Al-Mustaqbal University
College of Health and Medical Technologies
Radiological Techniques Department

Magnetic Resonance Imaging

First Semester

Lecture 7,8 : MRI safety, Preparation and contrast agent

By

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Introduction:

MRI is a valuable diagnostic tool, and safety measures are in place to ensure the well-being of patients and staff Communication between patients and healthcare providers, as well as adherence to safety protocols, are essential for a safe MRI experience. Patients with concerns about MRI safety should discuss them with their healthcare team to address any specific risks or considerations.

Scientific Content:

Prior to any examination being performed, the identity of the patient must be checked by the technologist.

Patients arriving into MRI Department are often worried or apprehensive and this may make it difficult for them to understand the instructions or may produce an apparently aggressive attitude. In such cases, the technologist should convince amicably and soft tone of voice often do a great deal of comfort and gives the patient confidence that he/ she is in an efficient hand.

The technologist should make every effort to obtain the willing cooperation of the patient consent. Children and uncooperative patients should be sedated before examination.

- Before entering the equipment room, the patient must wear a hospital gown and should remove all personal possessions such as watch, wallet, keys, hair pins, jewels, coils, removable dental bridge work, etc. Even credit cards and cell phones must be secured as the scanner will erase the information on them.

- Wheelchair and trolleys (MR noncompatible) must always be kept outside the magnet room.

The patient is made to lie down on a table. This table then passes through a tunnel within the equipment. Inside the tunnel, it is quite noisy when the scanning is going on. The region of interest is positioned at the center of the magnet. The patient can hear the voice of the radiologist or technologist and can respond. While the patient lies within the tunnel, images of the interested regions are taken from different angles. These images can be seen on a computer screen. The entire procedure takes 30 to 45 minutes approximately depending upon the strength of the magnetic field and the parameters set on.

It is most important that the patient should remain relaxed and completely still during the scan. The patient can resume the routine activities after getting the scan done.

- The patient should always be informed as to what is going to happen and what he/she is expected to do, so that he/she can cooperate as much as possible.
- The patient should not wear makeup because some products may contain metallic particles.
- The patient should be covered with a lightweight blanket.
- The patient must be made comfortable as far as possible because if the patient is in pain or in distress, it is unlikely that he will be able to remain still for long.

- Explanation: A detailed explanation of the exam to be performed (to be informed to the patient) to give the patient, particularly as to how long the procedure will take.
- The technologist from the start of examination/procedure should make an effort to remember the name of the patient with whom he or she is dealing and use it.
- Clear instructions regarding breathing or swallowing should be given and rehearsed to ensure that the patient does hold his breath or swallow when required to do so.

Due to the high magnetic field strengths used during MRI examination, certain patients are unsuitable for imaging. These include patients who have:

- Aneurysm clips (Older Ferromagnetic types)
- Cardiac pacemakers
- Patients with otologic implants and ocular implants
- Cochlear implants
- Metallic foreign bodies, especially within the eye.

Patient Screening

The following items can interfere with MR imaging and some can be hazardous to your safety. Please check if you have any of the following MR incompatible objects:

- Cardiac pacemaker/pacemaker lead wires
- Brain aneurysm clips
- Aortic clips

- Implanted neurostimulators or lead wires
- Artificial heart valve
- Insulin pump
- Electrodes
- Hearing aids
- IUD (Intrauterine Device)
- Shunts
- Joint replacements
- Fractured bones treated with metal rods, metal plates,
- pins, screws, nails or clips
- Harrington rod
- Bone or joint pins
- Prosthesis
- Metamesh
- Wire sutures

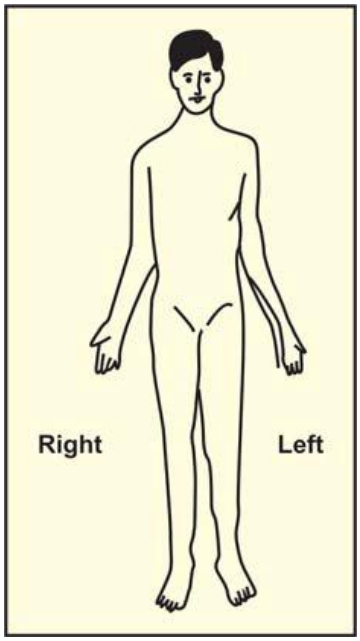

Fig. 4.1: To mark the location of any metal inside the body

- Sharpnel
- Dentures
- Metal silvers in the eyes
- Cochlear implants
- Tattoo eyeliner
- Others

On the drawing in Fig. 4.1, please mark the location of any metal “inside” the body.

Screening Prior to Scanning

- Removable dental work
- Hearing aid
- Jewellery
- Watch
- Wallet or money clip
- Pens or pencils
- Keys
- Coins
- Pocket knife
- Metal zippers or buttons
- Belt buckle
- Shoes
- Magnetic strip cards
- Credit cards, bank cards
- Hair pins or barrettes
- Glasses

EFFECTS OF RF POWER

The RF pulses used in MR causes tissues to absorb RF power under certain conditions. This may cause tissue heating. The amount of heating depends on several factors such as patient size and pulse-sequence timing.

Before the patient is being scanned, the computer estimates the level of heating and compares it to the predetermined exposure limits. If the scan exceeds these limits, the system then adjusts the scan parameters before starting the scan. The complete estimate is based partially on patient weight. Therefore, take care to enter the patient's weight correctly to prevent excessive RF.

Claustrophobia and Sedation

Although not thought of as a main safety issue, patient anxiety* and claustrophobia (specifically the fear of enclosed spaces) may be sufficient in some instances to prevent the completion of the scan. Published figures for the percentage of aborted scans in these situations vary widely from 1 to 20%. Undoubtedly, the type of scan (e.g., use of head coil) and the method of entry (head or feet first) makes a significant difference. Methods to improve patient comfort, not only to alleviate stress but also to minimize movement, include bore lighting, ventilation, and head coil mirrors to maintain visible contact with staffoutside the scanner. For certain scans music may be played through headphones to further relax the patient. Although the number of MR scans being performed continues to rise, modem scanner designs with shorter and wider bores, will help reduce the relative number of failed examinations.

Emergency Preparedness:

MRI facilities have emergency procedures in place in case of accidents. This includes protocols for dealing with metal objects accidentally brought into the MRI room and for responding to medical emergencies that may occur during a scan.

Contrast Agents and Kidney Function:

Gadolimum-based contrast agents are sometimes used in MRI to enhance the visibility of certain tissues. These agents are generally safe, but they can pose a risk to individuals with unpaired kidney function. Patients with kidney problems should be closely monitored and may need to undergo alternative linagmg tests.

Pregnancy and MRI:

While there is no known harm to the fetus from the MRI magnetic field or radio waves, MRI during the first trimester is generally avoided unless medically necessary. Pregnant patients should inform their healthcare providers and MRI technologists before the scan.

HAZARDS

Claustrophobia despite the fact that the patient lies in a confined space is rarely a serious problem. MRI has not been proved to have any adverse effects on fetuses. However, some teams avoid using during the first trimester of pregnancy. Till date, no harmful effects have been observed from magnetic influences.

Acoustic Noise

The most obvious dB/dt effect the patient will encounter is the loud noise in the scanner bore during the examination. It is a consequence of the force exerted on the gradient coils due to the rapidly varying current within them in the presence of the mam field. The frequency of the current is such that the coils vibrate against their surroundings and produce noise at an acoustic level. This noise, which increases with field strength and varies considerably with the type of sequence being used, is sufficient to warrant ear protection for all patients. High field systems have had to be designed with methods of reducing this noise.

QUENCHING

A magnet quench will result in several days of down time. So, do not press or push the button except in a real emergency. Do not test that button. It should be tested only by qualified service personnel. Quench button is located near the magnet.

Magnet Quench Hazards

Magnetic quench is indicated by a loud noise, warning message, dense white vapor (with vent failure), helium meter dropping considerably or the tilting of an image on the image screen.

- If the patient needs medical attention, press an emergency stop button on the console or magnet and remove the patient from the scan room.
- Evacuate the patient and personnel from the scan room and close the scan room door.

Contrast media:

A-Mechanism of action

In order to increase contrast between pathology and normal tissue enhancement agents may be introduced that selectively affect the T1 and T2 relaxation times in tissues. Both T1 recovery and T2 decay are influenced by the magnetic field experienced locally within the nucleus. These molecules rotate and the rate of rotation of the molecules is a characteristic property of the solution. It is dependent on:

- the magnetic field strength;
- the viscosity of the solution;
- the temperature of the solution.

Molecules that tumble with a frequency at or near the Larmor frequency have more efficient T1 recovery times than other molecules.

Types of main contrast media

*** Gadolinium**

Gadolinium (Gd) is a paramagnetic agent. It has a large magnetic moment and when it used The T1 relaxation times of nearby water protons are therefore reduced, resulting in an increased signal intensity on T1 weighted images. For this reason gadolinium is known as a T1 enhancement agent.

Gadolinium is a rare-earth metal that cannot be excreted by the body and would cause long term side effects, as it binds to membranes.

Side effects

- A slight transitory increase in bilirubin and blood iron
- Mild transitory headaches
- Nausea
- Vomiting
- Hypotension
- Gastro-intestinal upset
- Rash

Contra-indications

- Haematological disorders
- Sickle cell anaemia
- Pregnancy

Administration

The effective dosage of Gd-DTPA is 0.1 millimole (mmol) per kilogramme (kg) of body weight (mmol/kg), (approximately 0.2 ml/kg)

Clinical applications

Gadolinium has proven very useful in imaging the central nervous system because of its ability to pass through breakdowns in the blood-brain barrier (BBB). Clinical indications for gadolinium include:

- tumours pre and post surgery;
- pre and post radiotherapy;
- infection;
- infarction;
- inflammation;

- post-traumatic lesions;
- post operation lumbar disc;
- breast disease;
- prostatic disease;
- vessel patency.

Iron oxide

Iron oxides shorten relaxation times of nearby hydrogen atoms and therefore reduce the signal intensity in normal tissues. This results in a signal loss on proton density weighted or heavily T2 weighted images. Super-paramagnetic iron oxides are known as T2 enhancement agents.

Iron oxide is taken up by the reticulo-endothelial system and excreted by the liver so that normal liver is dark and liver lesions are bright on T2 weighted images.

Side effects

- Mild to severe back, leg and groin pain is experienced and. in a few cases, head and neck pain.
- Patients experience digestive side-effects including nausea, vomiting and diarrhea.
- Anaphylactic like reactions and hypotension have been reported in a few patients.

Contra-indications

- Contra-indicated in patients with known allergies / hypersensitivity to iron.
- Since the infusion is dark in colour, skin surrounding the infusion site might discolour if there is extraviseation.

Administration

The recommended dose of iron oxide is 0.56 mg of iron per kg of body weight. If using Feridex® dilute in 100 ml of 50% dextrose and give I.V. over 30 min.

Clinical applications

This is mainly used in liver imaging where normal liver is dark on T2 weighted images and lesions appear bright.

Other contrast agents

Gastrointestinal contrast agents are sometimes used for bowel enhancement. These include barium, ferromagnetic agents and fatty substances. However due to constant peristalsis, these agents enhance bowel motion artefacts more often than enhancing pathologic lesions. The use of anti-spasmodic agents helps to retard peristalsis to decrease these artifacts. Other agents include helium which is inhaled and assists in the evaluation of lung perfusion.