Acute human injuries call 010-103 1100

Or push the red button on the little emergency box between the CT and MR, with the text '*sökning av läkare vid akuta problem*'.
Note that you have to evacuate the patient/ research subject before pushing the red button.

Fire call 112

Fire extinguisher is located between the two MR scanner rooms.

The fire extinguisher is MR-safe and can be brought into the MR room. There are also automatic sensors that set the alarm. Manual fire alarms are at the entrances of CMIV, together with the fire hoses.

To shut down the electrical power push the red button, at the console, or at the scanner door.

Note that this will leave the magnet on field.

Danger related to the magnetic field

To shut down ('quench') the magnetic field push the red quench button above the console or inside the scanner room. Do not quench the magnet unless absolutely necessary, this is very expensive.

Pushing this button will result in a quench of the magnet which takes about a minute. It will not shut down water or electrical power. Quenching the magnet is very expensive: It may take about 2 weeks and > 200.000 SEK to reinstall the system. If there is time, it is better that Siemens Service ramps it down.

After a quench of the magnet, evacuate the magnet room immediately and close the RF-door.

A quench is in principle not dangerous because the system is designed to cope with it. However, about 1500 liters of helium at -269 °C is evaporated into a quench pipe leading outside. To avoid any risk of suffocation the RF-door should be closed and the surrounding rooms ventilated. After the quench some parts of the system might be extremely cold.

Technical Emergency: Call Medical Engineering 010-103 6000
Siemens Service Sweden: 020-225022
Security: 070-243 9570

MR Safety Handbook at CMIV

In this document an overview of potential risks associated with the use of magnetic resonance scanners at CMIV is provided. The basic safety rules, as well as normal conduct around the MR system, is described. Mostly this is all common sense and with normal use MR is completely safe. There are millions of MR-examinations conducted yearly and accidents are rare. However, the consequences of accidents can be dreadful and it is important to work with safety in mind at all times
At CMIV a lot of research is performed and not everyone working with the scanner may be properly trained or sufficiently experienced. Negligence or a lack of concentration might lead to serious accidents. The MR-system is a very powerful machine which is carefully controlled but one can never rule out human error. **Please take a moment to go through this document carefully**.

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1. Immediate doctor assistance

If you need immediate doctor assistance, you can call 010-103 1100 or push the red button on the little emergency box that sits between the MR and CT on the other side of the corridor. It only has a Swedish text ‘sökning av läkare vid akuta problem’.

Note that you have to evacuate the patient/ research subject before pushing the button.

Fig. 1. *Immediate doctor assistance button*

2. Extra ordinary events

There is an action plan in case of extraordinary events at the MR scanner. This action plan is available both digitally and in paper format in a plastic pocket at each MR scanner's control room. Link to the digital action plan can be found here:

https://ledsys.lio.se/Document/Document?DocumentNumber=30540

2.1. Stopping the scanner

The MR software provides many build-in checks and controls to make it impossible to inflict any harm on the patient within normal use. Moreover, the status of the hardware is constantly monitored. A malfunction will lead to a hardware interrupt that will immediately stop the scanner. Opening the magnet room door will also stop acquisition.

You can stop the scanner drastically by hitting stop on the system controller left of the console. This will cut power to the system and may cause a loss of data. Please use in emergency only.

2.2. High static magnetic fields

The magnetic field of a 1.5 T (or 3 T) scanner is 75 000 times (or 150 000) stronger than the earth's magnetic field. It can easily pull vacuum cleaners, keys, scissors, iron patient beds or oxygen tanks into the bore of the magnet, which might seriously injury a person inside or close to the scanner. Persons with pacemakers, aneurism clips or metal implants as well as pregnant women are not allowed inside the magnet room without special considerations.

Please take care to remove all pens, scissors, keys, etc. from your pockets. Note that information stored on your plastic card will be erased in the vicinity of the magnet. In other words: empty your pockets before going into the magnet room and monitor that others do too.

The scanner has an actively shielded magnet which means that the field strength goes up substantially within a short distance. In the magnet room the 2 mT (blue line) and the 20 mT (red line) areas are indicated. The 0.5 mT safety limit is typically confined within the scanner room walls. Once the magnet pulls something in you will not be able to hold it.

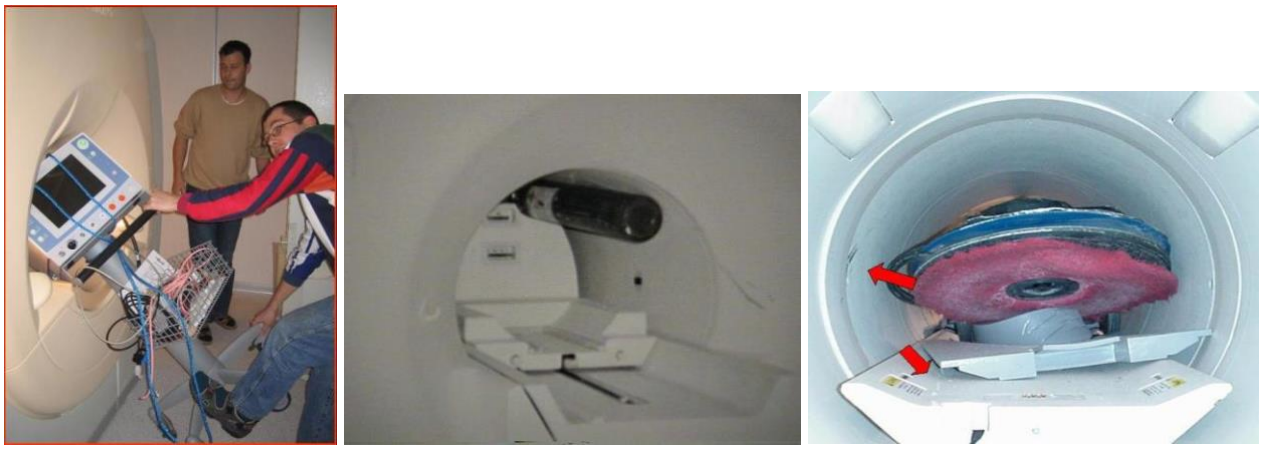

Fig. 3. *Examples of equipment pulled in the magnet: monitoring equipment, an oxygen tank and a vacuum cleaner.*

When anything happens that requires the magnetic field to be shut down, push the red button top right of the console or the one on the right side of the door inside the magnet room. Pushing this button will result in a quench of the magnet. A quench may take up to one minute to occur. A quench is when the superconductivity of the magnet windings is disrupted and the magnet currents start to heat up the system. In that case all helium is evaporated through a so-called quench pipe that leads to the exterior of the building. Since the system contains ca. 1500 liters liquid helium it will turn into more than 1000 m^3 of cold gas. The current in the magnet will come to a stop and the magnetic field disappears. To avoid any risk of suffocation by helium, evacuate the magnet room, the door should be closed and the surrounding rooms ventilated. After the quench some parts of the system might be extremely cold. Quenching the magnet is very expensive: It will take about 2 weeks and at least >200.000 SEK to make the system operational again. If the problem is not associated with immediate injury or risk of injury, it is far better to call Siemens service to let them ramp down the machine gently. This will only cost one day to make the system operational again.

Fig. 2. *Quench button for MR6. Also the button for start/stop of the entire scanner is shown here.*

3. High gradient fields

MR imaging relies on a spatially dependent, changing magnetic fields to determine where signal is coming from in the patient. These so-called gradient fields are rapidly turned on and off during scanning. A rapidly changing magnetic field can induce a current in anything that is electrically conductive (metals, carbon fibers, tissue, salty liquids), hence including nerves. A high gradient field therefore might lead to involuntarily movements (peripheral nerve stimulation, PNS), cardiac arrhythmia or pain. Gradient fields are both hardware and software controlled and will rarely get into a region where they can be sensed by a human subject.

4. High RF power

4.1. SAR

MR-signals are induced by a high power Radio Frequent Body Coil, located inside the bore of the magnet. These radio waves may heat up tissue to an extent that is determined by the power which is applied. The heating of a patient during an exam is strictly governed by regulations and with a high-power scan you will be notified on the console for a high (but acceptable) SAR (Specific Absorption Rate) value. The maximum overall SAR limit is 4W/kg (whole body average), which means for an average 70 kg person the applied RF-power will be 280W. For comparison, a patient at rest generates around 100W on its own, so a high power scan, especially for the abdominal region, can be felt as a warming sensation. The correct interpretation of the SAR model relies partly on you to give the correct weight and birthday of the patient in the database.

Note that a large fraction of the patient is actually outside the 70 cm Body Coil during scanning; hence locally the power deposition will be much higher, up to a maximum of 10 W/kg. To help the patient body temperature stay normal, the magnet room is air-conditioned and there is a ventilation fan inside the bore. It is advised to have the patient only wearing light clothing and to have regular voice contact with the subject during scanning. Make sure the fan works properly.

Under normal circumstances the SAR is well controlled by the scanner itself. However, inappropriate use of the RF coils might lead to much higher SAR values than what the system can predict and control

for. What can happen is that the conducting parts of the RF coil ‘couples in’ RF power from the Body Coil into the patient. This may happen if you curl up the coil cable into a loop, or use a combination of coils inside the bore that together can form a loop. RF coupling might lead to heating burns, where the coil itself reaches a high temperature or, even worse; it might lead to an RF burn. An RF burn is RF induced heating inside the patient, underneath the skin. This is sometimes not felt by the patient, only a day later when the burn turns into a subcutaneous blister. In other words, follow the instruction for use regarding the coils!

4.2. Skin to skin burns

A sweaty or wet patient body can conduct an RF induced current. At a place where there is a skin-to-skin contact the current might cause an arc across the skin contact area, resulting in a burn. This means that you can create an RF burn without even using a surface RF coil. Avoid contact between the subject (extremities, etc) and the bore of the magnet, as this may lead to similar arcing and subsequent skin burns; there should be a distance of at least 5-10 mm to the bore of the magnet. In other words: keep the patients dressed, preferably use patient clothing of natural fibers, not synthetic.

4.3. Interference with other medical equipment

The magnet room is a shielded room, where no radio-frequent noise from outside the room can interfere with the MR imaging. It is simultaneously shielded to keep the RF, generated during scanning, inside the room. You are warned at the entrance of the hospital to shut down your 10W mobile phone. The RF Body Coil acts as a transmitter that is capable of delivering about 5000W. This means that you should always keep the door closed during scanning in order to prevent other medical equipment in the hospital to malfunction.

5. Implants

There are several different risks and considerations regarding implants that it's important to be aware of. At the same time, it's necessary to understand that not all implants carry the same level of risk. Here are some of the dangers and risks that can arise:

1. **Heating and Burns:** Some implants, especially those made of metal, can heat up during an MRI examination due to their interaction with the strong magnetic fields and radiofrequency waves. This can potentially lead to burns or discomfort for the patient.
2. **Displacement or Movement:** Implants, especially those that are not securely anchored or are made of magnetic materials, can move or shift during the MRI examination, leading to complications or discomfort.
3. **Malfunction:** Some electronic or mechanical implants can be sensitive to malfunctions due to the magnetic fields and radiofrequency energy generated during an MRI examination, such as pacemakers.
4. **Artifacts:** Implants can create artifacts that can affect the quality and diagnostic accuracy of the MRI examination.

5.1. Tattoo and permanent makeup

Also tattoos and permanent makeup may contain metallic ink, which can pose a risk of heating and burning injuries during an MRI scan. Assessing their safety can be challenging as ink has not traditionally been labeled as "MR-safe" or "MR-unsafe".

5.2. Handling implants

The fundamental rule to remember when dealing with implants, tattoos, permanent makeup, and similar complications is as follows:

Never permit anyone to enter the MRI room if you have any doubts about their safety in this environment.

As a researcher, you have a responsibility for the safety of the participants in your research study, including the management of implants and related concerns. However, it's worth noting that there are people to turn to when questions about safety concerns arise:

1. **MR Personnel:** If MR personnel is nearby, you can consult with them, provided they have the time to assist. They are trained and have access to databases of commonly occurring implants.
2. **Medical Responsible Doctor:** Every research study with participants has a medical responsible doctor who can be consulted regarding patient safety.
3. **Principal Investigator:** Every research study has a principal investigator (PI) who has the overall and ultimate responsibility for the safety of the research study.

6. Acoustic noise

The high gradient fields in the scanner produce an acoustic noise that can reach 120 dBm, close to the noise of a jet plane at a distance of a few tens of meters. You should always provide the patient with suitable hearing protection, earplugs, the ear muffs (headset), or equivalent.

7. Psychological factors

Being inside a constrained space like the bore of an MR scanner may be uncomfortable and even scary for some people. It is important to prepare them well and explain in advance what is going to happen, also things like table movement during scanning and acoustic noise. Take good care of breath hold instructions (if required) because not to breathe inside a small hole is even worse. The subject must always have access to the alarm bell to be able to signal to the operator to stop at all times.

8. Fire

In case of fire or smoke there are two fire extinguishers. These fire extinguishers are MR safe and can be used anywhere at CMIV, including inside the MR room. They are located next to the RF-door of the 3T scanner and in the patient corridor next to the 3T scanner.

Fig. 5. *The MR-safe fire extinguisher, suitable for both 1.5T and 3 T. Most of them have a fire blanket above.*

9. Electric hazard

In case of fire or smoke or anything that would require the electrical power to switch off, use the main switch in the technical room. The power emergency stop buttons that are located both inside and outside the MR-scanner room.

10. Gas hazard

All MR-systems in the hospital are equipped with oxygen detectors located inside the scanner rooms. These detects if the oxygen concentration inside the scanner room is below 18% (v/v), and if such a condition should arise, it will cause an alarm (both by sound and flashing lights). Check if somebody is in the scanner room, close the door (if not instructed otherwise) and check that the emergency ventilation of the scanner room has started. The forced ventilation will normally start automatically upon an alarm condition.

Fig. 6. *Oxygen detection monitor and alarm lights above the 3T console.*

11. Floor plan for MR5 and MR6

The figure below is showing the floor plan for both MR5 and MR6 at CMIV. You can also observe the different buttons in both the magnet room and control room.

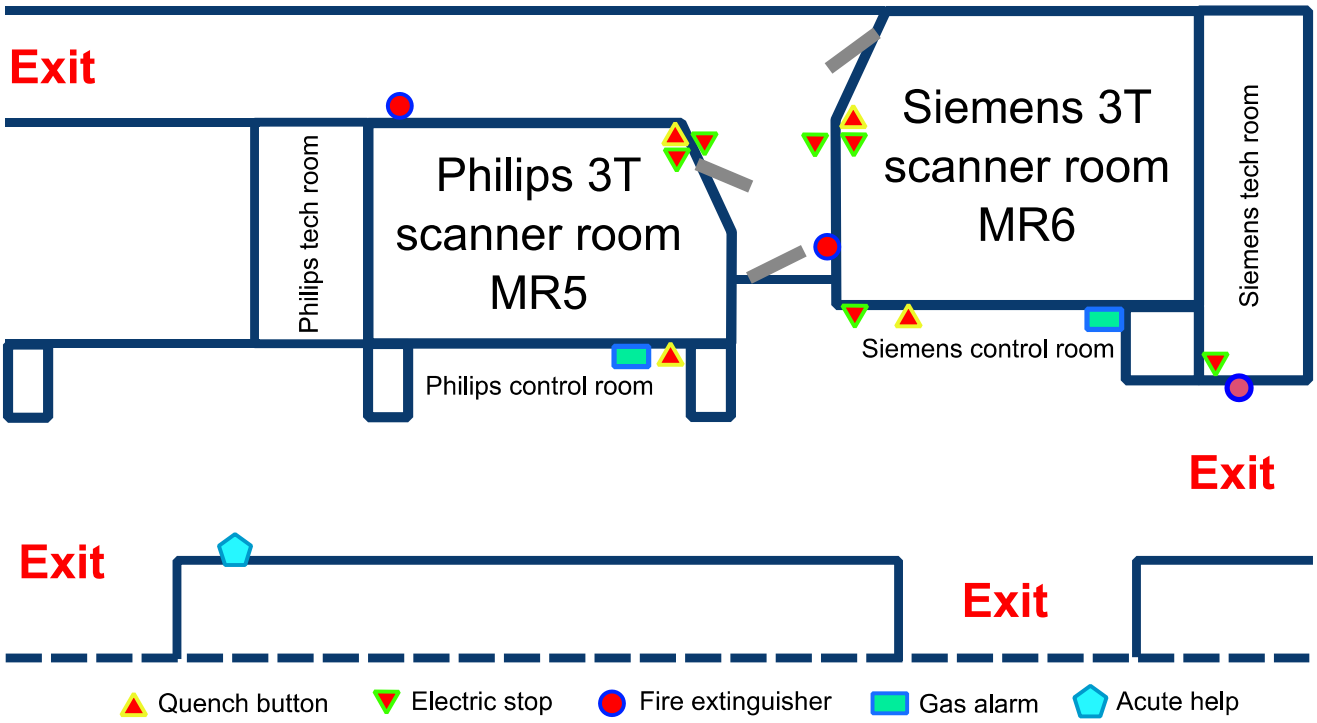

Fig. 7. *Overview of the CMIV scanner rooms with the locations of the quench buttons, the electric power emergency stop buttons, the fire extinguishers and exits.*