decides that serious injury or death can only be prevented by the relatively immediate cessation of the magnetic field. Ferromagnetic objects that are merely stuck to the magnet without endangering staff or patients do NOT require a quench, and should be removed under technical advice.
- In the 3T MRI scanner room (Siemens Skyra magnet) the Magnet Rundown Unit is positioned to the right of the console and inside the room on the wall between the magnet and the generator room.
- In the 9.4T MRI scanner room (Agilent magnet), the Magnet Rundown Unit is in the room on the wall under a Perspex cover between the door and the glass window of the control room. Lift the Perspex and depress the red button. Try to have the scan door open when quenching if time permits. Emergency Off – The electrical isolation switch is located in the control room on the wall right of the console. It is NOT a quench button. See below.

- It should be noted that a rapid quench results in a temporary increase in the size of the magnetic field. After the quench a residual field may still remain for up to 2 minutes and staff should treat the magnet as though it still powered up.
- Refer to Siemens/Agilent magnet safety notes for quenching the magnet.
- Personnel should only return to the MRI suite if the situation is back to normal, that is, noises have stopped and visibility is no longer obstructed. For safety reasons, all rooms should be thoroughly aired and windows and doors (i.e. generator rooms and those leading to the outside) should be open. The air conditioning unit should be enough to cover for effective gas exchange.

### 5.3. Points to consider in the event of a quench:

- Usually, the strongest gas flow occurs only after several minutes and will subsequently subside. However, the course of gas flow is not fully predictable, since at the time of occurrence the type of error in the quench line is generally not fully known.
- Prior to opening the door to the MRI scanner room, all available doors of the control room should be opened to ensure sufficient ventilation. All personnel in the vicinity of the system who are not needed for rescue activities should leave prior to the rescue of a patient in the examination room. When opening the door, possible overpressure in the room should be factored in as follows:
  - The Siemens door opens inward and may be impossible to open due to increased pressure. There is an emergency opening under the observation window at the console desk that may blow out.
  - The Agilent door opens inwards into the magnet room, and so it may be impossible to open it due to the overpressure in the room. There is no emergency opening.
- After opening the door to the examination room, the helium gas may escape to adjacent rooms, endangering the safety of the rescue personnel. It is possible to check the air with an oxygen monitor. A gas mask does not protect against oxygen displacement by the helium gas. There are oxygen gas outlets in the facility for emergencies due to escaping helium. In addition to the risk of suffocation there is also the additional risk of hypothermia.
- Since the helium gas warms up quickly and spreads downward from the ceiling, a rescue worker standing upright is exposed to greater danger than a patient lying in the magnet.
- After the patient has been removed from the examination room, no personnel should remain in the vicinity of the system until the quench has been stopped and ventilation has been ensured.
- During a total failure of the quench line in the MRI scanner room, the room will be quickly filled with cryogenic helium gas. Customer service must be notified as quickly as possible to put the system back into operation.

## 6. OTHER EMERGENCY SITUATIONS

### 6.1. Emergency off – Siemens MRI scanner

The Emergency Off button is located on the wall outside the Siemens MRI scanner room on the left side of the operator's console and on the talk-pad. It removes ALL electrical power from the MRI console and the subject table, including any power sources from the Uninterrupted Power Supply (UPS) devices. The effect of pushing the Emergency Off button is to turn off the entire MR system is turned off EXCEPT for the static magnetic field and the magnet rundown unit (described below), hence this DOES NOT PRODUCE A QUENCH.

The button should be used ONLY TO STOP A SCAN DURING A SUBJECT EMERGENCY or DURING A SERIOUS EQUIPMENT FAULT OR HAZARD, such as fire or water in the vicinity of the MR equipment.

### 6.2. Procedure for power failure

In the event of a power failure, if an MRI scan is in progress, the subject will first be removed from the bore manually. Simply pull the subject table from the bore. Reassure the subject and explain the situation. Restart the computer software again, as described in the appropriate scanning manual – refer to the trouble-shooting guide in the Siemens protocol tips folder.

### 6.3. Emergency off – Agilent MRI scanner

The Emergency Off button is located on the wall outside the Agilent MRI scanner room on the left side of the operator's console and on the keyboard. It removes ALL electrical power from the MRI console and the patient table, including any power sources from the Uninterrupted Power Supply (UPS) devices. The effect of pushing the Emergency Off button is to turn off the entire MR system is turned off EXCEPT for the static magnetic field and the magnet rundown unit (described below), hence this DOES NOT PRODUCE A QUENCH.

The button should be used ONLY TO STOP A SCAN DURING AN EMERGENCY or DURING A SERIOUS EQUIPMENT FAULT OR HAZARD, such as fire or water in the vicinity of the MR equipment

## 7. MRI SAFETY AND RISKS

Key areas where caution needs to be exercised:

- The control of all personnel having access to the equipment and its immediate environment.
- The potential missile effect when ferromagnetic materials are present in a strong static magnetic field.
- Control of the exposure to both the static magnetic field, B<sub>0</sub>, the time varying magnetic field, B<sub>1</sub>, and to radiofrequencies to which individual patients and volunteers are subjected.
- The presence of large amounts of cryogenics (liquid helium and nitrogen) and their associated risks.

### 7.1. MRI Risks

#### 7.1.1. Powerful static magnetic field

There are small but important considerations on the effect of these fields on belongings, in particular watches and credit cards. Current recommendations are that conventional watches and credit cards should be excluded from static field strengths greater than 10 Gauss.

The static magnetic field is a constant phenomenon and the risks are present whether or not the MRI scanner is being used.

Static magnetic fields exert a missile effect on loose ferromagnetic objects. These must therefore be excluded from the area of high field strength.

Examples:

Watches        >10 Gauss

Credit cards   >10 Gauss

Missile effects - loose metal objects excluded > 30 Gauss

\* Refer to Journal Magnetic Imaging (2004) 19:141-143.

The magnetic field may also exert a torque on metal objects such as implants and arterial clips. In large metallic implants there may be significant inductive heat generation, although the examination equipment is designed to limit this to recommended safety margins.

The field may interfere with cardiac pacemakers and other electro-inductive devices. Current safety recommendations are that all patients with cardiac pacemakers and similar devices should be excluded from field strengths greater than 5 Gauss.

## 7.2. Radiofrequency signal & time-varying magnetic field

### 7.2.1. Heat Dissipation

The radiofrequency signals produced in MRI scanning interact with the patient and can lead to risks of burns and overheating. Radiofrequency loses its energy in tissue by both creating heat as it meets resistance in and on the tissues and by causing molecules to oscillate. In humans this is dissipated by blood supply to the area increasing, with the blood “carrying” the heat away to be disposed of, usually via the skin.

Any deficiencies in this system, either because of the amount of radiofrequency the patient is subjected to or an inability of the patient to dissipate the heat produced, can lead to burns or hyperthermia. These risks can be minimised by providing a good airflow across the patient and the application of cold compresses as well as close monitoring of the patient’s condition during the scan. The decision to scan a subject with a compromised thermoregulatory system lies with the consultant radiologist on duty.

### 7.2.2. Peripheral Nerve Stimulation

At low frequencies, induced currents are able to produce an additional effect of stimulation of nerve and muscle cells. The extent depends on the pulse shape and repetition rate. At sufficient amplitudes, peripheral nerve stimulation is perceptible i.e. tingling or tapping sensations. Subjects may become uncomfortable at amplitudes 50-100% above perception thresholds. There have been reported incidents of subjects experiencing peripheral nerve stimulation.

### 7.2.3. Biological Effects

Subjecting the body to time-varying electromagnetic fields leads to induced electric fields and circulating currents in conductive tissue. At any particular location, the currents induced will be determined by the rate of change of the magnetic field and the local distribution of the body impedance. In general, the faster the imaging sequence the greater the rate of change of the gradient fields and the resultant current density induced. To reduce this phenomenon the subject should be asked not to form closed loops by crossing their hands or legs. Pads (at least 7mm thick) can be placed between hands and body or between thighs/knees so as to prohibit contact of these areas.

Refer to SMRT Educational Seminar Vol 8, No 3 (15-17).

## 7.3. Acoustic Noise

The gradient coils sit inside the main magnet. The gradient current switches direction very rapidly during the pulse sequence and forces are exerted on the coils which cause them to vibrate in their mountings and emit sound waves in a process similar to a stereo speaker.

This noise causes concern for three reasons. Firstly, it has been established that MRI acoustic noise can lead to temporary shifts in the hearing threshold for patients (“Potential hearing loss resulting from MR imaging” Radiology (1988) 169:539-540). Secondly, noisy sequences can be expected to increase patient stress (“Anxiety in patients undergoing MR imaging” Radiology (1988) 170 463-466). Thirdly, staff who spend extended periods in the scanner room could face gradual and permanent hearing loss from long term exposure (“Measurement of acoustic noise during MR imaging: evaluation of six “worst case” pulse sequences” Radiology (1994) 191:91-93).

#### 7.4. Cryogenics

Liquid cryogenics present a risk if an inadvertent escape of gas causes displacement of atmospheric oxygen. This may occur during handling or storage, or due to destabilisation of the magnet. The latter causes a particularly rapid accumulation of large volumes of gas (quenching: refer to Procedure in the event of a quench outlined previously). There are also handling difficulties associated with cryogenics.

## 8. SAFETY CONTROLS

In the MRI scanner rooms these hazards are controlled by a combination of architectural, technical and operational factors.

The radiologist and radiographer are responsible for ensuring that only properly screened subjects are allowed to enter the MRI scanner room.

### 8.1. Controlled and Restricted Areas

All hazards due to the strength of the magnetic field are restricted to the magnet room. The entrance to the magnet room therefore is the final point of supervised access, to be known as the controlled area.

**All restrictions and controls as discussed in this document should be enforced prior to entry to the controlled area.**

Entrance to the MRI suite itself is controlled through doors fitted with electronically controlled locks operated by the MRI staff and at reception, with no person entering this area except under the supervision of appropriate staff. This area is known as the restricted area. This provides a safety buffer to more adequately control access to the MRI scanner room.

The doors at the point of access to the restricted area carry a sign displaying:

## WARNING STRONG MAGNETIC FIELD

Further signage on the security doors indicates:

Danger symbols. Danger of electromagnetic disturbances and implantations e.g. cardiac pacemakers, defibrillator, hearing instruments, insulin pumps, dosage deliverers for medication.

- NO PACEMAKERS
- NO METALLIC IMPLANTS
- NO NEUROSTIMULATORS
- NO FIRE EXTINGUISHES WITH MAGNETIZABLE HOUSING
- NO METAL PARTS AND MEDICAL INSTRUMENTS OF ALL TYPES
- NO IMPLANTS MADE OF METAL AND OTHER METAL
- NO OBJECTS IN THE BODY SUCH AS SPLINTERS
- NO OPEN FIRE
- NO DATA CARRIERS SUCH AS CREDIT CARDS AND IDENTITY CARDS WITH MAGNETIC STRIPS AND TAPES
- NO MECHANICAL WATCHES, ELECTRICAL DATA CARRIERS SUCH AS POCKET CALCULATORS, DIGITAL CLOCKS ETC.

All volunteer subjects, staff and visitors must complete a screening sheet before entry into the scan room. All people with contraindications to MRI as listed in this document will be excluded from the controlled area. Only properly screened subjects (and a relative or close friend if deemed appropriate) and properly screened personnel, will be allowed into the controlled area.

All persons needing to enter the controlled area will remove all ferromagnetic items, and other items such as watches and credit cards. Secure changing facilities and lockers are provided for staff and patients. Any equipment or accessories should be acknowledged and checked for MRI compatibility and deemed safe to enter the MRI environment, especially medical equipment brought in by staff or on patient beds. Such examples would include patient monitoring equipment, infusion pumps, catheter bags, oxygen cylinders, scissors and clamps.

The radiology and radiography staff in the restricted area will control access to the controlled area via the manually controlled MRI scanner room door. No one other than radiology staff (i.e. radiographers, radiologists clinical staff and other researchers working in the MRI scanner room on a permanent basis) is to be left unsupervised in the restricted area at any time.

In order to exclude the possibility of damage caused by missile effect, in the unlikely event of personnel entering in the absence of the radiology staff, the MRI scanner room door will be closed whenever possible.

## 8.2. Staff screening

Keys for the MRI scanner room doors are held only by the MBI Director, the MBI Clinical Head (MRI Supervisor), and the MRI Radiographer. The cleaning, engineering and security staff have been notified that no one is to enter the scan room without clearance from a radiographer or radiologist.

The scanner doors are to be kept closed as often as possible when not scanning to reduce the chances of someone entering the controlled area.

There are no known side effects of MRI on pregnant workers when the MRI scanner is being used. However, it is up to the discretion of each female staff member as to whether they want to be in the room if they are pregnant. Staff in the first trimester of pregnancy should not be in the controlled area (i.e. scanner room) when the MRI scanner is being used.

### 8.2.1. Radiology Staff

Radiographers and research staff who are sent to work in the MRI scanner restricted area must complete the MR Safety Induction.

All radiologists, researchers and radiographers that enter MRI need to complete a staff MRI screening form annually. This will be done in January or February of each year as changeover of staff can more frequently occur at this time. The completed screening forms need to be checked by the MRI Supervisor and the MRI Radiographer, signed accordingly and documented in the current year 'list of screened staff' book. The screening sheets are placed and subsequently kept in the staff safety file in the MRI Supervisor's office.

MBI research staff who are not anticipated to enter the MRI restricted area do need not complete the screening form annually. However, if they do have a reason to enter the magnet room at any time they will need to complete a MRI screening form each time they enter. This also applies to academic researchers and students and other staff from elsewhere in the university.



### 8.2.2. Other Staff

Education of all staff working in the area must be thorough. Cleaning staff, security, receptionists, trades-people etc. who might come in contact with the magnet room need to complete the staff screening form and have it approved by the MRI Supervisor or MRI Radiographer annually prior to entering the controlled area.

### 8.2.3. Other Health Staff

Staff who need to accompany subjects into the scan room for any purpose must have a reason deemed valid by the MRI radiographer. Their name is to be checked to see it is written in the current “years list of screened staff” book. If so they must then be asked if anything relevant to their MRI safety (as described above) has changed since their last visit inside the scan room. If their name is not in this book they then need to complete a staff MRI screening form and have it checked and cleared by the MRI radiographer and then written in the book. The screening forms should be filed in the appropriate folders in the staff safety file in the MRI Supervisor’s office. These staff must be given a clear indication of the precautions involved with the strong magnetic field and know what to do and what not to do in the various situations.

### 8.2.4. Cleaning staff

Cleaners must complete the safety screening form and have this checked by the MRI Supervisor or MRI Radiographer prior to them being sent to work in the MRI controlled area and annually thereafter. Cleaners must also view the MRI Safety information session provided and must ensure they understand the limitations applicable to MRI.

It is the responsibility of the Cleaning Company/Environmental Services to ensure that only staff that have completed the appropriate safety questionnaire and have it approved by the MRI Supervisor be sent to work in the MRI restricted area. The questionnaires are stored with other staff forms. It is also the responsibility of the Cleaning Company/Environmental Services that staff are aware of the safety precautions required to work in the MRI environment. The cleaning staff should not enter the controlled area (i.e. the scanner room) at any time. This room is the responsibility of the radiographers.

## 8.3. Subject screening

Before entering the scanner room all subjects must complete a safety questionnaire (Appendix 5). Those subjects who have had a scan in the last 6 months may fill out a limited form but it must be stressed that it is important to reveal any operations/incidents involving possible contraindications that may have become applicable since the last scan. This will identify any implants and possible dangers to the subject. The safety of any implants must be certified by the manufacturer or verified by the latest version of the implant publication by Frank Shellock and Emanuel Kanal (2007 edition).

If any implant is deemed unsafe or cannot be identified, the subject will not be allowed to enter the scan room, and the examination cancelled or postponed until the implant can be identified as safe. Decisions radiographers make can only be over-ruled by the head radiologist. Also reference can be made to the MRI screening action sheet, updated annually as a working guideline if the MRI Supervisor is unavailable

### 8.3.1. Prior to scan

- screening questionnaire to be verbally double checked by the MRI radiographer;

- read the subject consent and screening forms;
- make sure the consent form has been filled out as per protocol (i.e. signed by the subject) and refer any queries to the MRI Radiologist or the researcher;
- the MRI scanning protocol should already be assigned by the researcher or the radiologist on duty, and refer any queries as above;
- introduce yourself to the subject;
- check the identity of the subject as per the subject identification protocol
- emphasize the importance of accurate information/answers to the screening questions (including the possibility of significant subject harm if inaccurate answers are given)
- check all items on the screening sheet with the subject verbally (see documents for demented and paediatric subjects)
- note whether the subject's answers are plausible and consistent, and that the subject is of sound mind. If this is not the case, screening must be done via a close relative or friend who is certain of the answers. If this cannot be done the procedure must be postponed until the correct information is obtained.

### 8.3.2. Questions to double check (MRI contra-indications)

Have you ever had:

- an eye injury or worked with metal? If yes, then an X-ray of the orbits is necessary if the injury was caused by a high velocity penetrating piece of metal and if the subject was not told it was extracted in its entirety by a doctor.
- heart surgery? If the subject has had a valve replacement this must be identified and its safety determined. If the subject has had bypass grafts or a stent then we should wait until 6-8 weeks post-op before MR imaging. However titanium stents and clips, including those used in biliary and other procedures are safe to scan immediately.
- a pacemaker or permanent pacing wire? If yes, then a scan is not to be performed.
- any brain surgery or aneurysms clipped? If the subject has had aneurysms clipped the clips must be identified in writing (e.g. theatre notes or a letter from the surgeon) and deemed safe by the manufacturer, the Shellock publication or by the MRI Supervisor in writing.
- any ear operations? If the subject has had an inner ear implant, this must be identified and deemed safe prior to the scan.
- any recent surgery? If surgery has taken place in less than 6-8 weeks and there was, or could have been metal inserted during the operation, the type of metal must be researched. If there is a possibility this metal is magnetic then the scan should be postponed until the 8 week post operative period has elapsed. The subject can only be scanned at the MRI Radiologist's discretion.
- electronic or mechanical implants/ attachments (pumps)/ catheters? The examination is not to be undertaken until the item has been identified and certified as MRI safe.

Clarify problem areas, record them on the screening sheet and always refer to the MRI Radiologist if in doubt.

- Any other implants or items identified on the screening questionnaire must be considered and removed where necessary e.g. hearing aids, dentures etc. Removal of an item will depend on the body part being scanned e.g. dentures may remain if the lumbar spine is to be scanned. If there are any foreign bodies e.g. shrapnel that may move during scanning,

the location of the foreign body relative to surrounding structures must be ascertained prior to taking the subject into the scan room. Those not in a dangerous position should be good to scan e.g. a small piece of shrapnel in muscle, skin staples etc. In these cases it is important that the subject understands that they may experience pain, tingling or heating during the scans. If this occurs the scan is to be terminated and the subject to be slowly removed from the magnet.

- Please note there are many implants that have the potential to cause harm and possibly more severe adverse events. Some of these may not be specified on the screening form:
  - Breast implants
  - Cardiovascular Catheters e.g. Swan-Ganz
  - Stapes prosthesis
  - Enteral feeding tubes or their anchors
  - Epidural catheters Ocular implants/springs Endovascular filters or stents
- Only some of these are inadvisable in the magnet environment. Accurate identification is required before scanning the subject.
- It is important each subject be screened appropriately and according to the guidelines above and those in published safety documents. If unsure about any implants or safety issues, please refer to the above-mentioned reference books or contact an MRI Supervisor. If the issue cannot be resolved satisfactorily, the subject must not be taken into the scan room.
- Relatives or close friends entering the scan room must fill out a limited visitor screening form.

Refer to Appendix 1 for specific criterion for MR safety inclusion/exclusion.

## 9. APPENDIX 1: ISSUES TO CONSIDER WHEN SCREENING A PARTICIPANT

The following table outlines some of the issues that may be identified. The radiographer and radiologist are responsible for determining whether the participant can be scanned. The table provides information for researchers, but is not intended to be a direct decision regarding whether an individual may be scanned at MBI. In all cases the decision of the radiologist/radiographer is final, and should be take into account the risks vs. clinical need for the scan.

Weight and height	Important to set SAR limits.
Have you had a previous MR?	Keep current & previous MRI's & CT's for comparison. Gives information about the patients past experiences & possible comparison images.
Ever had any eye injury by metal?	<b>To be discussed with radiographer.</b> If the subject answers yes to all the sub-questions then proceed with scan. If unsure or answers no to any question then <b>do not scan</b> .
Are you pregnant or suspect you are pregnant?	<b>To be discussed with radiographer/ Not scanned at MBI if positive pregnancy test obtained.</b> If the subject is not sure about pregnancy, then <b>the scan should not proceed</b> until a pregnancy test is carried out. If the subject is pregnant, then <b>do not scan</b> .
Staff pregnancy or relative pregnancy (e.g. mother accompanying child)	<b>To be discussed with radiographer.</b> Policy is that pregnant staff and visitors should not go in whilst the scanner is operating.
Scanning breast-feeding mother using IV contrast.	<b>Not applicable</b>
Cardiac Pacemaker / Defibrillator.	<b>Do Not Scan</b>
Retained Pacing wires	<b>Do Not Scan</b>
Internal defibrillator	<b>Do Not Scan</b>
Artificial heart valve / annular rings.	<b>To be discussed with radiographer.</b> Get make & model number (subject usually has info card). If information is not available, <b>do not scan</b> & request subject history for operation notes. Some are magnetic but the force exerted on them during the scan is less than that during their function.
Cardiac Stents	<b>To be discussed with radiographer.</b> Do not scan within 6-8 weeks after procedure.
Brain Aneurysm clips	<b>To be discussed with radiographer.</b> Many used today are safe – made of Titanium. Must check through written information from Surgeon, or operation notes to identify type. <b>Do not scan</b> if any uncertainties regarding the make and model remain.
Aneurysm Repairs	<b>To be discussed with radiographer.</b> Some thoracic & abdominal stents cause a large artifact & deflection & maybe unsafe.

Swan Ganz catheters.	<b>To be discussed with radiographer. Do Not Scan.</b> Only Triple lumen thermodilution catheters can heat up & possibly melt – they have a wire in them. All others vascular catheters without thermal wires are OK.
Neurological / muscular stimulators	<b>Do Not Scan</b>
Bone / spinal fusion	<b>Do Not Scan</b>
Neuro Stimulation	<b>Do Not Scan</b>
Cochlear Implant	<b>Do Not Scan</b>
Otological implants	<b>To be discussed with radiographer.</b> Determine type & model. Will require obtaining operation notes or identification card. Unsure of type of implant, or existence of implant – <b>Do not scan.</b> Items such as grommets are safe.
Spinal shunt Tube /Cerebral spinal shunts	<b>To be discussed with radiographer.</b> Generally safe to scan as long as there are no pump or valve systems. Check operation notes / doctor. Some epidural catheters maybe an issue.
Vascular access port	<b>To be discussed with radiographer.</b> Safe. Some are metal & some are silicone. Presence has to be recorded just in case of an artifact
Cardiac stents	<b>To be discussed with radiographer.</b> Delay scan 6 weeks after surgery.
Drug infusion Pumps	<b>To be discussed with radiographer.</b> <b>No Pumps, internal or external are allowed to enter the MRI Scanner room.</b> They may act as a projectile, or as with internal pumps- be permanently damaged. Slow infusion pumps may still be used outside the room, running through the RF waveguide.
Monitoring devices	<b>To be discussed with radiographer.</b> Only MRI safe devices may be used. No external departmental devices maybe used. Check with the radiographer about any equipment before taking it into the room. This includes all other blood pressure, pulse oxymetry, ECG. All ECG dots must be removed (possible burning) & fresh dots applied. The ECG MRI monitoring dots are placed in different locations to the normal.
Embolisation coils	<b>To be discussed with radiographer.</b> Must research make and model to assess safety.
IVC Filters	<b>To be discussed with radiographer.</b> These are safe, although some require 6 weeks after implantation before scanning. It is preferable to wait 6 weeks post implantation.
Ocular implants or surgery.	<b>To be discussed with radiographer.</b> Cataract surgery is safe. Some retinal tacks, eyelid springs are unsafe. Some eye socket implants are magnetically held in place & should not be imaged.
Joint replacements or Prosthesis	<b>To be discussed with radiographer.</b> Should note presence to explaining possible artifact. Usually unable to scan area of implant.

Surgical Clips or wires.	<b>To be discussed with radiographer.</b> Generally safe after 6 weeks. Again note to explain possible artifacts. Carotid vascular clamps need to be checked. Sternal wires are safe. Other wires have already been discussed.
Cranial flap repairs	<b>To be discussed with radiographer.</b> Safe – may cause a slight artifact.
Metal in bone (screws or plates)	<b>To be discussed with radiographer.</b> Safe but will cause artifact in region.
Metal or mesh in soft tissue.	<b>To be discussed with radiographer.</b> Mesh e.g. post hernia repair is safe. Metal in soft tissue will produce an artifact. Maybe dangerous, e.g. near spine, brain, neck, abdomen. Items just under the skin on extremities should be all right. It may cause heating or discomfort. Give the subject the alarm buzzer in case they feel any of these effects. In these cases remove the subject SLOWLY from the magnet. May have to x- ray & always discuss with Radiologist. <b>Do not scan</b> if there are any doubts.
Shrapnel, bullets	<b>To Be discussed with a radiographer.</b> Depends on the location of the foreign body relative to blood vessels and nerves.
Penile prosthesis	<b>To be discussed with radiographer.</b> Check make and model.
IUD & diaphragms	<b>To be discussed with radiographer.</b> Some diaphragms and IUDs are magnetic & may need checked after the examination.
Breast implants	<b>To be discussed with radiographer.</b> Saline & silicone implants are safe. Expander implants use magnetic ports and are not suitable for imaging. Dislodgement & damage may occur.
Tattoos –including cosmetic e.g. eyeliner etc.	<b>Only tattooed eyelids need be discussed with radiographer.</b> All others are safe. Possibility of heating, or strange sensations. Warn subject & if they have difficulties they can inform you and the scan will be abandoned. Give the subject the emergency buzzer in case of heating.
Hearing aids	<b>Must be removed</b> – will be damaged by the scanner.
Watches	<b>Must be removed</b>
Wallets / hand bags	<b>Not to enter the scan room.</b> Scanner will damage magnetically encoded cards, & items may become projectiles.
Personal items	Metal & any electronic devices must be removed before entering the scan room. They may become projectiles or be damaged. Belts, braces, hair clips etc. are often highly magnetic.
Dentures, Partial plates	Dentures don't need to be removed for areas other than the cervical spine & brain. If scanning these areas & they have metal- remove them. Partial plates always have metal & must be removed when scanning the head or cervical spine.
Operation in the last 8 weeks.	<b>To be discussed with a radiographer.</b>

Drugs prior to the procedure.	<b>To be discussed with radiographer.</b> Gives background information about the subject. Also some drugs may cause changes in the imaging.
Asthma	An added situation to be aware of. Bad asthmatics often like to use their puffer before the scan to help them breathe. Let them do this outside of the room.
Allergies	<b>Do not give gadolinium contrast to any patient at MBI with any allergy.</b>
Transdermal patches	<b>All transdermal patches to be removed.</b> Foil patches especially bad but also other drugs used in clear patches may have metal ingredients and so cause burning.
Surgery in region of scan / Radiation treatment	Appearance change or artifact may result
Halo vests	<b>Do Not Scan</b>
Noise sensitivity	Subject <b>MUST</b> have earplugs or headphones.

### 9.1. Signatures on screening forms

Signature	Subject must sign the screening form.
Staff Signature	Radiographer must read the subject's form, noting any items indicated by "yes". Make notes in the margin if needed, e.g. date of implant. Also note if the implant was checked & deemed safe. Initial this note. Note which Radiologist checked x-rays.

## **10. APPENDIX 2: CONTRAST INJECTIONS FOR MRI**

Contrast administration is NOT to be performed in humans at MBI.

## **11. APPENDIX 3: INTRAVENOUS SEDATION / ANALGESIA**

Intravenous sedation/analgesia is NOT to be performed in humans at MBI



## 12. APPENDIX 4: PRACTICAL OPERATIONAL ASPECTS

### 12.1. Protocol for incorrectly completed request forms

Researchers are responsible for ensuring that the safety/contraindication section on the subject form for MRI scans is completed before the MRI booking. If the subject form is not filled in completely then the subject must be refused a scan until the relevant information has been completed.

The subject should not be presumed to be safe to have an MRI scan just because the questions have been answered on the subject form. It is still the MRI Radiographers' responsibility to screen the subject in a thorough manner.

On occasions where incorrect details are completed on the subject form give a photocopy of the form along with notes about incorrect information to an MRI Supervisor. If any evidence of incorrect information is available these should be included as well.

### 12.2. Storage

- Scans performed on all human subjects are stored on the Picture Archival Storage (PACS) system (DaRIS) permanently. Access to these can be made through the internet retrieval system.
- Record of scans and technical factors
- All scans done on human subjects are to be entered in the File Maker Pro ordering system, and so a record of exams must be kept on this system. Talk to the MBI receptionist for further details.
- Technical factors are stored on the images kept in the DaRIS system.
- All scans are also kept in the examination logbook. This data includes dates, names, subject numbers, examination done, radiographer(s) and referring researcher(s).

### 12.3. Manual Handling

All lifting and subject transport/positioning are to be done according to the procedures and policies as outlined in the manual handling and lifting ide.

Subject slides are available for use.

### 12.4. Visitor Arrangements

Visitors are welcome to come and view the MRI scanner and the surroundings between 8.30am – 5pm if the workload permits. Entry into the control room must be permitted by the researcher and participant in advance.

All visitors (including MBI staff) must call the control room from reception and request entry into the room between 8.30am-5pm.

### 12.5. Incident reports

It is the duty of the MRI Supervisor to report all violations of safety procedure and accidents to

Management. The MRI Radiographer will document any of the following incidents. A copy must be sent to the responsible OH&S officer and appropriate university authorities.

Appropriate details include:

1. Incidents in which any person was injured.
2. Incidents requiring the emergency quench of the magnet.
3. Incidents involving damage or potential damage to MRI and ancillary equipment.
4. Conditions that constitute a safety hazard.
5. Incidents in which an approved protocol was not followed causing an unsafe condition

## 13. APPENDIX 5: SCREENING FORMS

### 13.1. Standard screening form

#### MRI Appointment, Screening & Information Form

Please complete **BEFORE** scan and bring with you to MBI on the day of the scan

Surname: ..... Given Names: .....

SEX: M / F    Address: .....

..... Post Code ..... Date of Birth: ..... / ..... / .....

Age: ..... Phone: .....

Your MRI appointment has been scheduled for: Date: ..... / ..... / .....

Arrival time: ..... am/pm    Scan time: ..... am/pm

Your Contact Person /Researcher's Name (if known): .....

MBI Project ID (if known): MRH.....

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#### WHAT IS MRI? ARE THERE ANY RISKS?

Magnetic Resonance Imaging (MRI) uses radio waves and very strong magnetic fields to make detailed pictures of the inside of your body.

There are no known harmful effects, from either the radio waves or the magnetic field, on your body. However, some people have electronic devices (such as cardiac pacemakers), metal fragments in the eye, or surgically implanted metal objects, which could be badly affected by the strong magnetic field. Attached is a detailed safety questionnaire about such objects, to help us decide if there would be any risk to you during an MRI scan.

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#### PREPARATION

No special preparation is necessary – please eat, drink and take usual medications normally. Please do not use makeup or hairspray if you are having a scan of the head, face, or neck.

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#### WHAT WILL HAPPEN?

We will review the questionnaire sheet with you, to double-check any possible risks.

We will then explain the scanning procedure to you, and will be happy to answer any questions you may have. You can also ring us in advance – 9905 0100

Before you enter the MRI scan room, you will be asked to take off your watch and any metallic jewellery. Occasionally you may be asked to change into a hospital-style gown. Items such as CREDIT CARDS, PAGERS, and MOBILE PHONES MUST NOT be brought into the scan room – they may be severely damaged, and may also be hazardous to other persons in the room. A locker will be provided for safekeeping of such objects, other valuables, and clothing.

The MRI machine looks like a large metal doughnut. The table on which you lie passes through the middle of the doughnut; the part of the body being scanned must be positioned at the centre of the doughnut. Cushions and pillows will be provided to make you comfortable on the table, and mirrors will allow you to see out of the "doughnut".

During the scan, it is important that you keep as still as possible - particularly when the scanner is making noises. You will hear various clicking, tapping, buzzing and banging noises during the scan - these are quite normal. They are sometimes quite loud, and headphones or earplugs will be provided to protect your ears. If you wish, music of your choice can be played through the headphones during some scans. The scan will take between 15 and 45 minutes. At all times, you will be able to talk to us through an intercom system built into the MRI machine. We will speak to you periodically, through this system, throughout the scan.

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#### AFTER THE TEST

Once the scan is completed, you will be free to get dressed and go. There will be no after-effects from the scan. Although the MRI scans are setup for the individual research projects and not chosen to show clinical information, they will be viewed and reported by an MRI radiologist.

Name: ..... Age: .....  
 Weight: ..... Kg Height : ..... Date of Birth: ..... /...../.....  
 DARIS Number (to be filled in by researcher on the day of scan) .....

**TO ENSURE YOUR SAFETY & COMFORT PLEASE ANSWER THE FOLLOWING:**

Have you ever had any eye injury caused by metal? ..... NO / YES  
 If yes, did you see a doctor at the time? ..... NO / YES  
 Did they remove the foreign body? ..... NO / YES  
 Did they tell you that they got it all out? ..... NO / YES  
 Was this the last injury involving metal? ..... NO / YES  
 Are you pregnant, suspect you may be pregnant or breastfeeding? ..... NO / YES

**Do You Have (Or Have You Ever Had):**

A Cardiac Pacemaker/stent/defibrillator/wire ..... NO / YES  
 Any heart operation or valve replacement ..... NO / YES  
 Any Brain operation ..... NO / YES  
 Abdominal Aneurysm repair or IVC filter ..... NO / YES  
 Brain Aneurysm Clips ..... NO / YES  
 Deep Brain Stimulator ..... NO / YES  
 Brain Shunt Tube ..... NO / YES  
 If YES, is it programmable ..... NO / YES  
 Any Ear operations /cochlear or stapes implants ..... NO / YES  
 Implanted drug infusion devices ..... NO / YES  
 Neuro or Bone growth stimulator ..... NO / YES  
 Shrapnel, bullet, gunshot ..... NO / YES  
 Any stents, vascular, oesophageal or biliary ..... NO / YES  
 Any Surgical clips/wire sutures/screws/mesh/prosthesis ..... NO / YES  
 Joint Replacement or Prosthesis ..... NO / YES

**Do You Have:**

Ocular prosthesis (eye implants) ..... NO / YES  
 A Swan-Ganz Catheter..... NO / YES  
 Skin patches ..... NO / YES  
 Intrauterine device (IUD) ..... NO / YES  
 A penile prosthesis ..... NO / YES  
 Any other implant, or breast tissue expander ..... NO / YES  
 Tattooed eyelids or tattoos ..... NO / YES  
 Hearing Aid ..... NO / YES  
 Removable dentures ..... NO / YES

**Have You:** **What? / When?**  
 Had an operation or procedure within the last 8 weeks NO / YES .....  
 Had a history of seizures or epilepsy NO / YES .....

**IF YOU ANSWERED YES TO ANY OF THE ABOVE QUESTIONS PLEASE PHONE MRI RECEPTION ON 99050100 BEFORE ATTENDING**

Have you had a previous MRI ..... NO / YES

Print Name.....  
 Signature ..... Date ..... /...../.....

**If not completed by Subject**, the name of the person completing the form .....  
 Relationship to the Subject .....  
 Contact number (mobile) .....

**Would you be willing to be contacted about possibly participating in another study? YES / NO**

**MBI / MRI Staff**  
 Print name..... Signature ..... Date ..... /...../.....

## 13.2. Accompanying persons form



### Magnetic Resonance Imaging Limited Safety Screening Form

For those accompanying subjects into the scan room

Surname: ..... Given names .....

Position: ..... Date: ...../...../.....

**To ensure your safety please read the following carefully  
and answer all the questions**

#### **Have you had any of the following?**

1. A brain aneurysm clipped? ..... YES / NO
2. A pacemaker inserted? ..... YES / NO
3. Any heart operations? ..... YES / NO
4. Any metallic or electronic implants? ..... YES / NO
5. Do you think you could be pregnant? ..... YES / NO
6. Have you had any metal injury to the eyes? ..... YES / NO  
If you have had an eye injury, did a doctor remove it  
and tell you it was all out? ..... Yes / No / Not applicable
7. Any ear operations? ..... YES / NO
9. Any shrapnel, gunshot injuries? ..... YES / NO
8. Any other implants e.g. stents, surgical clips? ..... YES / NO

If so, please list .....

.....

.....

Please remove: watches, mobile phones, pagers, wallets, credit cards, and loose metallic objects (e.g. forceps and scissors)

Jewellery, dentures, and clothing with metal clips and buttons  
are alright to wear into the scan room

If you have any questions please ask the technologist

**DO NOT TAKE ANYTHING INTO THE SCAN ROOM  
WITHOUT ASKING THE TECHNOLOGIST**

Signed..... Print name..... Date...../...../.....

Checked and signed  
(Radiology Staff)..... Print name..... Date...../...../.....

**MONASH BIOMEDICAL IMAGING**

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