Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Magnetic Resonance Imaging (MRI)

1. Magnetic Resonance Imaging (MRI)

- An MRI (magnetic resonance imaging) scan is a test that creates clear images of the structures inside your body using a large magnet, radio waves and a computer. Healthcare providers use MRIs to evaluate, diagnose and monitor several different medical conditions.
- An MRI (magnetic resonance imaging) scan is a painless test that produces very clear images of the organs and structures inside your body. MRI uses a large magnet, radio waves and a computer to produce these detailed images. It doesn't use X-rays (radiation).
- Because MRI doesn't use X-rays or other radiation, it's the imaging test of choice when people will need frequent imaging for diagnosis or treatment monitoring, especially of their brain.

2. What does Magnetic Resonance Imaging (MRI) work?

- The brain, spinal cord and nerves, as well as muscles, ligaments, and tendons are seen much more clearly with MRI than with regular x-rays and CT; for this reason MRI is often used to image knee and shoulder injuries.
- One kind of specialized MRI is functional Magnetic Resonance Imaging (fMRI.) This is used to observe brain structures and determine which areas of the brain "activate" (consume more oxygen) during various cognitive tasks. It is used to advance the understanding of brain organization and offers a potential new standard for assessing neurological status and neurosurgical risk.

Email: forqan.ali.wahhab@uomus.edu.iq

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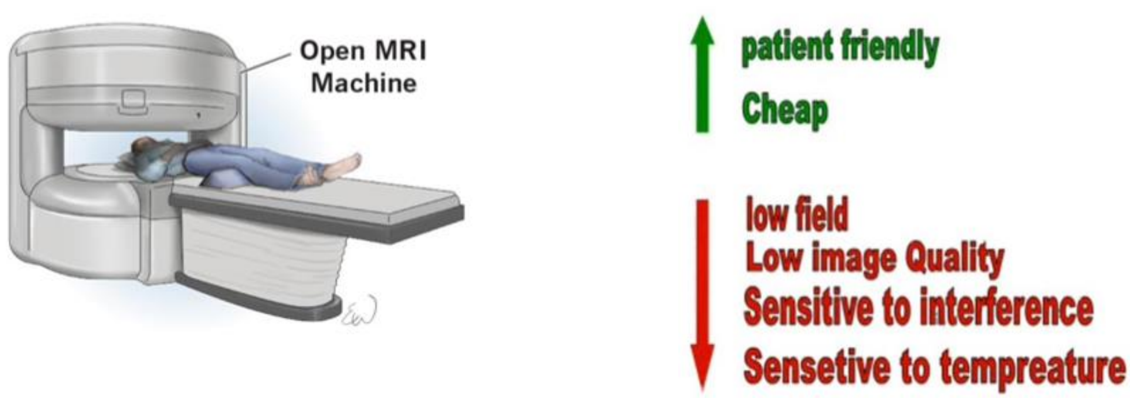
1. Components

1. Static magnetic field Coils

In terms of shape, magnets are divided into:

1. Open



2. Closed

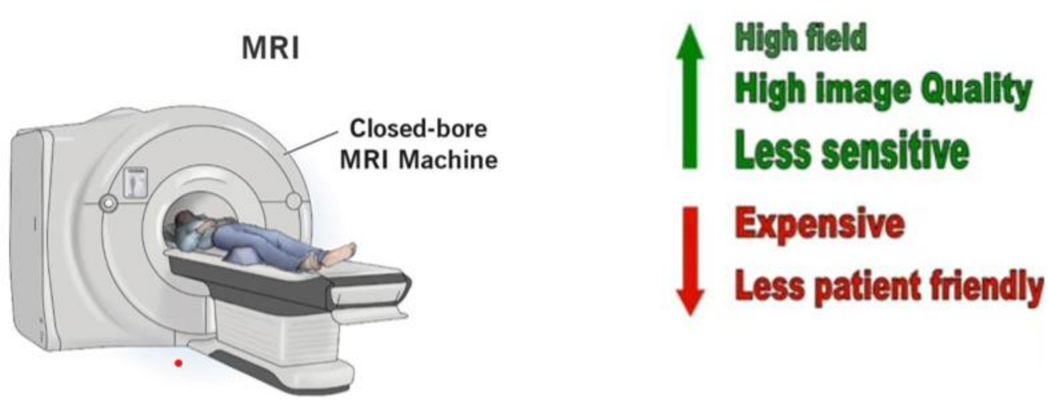


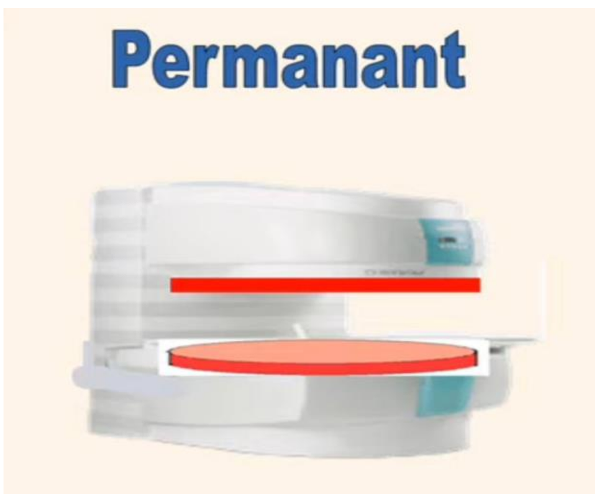
Fig 1:open and closed MRI

Email: forqan.ali.wahhab@uomus.edu.iq

Three methods to generate magnetic field :

1. Permanent magnet

Permanent MRI magnets use permanently magnetized iron like a large bar magnet that has been twisted into a C-shape where the two poles are close together and parallel. In the space between the poles, the magnetic field is uniform enough for imaging. Up to 30 tonnes of iron may be needed, restricting their placement to rooms with a strong-enough floor. Their low-field strength of about 0.15 - 0.4 T restrict their use to diagnostic imaging; being impractical for spectroscopy, chemical shift and susceptibility imaging such as functional brain imaging. Their magnetic field homogeneity is also sensitive to ambient temperature so room temperature must be controlled carefully. The initial purchase price and operating costs are low compared to superconductive magnets. These magnets can also be made with alloys containing metals such as neodymium, markedly reducing the weight of the magnet but at significant additional cost.



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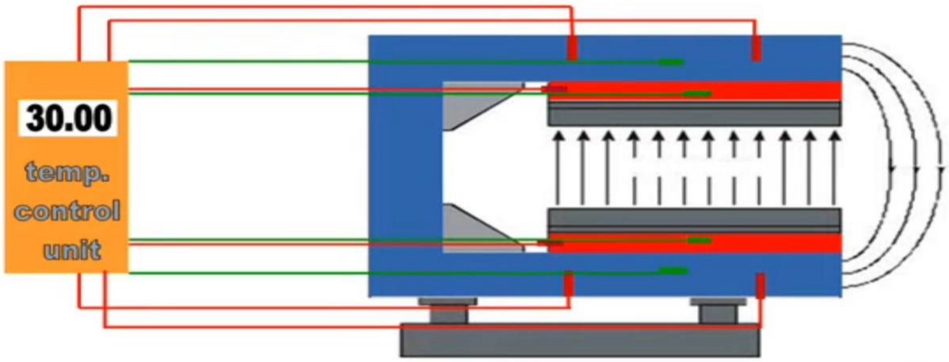

Fig 2: Permanent magnet

2. Resistive magnet

Resistive (air core) MRI magnets operate at room temperature using standard conductors such as copper in the shape of a solenoid or Helmholtz pair coil. A solenoid is a cylindrical-shaped coil of wire. The uniform magnetic field is found inside the coil, especially in the center. These magnets are relatively inexpensive to make but require a large constant flow of current while magnetized and imaging. The coil has an electrical resistance that requires cooling of the magnet. The operating costs are high because of the large power requirements of the magnetic coils and the associated cooling system.

Both permanent and resistive MRI scanners are limited to low-field applications, primarily open MRI and extremity scanners. These magnets are useful for claustrophobic patients.

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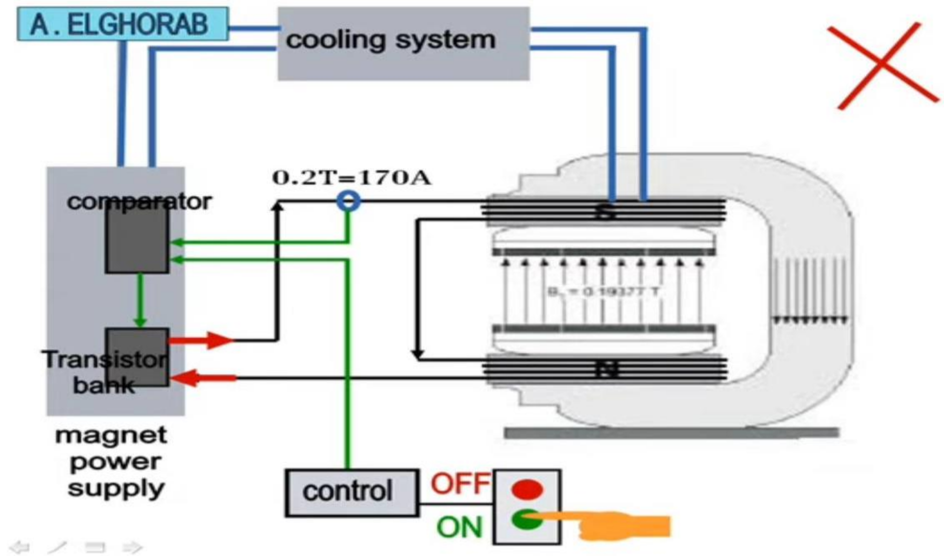

Fig 3:Resistive magnet

3. Super conducting magnet

- High- resolution imaging systems use super conducting magnets.
- The super- conducting magnets are large and complex .
- They need the coils to be soaked in liquid helium to reduce their temperature to a value close to absolute zero.
- Superconducting magnets at 1.5 T and above allow functional brain imaging.

2. Gradient coils

- Gradient coils are used to produce deliberate variation in the main magnetic field.
- There are usuallythree sets of gradient coils, one for each direction.
- The variation in the magnetic field permits loclization pf image slices as well as phase encoding and frequency encoding.
- The set of gradient coils for the Z axis are helmholtz pairs, and for the X and Y axis paired saddle coils.

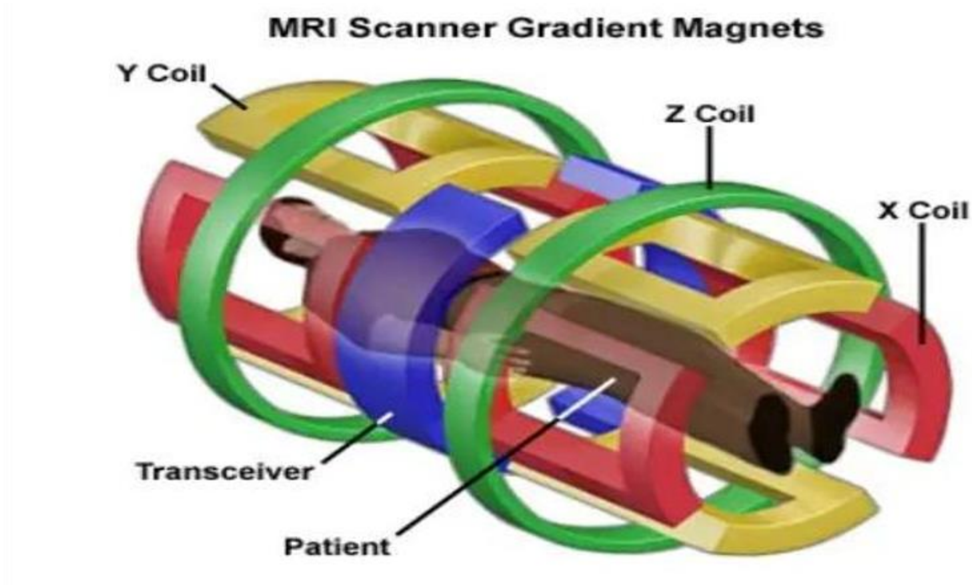

Fig 4:Gradient coils

3. Radiofrequency coil (RF)

- RF coils act as transmitter and receiver
- They transmit the RF signal and receives the return signal.
- They are used as the gradient coils in MRI scanners.
- Paired saddle coils are also used for the X and Y gradient coils.

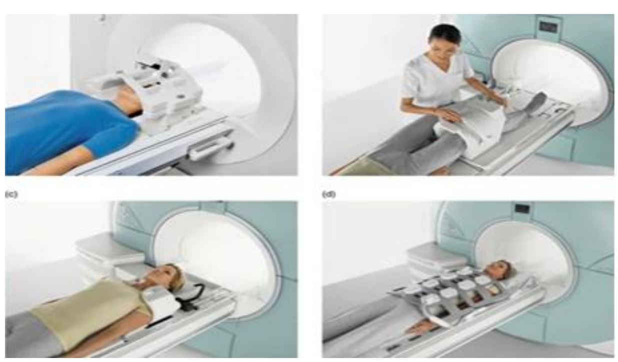

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Fig 5: Radiofrequency coil (RF)

4. Table

5. Computer

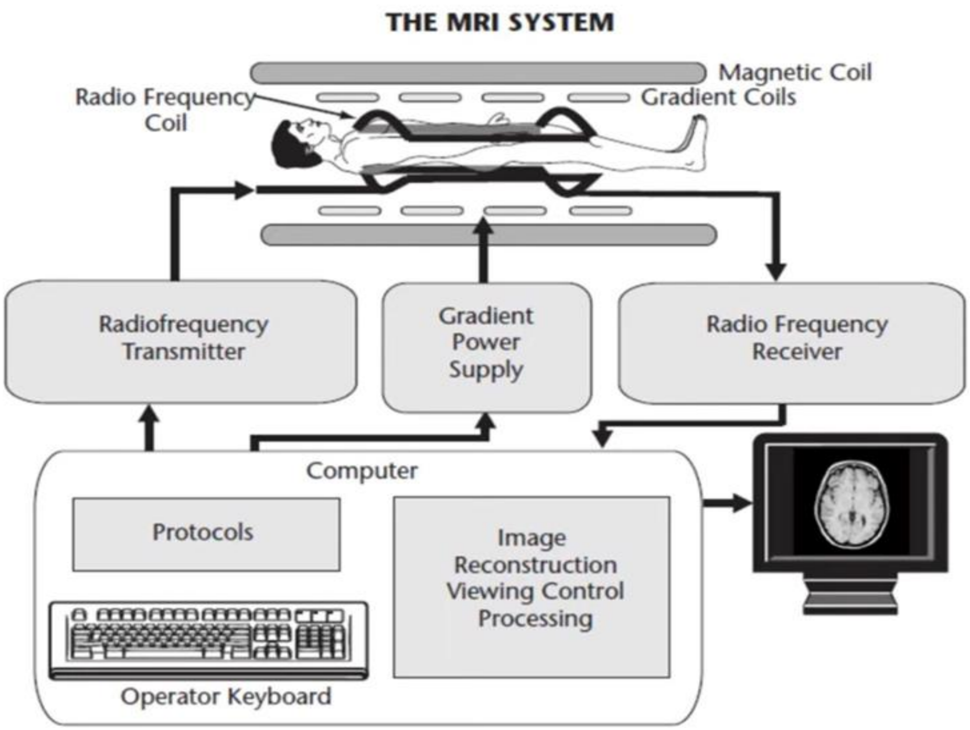

Fig 6:The block diagram of MRI system

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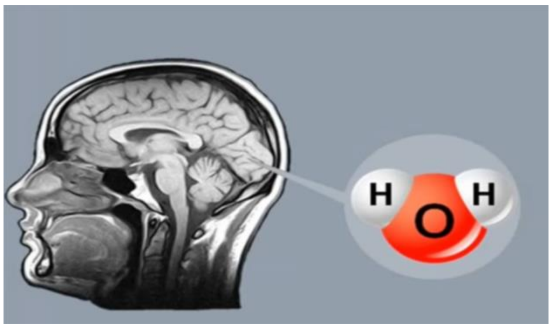
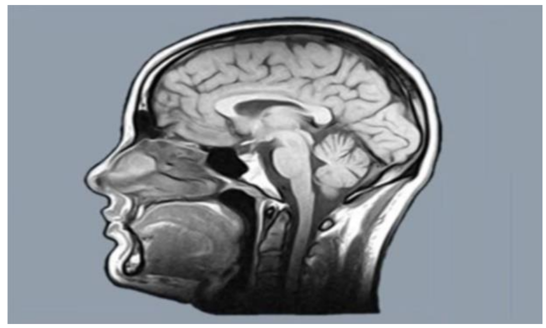
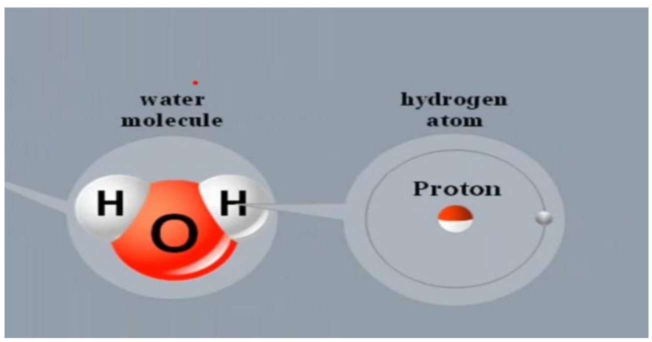
4. Hydrogen Atoms and Magnetic Moments

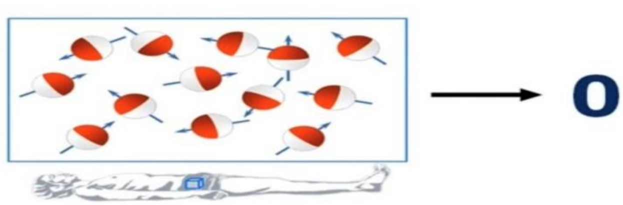
When patients slide into an MRI machine, they take with them the billions of atoms that make up the human body. For the purposes of an MRI scan, we're only concerned with the hydrogen atom, which is abundant since the body is mostly made up of water and fat.







These atoms are randomly spinning, or precessing, on their axis, like a child's top. All of the atoms are going in various directions, but when placed in a magnetic field, the atoms line up in the direction of the field.



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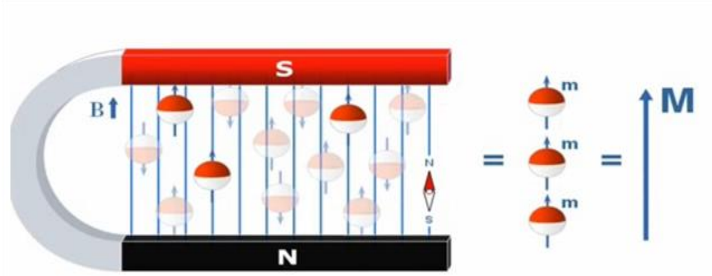

These hydrogen atoms have a strong magnetic moment, which means that in a magnetic field, they line up in the direction of the field. Since the magnetic field runs straight down the center of the machine, the hydrogen protons line up so that they're pointing to either the patient's feet or the head. About half go each way, so that the vast majority of the protons cancel each other out -- that is, for each atom lined up toward the feet, one is lined up toward the head. Only a couple of protons out of every million aren't canceled out. This doesn't sound like much, but the sheer number of hydrogen atoms in the body is enough to create extremely detailed images. It's these unmatched atoms that we're concerned with now.

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