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

Magnetic Resonance Imaging

First Semester

Lecture 1 :

- **Review about MRI machines**
- **Role of the technologist in MRI**

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Introduction:

1- MRI components

Scanners of MRI come in many varieties. The most important hardware within MRI system are as follows (fig 1):

1.**A large magnet to** generate the magnetic field. The static magnetic field in MRI system can be created by:

A- Permanent magnets, or B- Electromagnets. C. superconducting Magnets

2. **Shim coils to** make the magnetic field as homogeneous as possible.

3. **A radiofrequency (RF) coil** to transmit a radio signal into the body part being imaged.

* Transmit (Tx): Generate precise RF pulses (at the Larmor frequency) via the Body Coil (usually integrated into the scanner bore) to excite nuclei (flip angles).

4. **A receiver coil to** detect the returning radio signals.

* Receive (Rx): Detect the weak MR signals emitted by relaxing nuclei using specialized

- **Surface Coils** (placed close to anatomy - head, knee, spine) or
- **Phased-Array Coils** (multiple small coil elements for better signal-to-noise ratio (SNR) and parallel imaging).

5. **Gradient coils to** provide spatial localization of the signals.

Special coils called gradient coils vary the strength of the magnetic field, frequency and phase of the electromagnetic wave in the transverse (X and Y axes) and longitudinal (Z axis) planes.

6. **A computer to** reconstruct the radio signals into the final image.

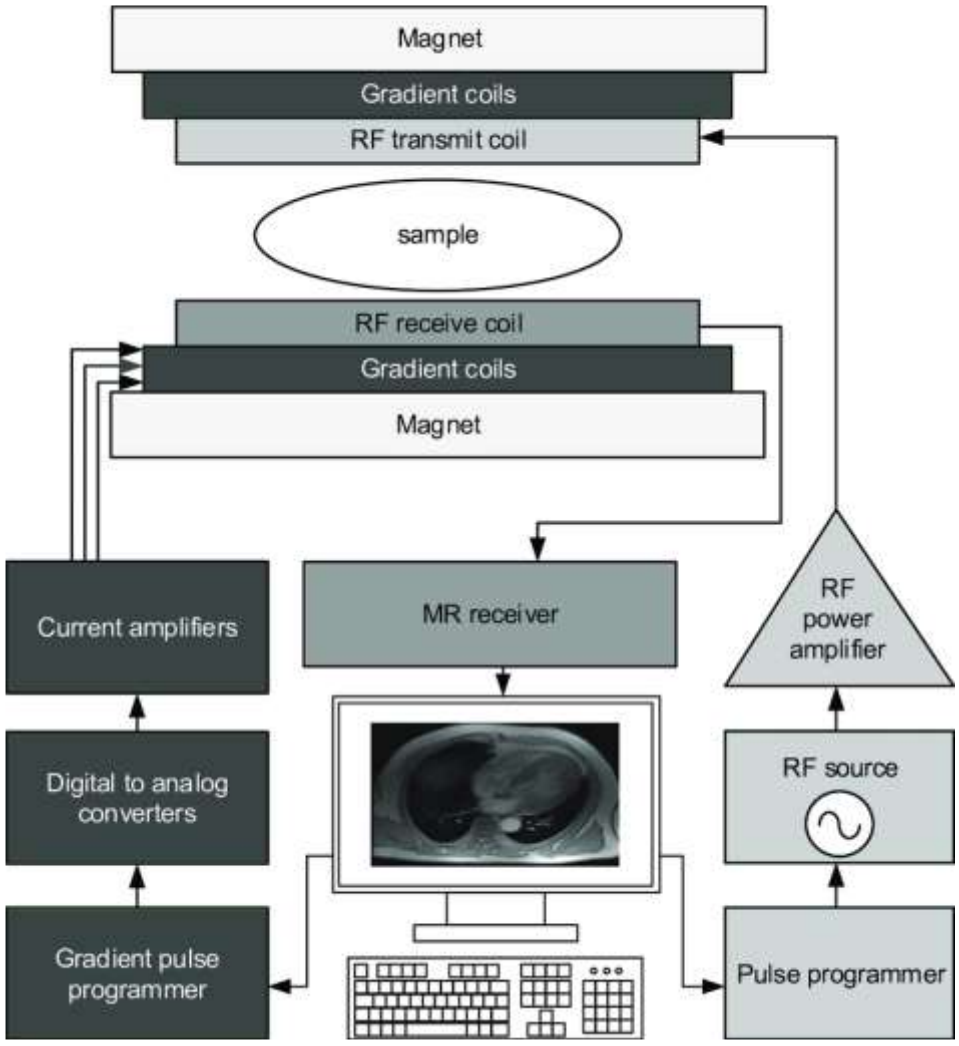

Fig.1: Block diagram of a typical magnetic resonance imaging scanner

2-Types of MRI Machines (Classified by Magnet Design & Field Strength)

Manufactures produce **magnets of varying strengths**. The most common magnetic field strengths clinically are 0.3, 0.5, 1.0, 1.5 and 3 Tesla. Magnets of 1.0 Tesla or higher are treated high-field strength which **generate higher signals** and usually **more appealing images** than lower-field strength units. Therefore, **the high-field strength units generally offer more esthetic and diagnostic images than the open units and should preferably be used whenever possible. I**t is easy to answer to the question about the ideal horsepower for a motor bike.

1. Closed-Bore MRI (Cylindrical):

* **Design:** Superconducting magnet with a long, narrow cylindrical bore (typically 60-70 cm diameter, 1.5-2m length). Patient lies on table that moves into the bore.

* **Field Strengths:**

* High-Field (1.5 Tesla): Clinical workhorse. Excellent balance of SNR, image quality, speed, safety, and cost-effectiveness. Suitable for most applications.

* Ultra-High-Field (3 Tesla & Above): Significantly higher SNR (potentially doubling resolution or halving scan time). Enhanced spectral resolution for spectroscopy. Challenges include:

* Increased artifacts (susceptibility, dielectric shading at 3T+).

* Higher Specific Absorption Rate (SAR - heat deposition).

* More stringent safety requirements (projectile risk, peripheral nerve stimulation).

* Primarily 3T clinical; 7T+ mainly research.

* **Advantages:** Highest image quality/resolution, fastest imaging, widest range of advanced applications (fMRI, DTI, spectroscopy).

* **Disadvantages:** Patient claustrophobia, limited access for obese patients/interventions, loud acoustic noise.

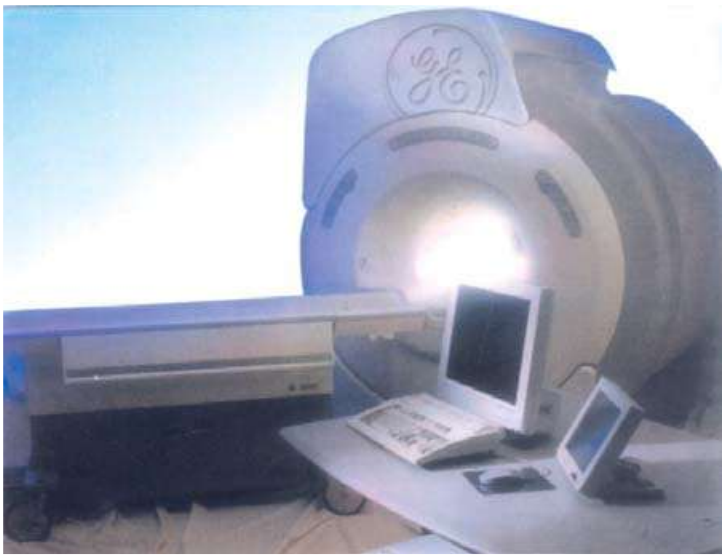

Fig. 3.2: A modern MRI unit (Courtesy of GE Medical Systems)

2. Open MRI:

* **Design:** Aims to reduce claustrophobia and improve patient access. Main configurations:

* Permanent or Resistive Magnet "C-Shaped".

* Wide-Bore Superconducting: Shorter, wider bore (e.g., 70cm+ diameter). Less "tunnel-like" than traditional bore.

* **Field Strengths:** Typically Low-Field (≤0.6T) or Mid-Field (0.7T - 1.2T). Some wide-bore superconducting models operate at 1.5T.

* **Advantages:** Reduced claustrophobia, better accommodation for large/obese patients, potential for upright/weight-bearing imaging (some designs), easier access for interventional procedures or patients requiring monitoring.

* **Disadvantages:** Lower SNR (especially low-field) → longer scan times, lower resolution, reduced capability for advanced sequences. Field homogeneity can be more challenging.

Fig. 3.1: Open MRI unit (Courtesy of Siemens)

3- Role of the MRI Technologist in:

A) Precaution to be taken

In order to maintain a safer scan environment, the following precautions are to be taken:

1- MRI systems are equipped with laser alignment lights.
2- Exposing eyes to the laser alignment lights may result in eye injury.
3- Do not stare directly into the laser beam.
4- Instruct the patients to close their eyes during land marking in order to avoid eye exposure to the alignment light while the laser light is "ON."
5- Do not leave the laser beam ON after you position the patient.
6- Place foams between the patient and the bore wherever a portion of the body comes in contact with the bore.
7- Ensure that the patient does not touch the magnet bore.
8- Orient the patient (head first or feet first) to minimize the length of the cable in the bore.
9- For larger patients, use wide patient straps to secure the arms, preventing them from touching the bore.

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 compare 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.**

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**.

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.

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.

Patients' Safety, Contraindication and Preparation

MR EXAMINATION PROCEDURE

1. Identity: - 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 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.**

2. 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.

3. **Wheelchair and trolleys must always be kept outside the magnet room.**

4. 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 40 min

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.

5. **The patient should always be informed as to what is going to happen and what he expected to do,** so that he can cooperate as much as possible.

6.**The patient should attend without any makeup because some products may contain metallic particles.**

7.**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

8. **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.

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

A- Aneurysm clips (older ferromagnetic types).

B- Cardiac pacemakers.

C- Patients with otologic implants and ocular implants.

D- Cochlear implants.

E- Metallic foreign bodies, esp. 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
- Sharpnel
- Dentures
- Metal silvers in the eyes
- Cochlear implants
- Tattoo eyeliner

Screening Prior to Scanning

- Glasses
- 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
- Metal bra hooks
- Bra and girdle underwear support
- Sanitary belt
- Safety pins

Remove any of these items before entering the scanner room