

# UNIT 4

## Medical Equipments



# Introduction

- Medical equipment is designed to aid in the diagnosis, monitoring or treatment of medical conditions.
- **Diagnostic equipment** includes medical imaging machines, used to aid in diagnosis.

Examples: Ultrasound and MRI machines,  
CT scanners, and  
x-ray machines.

- **Therapeutic equipment** includes  
Examples: infusion pumps, medical lasers and  
LASIK surgical machines.

# Introduction...

- **Life support equipment** is used to *maintain* a patient's bodily function.

Examples: medical ventilators,  
anaesthetic machines,  
heart-lung machines, and  
dialysis machines.

- **Medical monitors** allow medical staff to measure a patient's medical state. Monitors may measure patient vital signs and other parameters

Examples: ECG, EEG,  
blood pressure

# X-Rays

- X-rays are very high energy electromagnetic waves.
- X-rays are produced by deceleration of high velocity electrons.
- As the electrons decelerate in the target through interaction, they emit electromagnetic radiation in the form of x-rays.
- Conventional X-ray images are taken by passing the rays through the body and exposing a photographic film.
- patient is located between an x-ray source and a film -> radiograph

👍 *cheap and relatively easy to use*

👎 *potentially damaging to biological tissue*

# X-Rays...

## *How does X-rays work?*

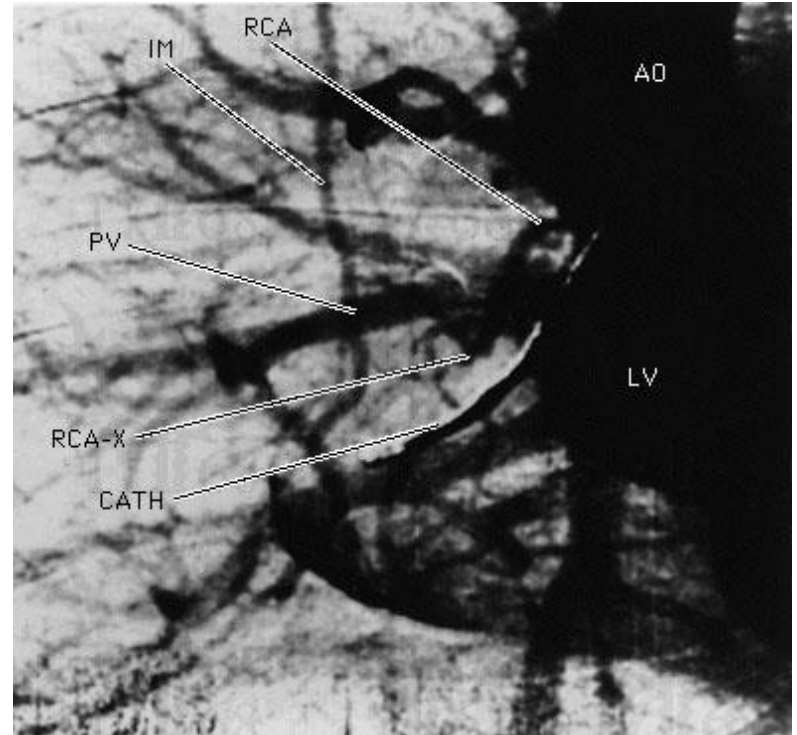
- As X-rays from the source pass through the body, they lose their energy. The loss of energy, called attenuation, depends on some tissue characteristics.
- A **"transparent"** tissue between the source and the film implies that more X-rays strike the film leading to a black image,
- an **"opaque"** tissue will block a lot of X-rays and the image is white.
- *X-ray image on film is seen as a negative film!*



# X-Rays...

- Bones contain heavy atoms -> with many electrons, which act as an absorber of x-rays
- Commonly used to image gross bone structure and lungs
- Excellent for detecting foreign metal objects
- All other tissue has very similar absorption coefficient for x-rays

# X-Rays - Images



- X-Rays can be used in computerized tomography.

# ULTRASOUND

- Ultrasound imaging, also called sonography, involves exposing part of the body to high frequency sound waves to produce pictures of the inside of the body.
  - The sound pressure wave with a frequency greater than the upper limit of the human hearing range.
- Ultrasound is thus not separated from 'normal' (audible) sound based on differences in physical properties, only the fact that humans cannot hear it.
- Ultrasound examinations do not use ionizing radiation(as used in x-rays).
- Ultrasound devices operate with frequencies from 20 kHz up to several gigahertz.



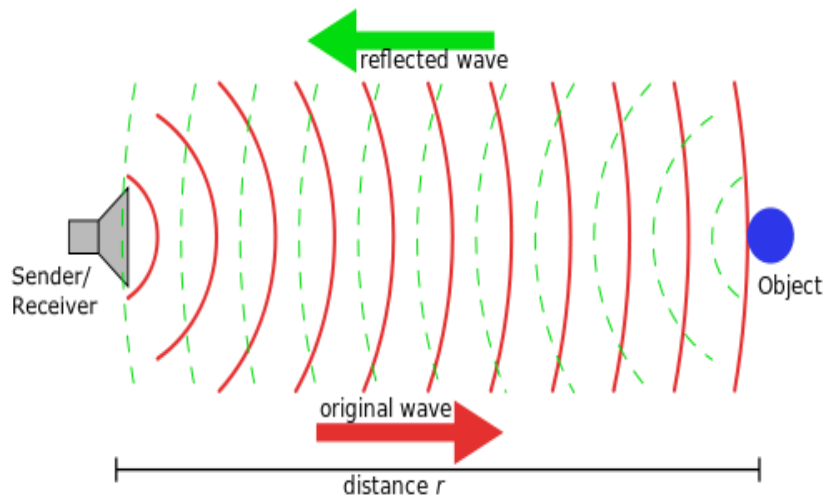
# ULTRASOUND...



Bundesarchiv, Bild 183-1990-0417-001  
Foto: Grubitzsch (geb. Raphael), Waltraud | 17. April 1990

# ULTRASOUND...

- Medical sonography (ultrasonography) is an ultrasound-based diagnostic medical imaging technique used to visualize **muscles, tendons, and many internal organs**, to capture their size, structure and any pathological lesions with real time tomographic images.



# ULTRASOUND...

## ■ Components

- ❑ *Transducer Probe*
- ❑ *Transducer Pulse Controls*
- ❑ *CPU*
- ❑ *Display*
- ❑ *Keyboard/Cursor*
- ❑ *Disk Storage Device*
- ❑ *Printer*

## Uses of Ultrasound:

- ❑ *Detection of tumors (Oncology).*
- ❑ *Assessment of the development of fetus (OB/GYN).*
- ❑ *Evaluation of blood flow (Cardiology).*
- ❑ *Insertions*

# CT scanner

- X-ray computed tomography, also computed tomography (CT scan) or computed axial tomography (CAT scan), is a medical imaging procedure that utilizes computer-processed X-rays to produce tomographic images or 'slices' of specific areas of the body.



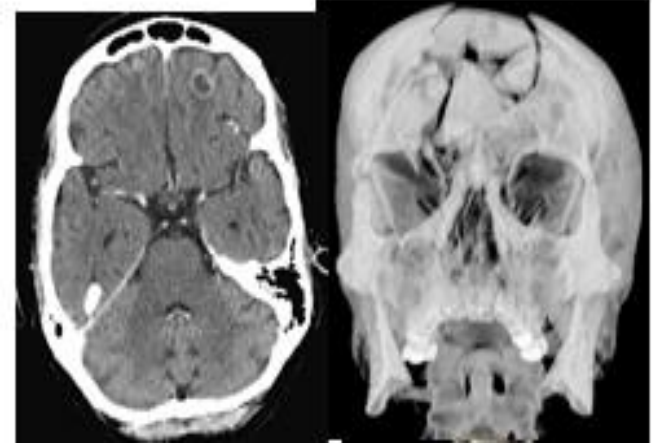
# CT scan...

## *How does CT scanner work?*

- A CT scanner uses X-rays. Like an X-ray, it is painless.
- The CT machine takes a lot of pictures of your body from different angles.
- These pictures are fed into a computer.
- The computer puts them together to give a series of cross sections or 'slices' through the part of the body being scanned.
- A very detailed picture of the inside of the body can be built up in this way.

# CT scan...

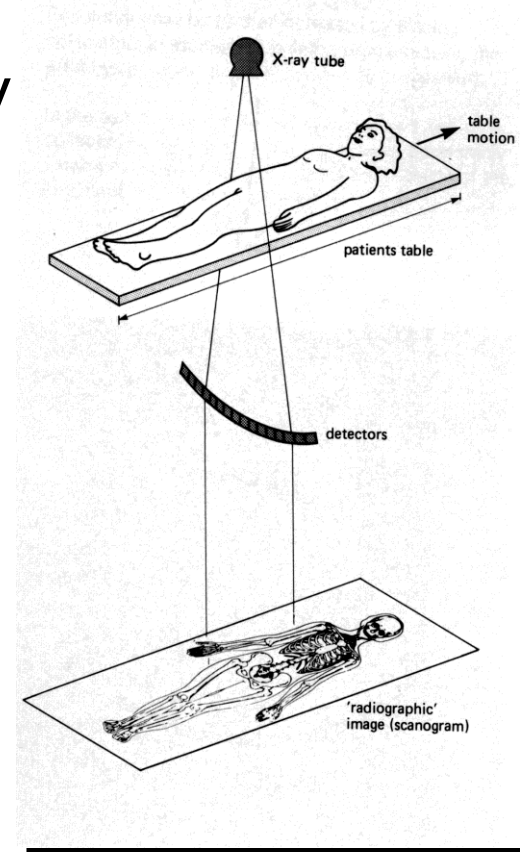
- Used to determine:
  - ❑ extent of trauma
  - ❑ location and type of tumors
  - ❑ status of blood vessels
  - ❑ pre surgical planning



# Scanning Method

## A) Digital projection

- X-ray tube and detector remain stationary
- Patient table moves continuously
  - With X-rays “on”
- Produces an image covering a range of anatomy
  - Similar to a conventional X-ray image, e.g. flat plate of the abdomen
- Image used to determine scan location

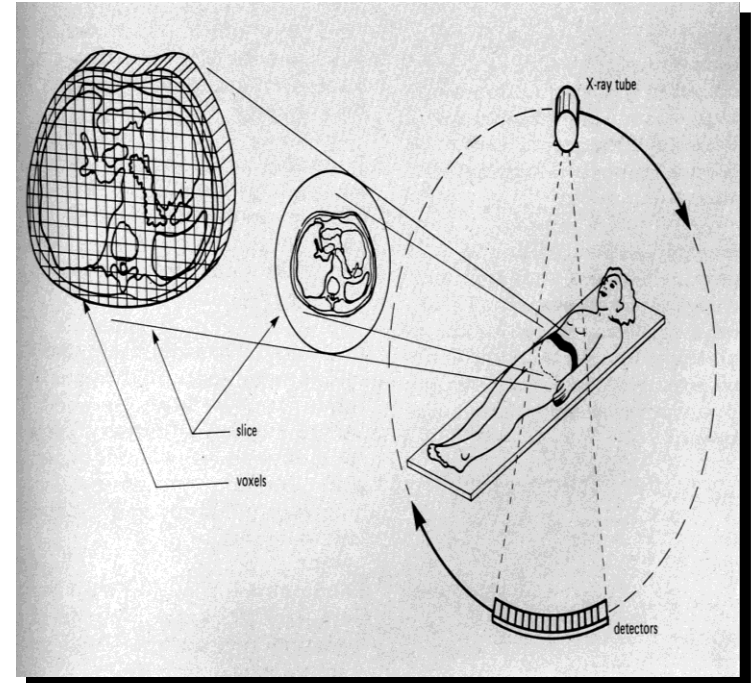




# Scanning Method...

## B) Axial CT

- X-ray tube and detector rotate 360°
- Patient table is stationary
  - With X-ray's "on"
- Produces one cross-sectional image
- Once this is complete patient is moved to next position
  - Process starts again at the beginning

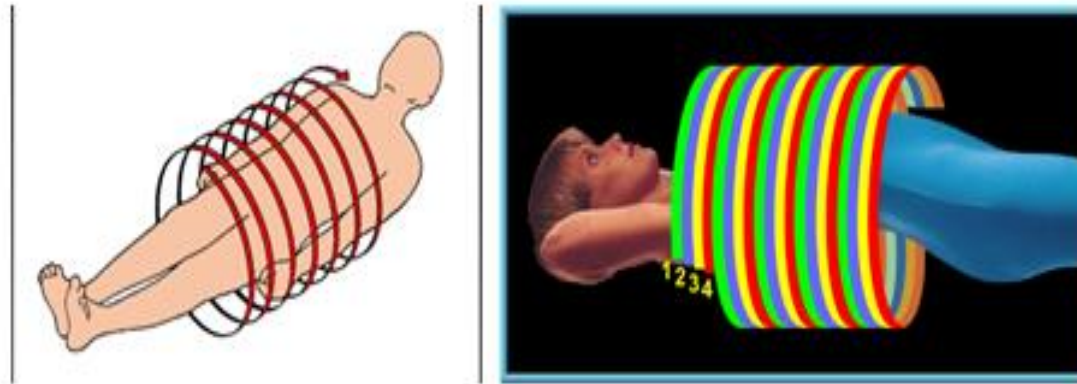




# Scanning Method...

## C) Volume CT

- X-ray tube and detector rotate 360°
- Patient table moves continuously
  - With X-ray's "on"
- Produces a helix of image information
  - This is reconstructed into 30 to 1000 images



# Scanning Method...

## Advantages of Volume CT

- More coverage in a breath-hold
  - Chest, vascular studies, trauma
- Reduced misregistration of slices
- Potentially less IV contrast required
- Gapless coverage

# General Diagnostic applications of CT Scan

## Head

- CT scanning of the head is typically used to detect infarction, tumors, hemorrhage and bone trauma.

## Lungs

- CT can be used for detecting both acute and chronic changes in the lung parenchyma, that is, the internals of the lungs.

# General Diagnostic applications...

## **Pulmonary angiogram**

- CT pulmonary angiogram (CTPA) is a medical diagnostic test used to diagnose pulmonary embolism (PE).

## **Cardiac**

- the advent of subsecond rotation combined with multi-slice CT (up to 320-slices), high resolution and high speed can be obtained at the same time, allowing excellent imaging of the coronary arteries (cardiac CT angiography).

# General Diagnostic applications...

## **Abdominal and pelvic**

- CT is a sensitive method for diagnosis of abdominal diseases. It is used frequently to determine stage of cancer and to follow progress.

## **In Extremities**

- CT is often used to image complex fractures, especially ones around joints, because of its ability to reconstruct the area of interest in multiple planes. Fractures, ligamentous injuries and dislocations can easily be recognised with a 0.2 mm resolution.

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# Magnetic Resonance Imaging (MRI)

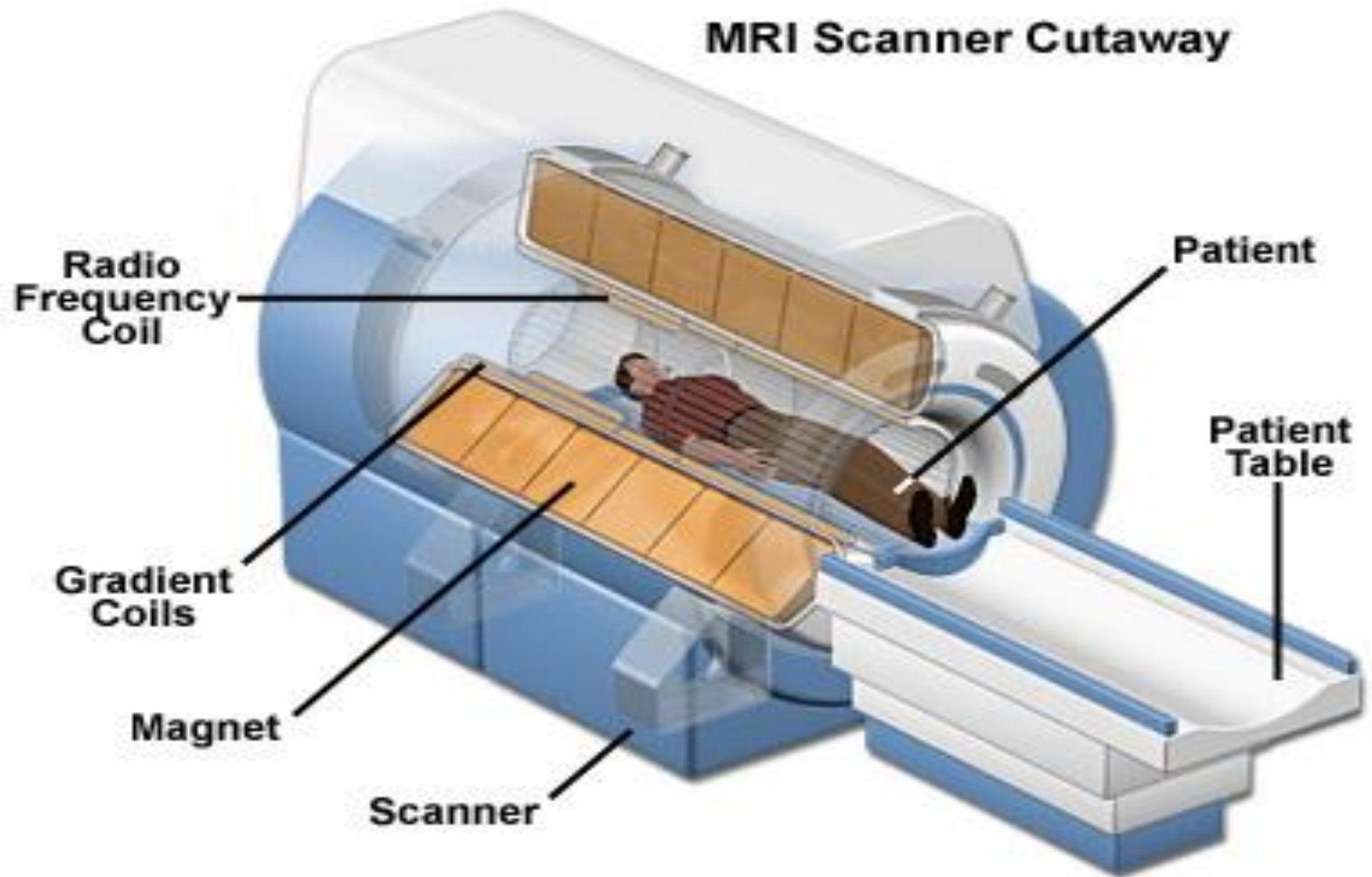
- MRI is a medical imaging technique used in radiology to visualize internal structures of the body in detail.
- An MRI is a non invasive medical test that uses a magnetic field, radio frequency pulses, and a computer to produce images of your inner body (including bone, soft tissues, and organs)
- ***MRIs can better evaluate the body in comparison to X Ray, ultrasound, or CT Scans.***

# MRI...

## *How does an MRI scanner work?*

- MRI makes use of the property of nuclear magnetic resonance (NMR) to image nuclei of atoms inside the body.
- The patient lies inside a large, cylinder-shaped magnet. Radio waves 10,000 to 30,000 times stronger than the magnetic field of the earth are then sent through the body.
- This affects the body's atoms, forcing the nuclei into a different position. As they move back into place they send out radio waves of their own.
- The scanner picks up these signals and a computer turns them into a picture.
- These pictures are based on the location and strength of the incoming signals.

# MRI...





# MRI...

## Clinical applications of MRI

### ■ Clinical neurology

- Segmentation and classification
- Measuring volumes of brain structures
- Multiple sclerosis, neurodegeneracy, stroke, etc.

### ■ Cardiology

- Certain types of heart problems.
- Blockages or enlargements of blood vessels, including the aorta,

### ■ Cancer

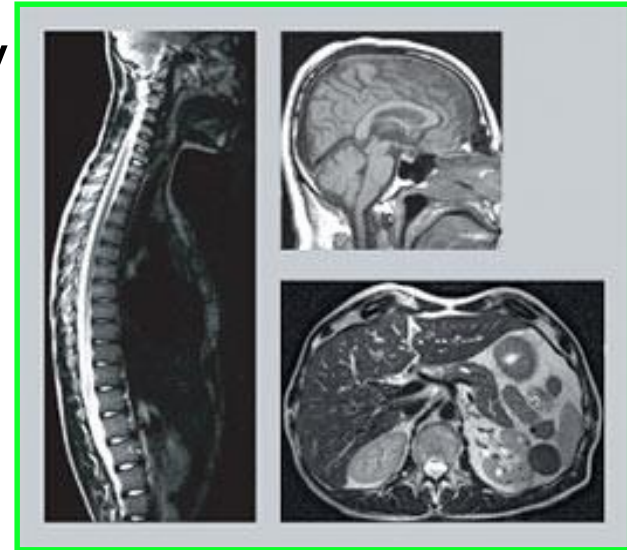
- Breast, colorectal, liver, prostate, etc.

### ■ Soft tissue damage

- Cartilage, ligaments, etc.

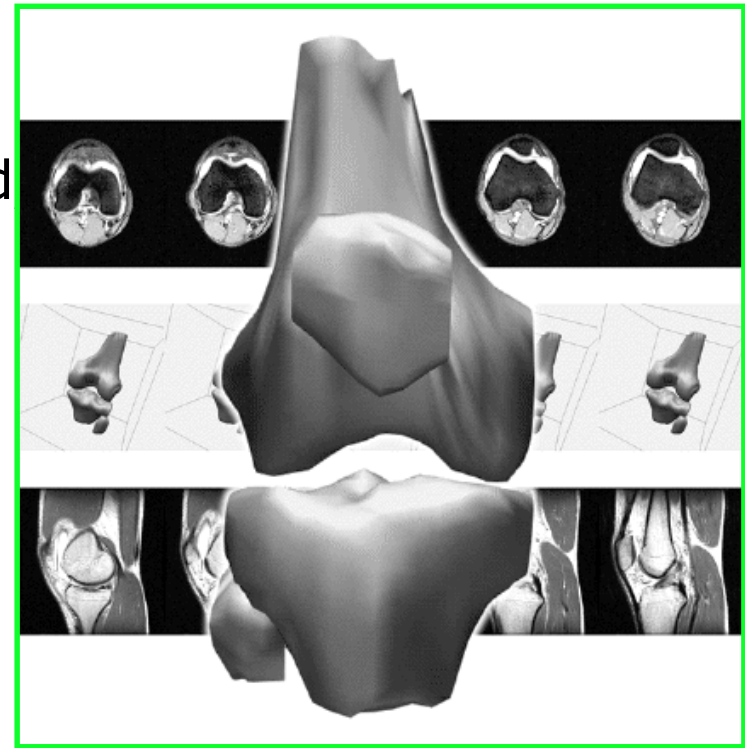
# MRI...

- Allows the clinician to see high quality images of the inside of the body:
  - ❖ Brain, spine
  - ❖ Heart, Lungs
  - ❖ Knees, Wrist Etc.
- MRI machines look like a large block with a tube running through the middle of the machine, called the bore of the magnet.



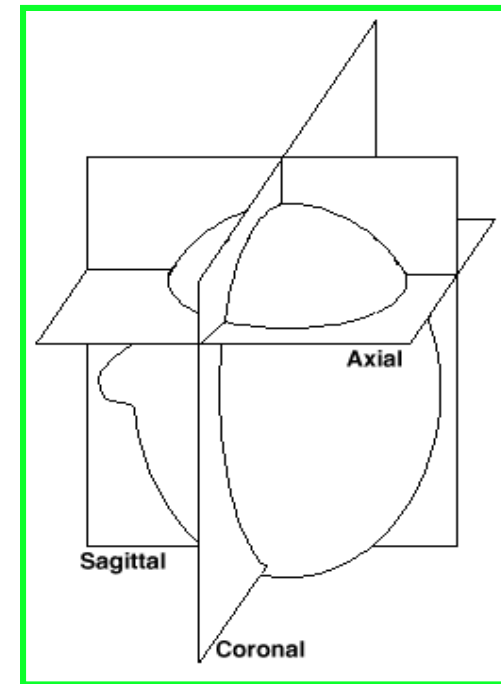
# MRI...

- The MRI machine picks points in the patients body, decides what type of tissue the points define, then compiles the points into 2 dimensional & 3 dimensional images.
- Once the 3 dimensional image is created the MRI machine creates a model of the tissue.
- This allows the clinician to diagnose without the use of invasive surgery.



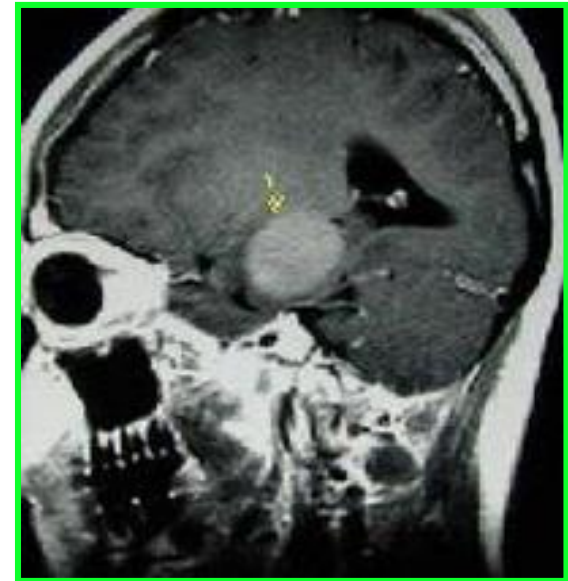
# MRI...

- The largest and most important components of the MRI machine are the magnets.
- The magnet strength is measured in units of Tesla or Gauss (1 Tesla = 10,000 Gauss).
- *Today's MRI machines have magnets with strengths from **5000 to 20,000 Gauss**.*
- These magnets are responsible for altering the magnetic field in the area to be scanned and can magnetically "slice" the tissue to be examined from every angle.



# MRI...

- MRI's of the brain can evaluate how the brain is working, whether normal or abnormal.
- Brain MRI's can show damage resulting from different problems such as: damage due to stroke, abnormalities associated with dementia and/or Alzheimer's, seizures, and tumors



# **How does an MRI scan differ from a CT scan?**

**Individual assignment:**

**Who cannot have MRI scan and CT scan?**

# **LIFE SUPPORT EQUIPMENT**

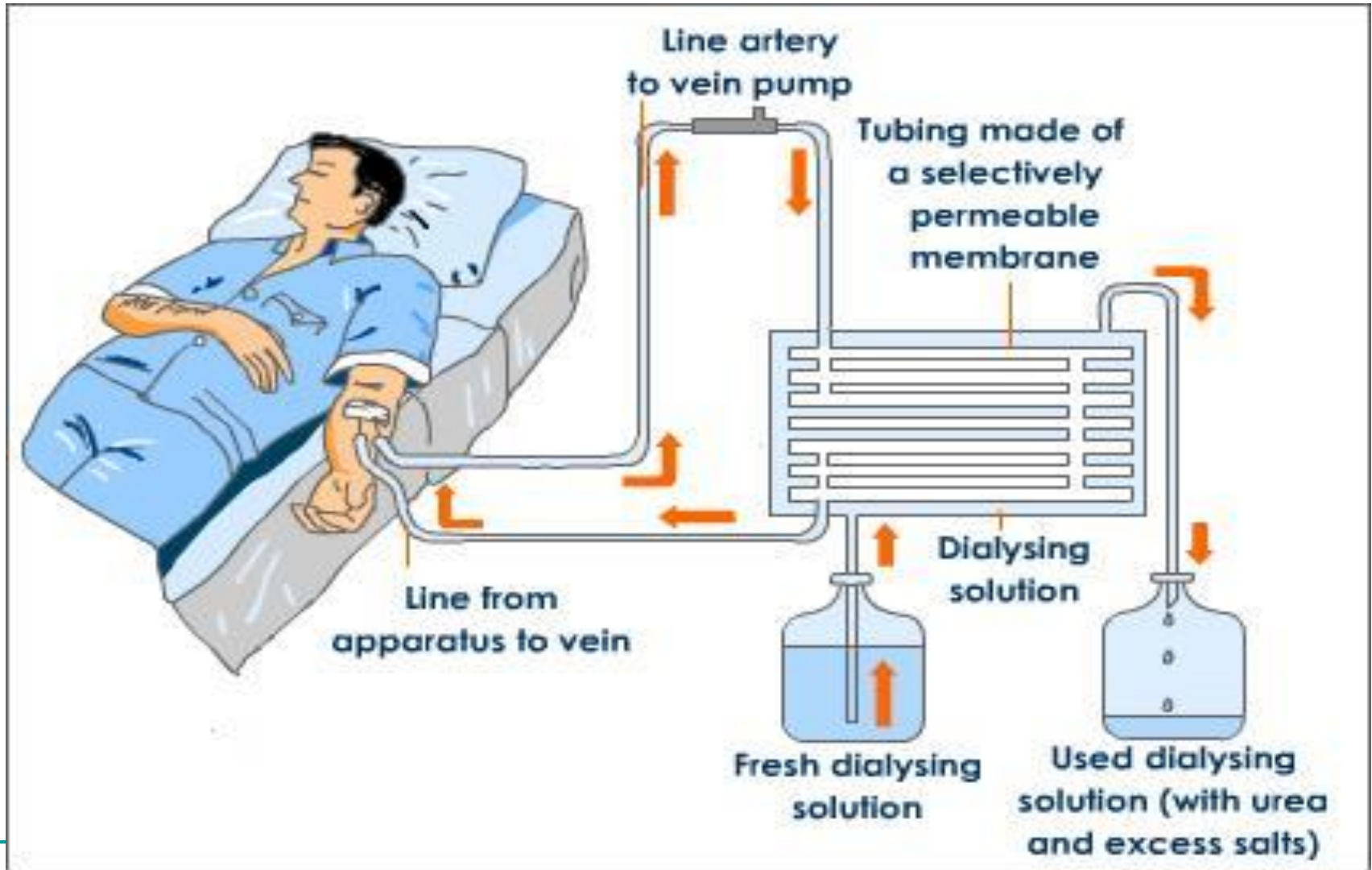
- **Medical ventilators,**
- **Heart - Lung machines,**
- **Dialysis machines**

# Dialysis

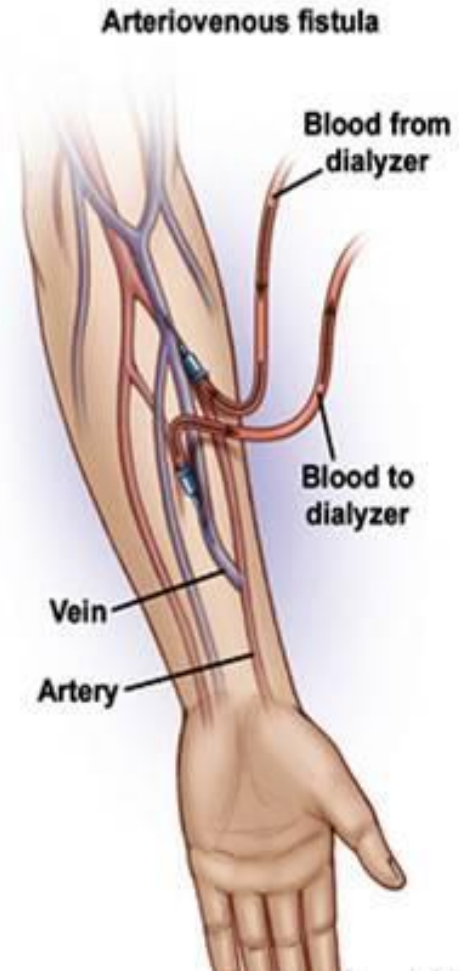
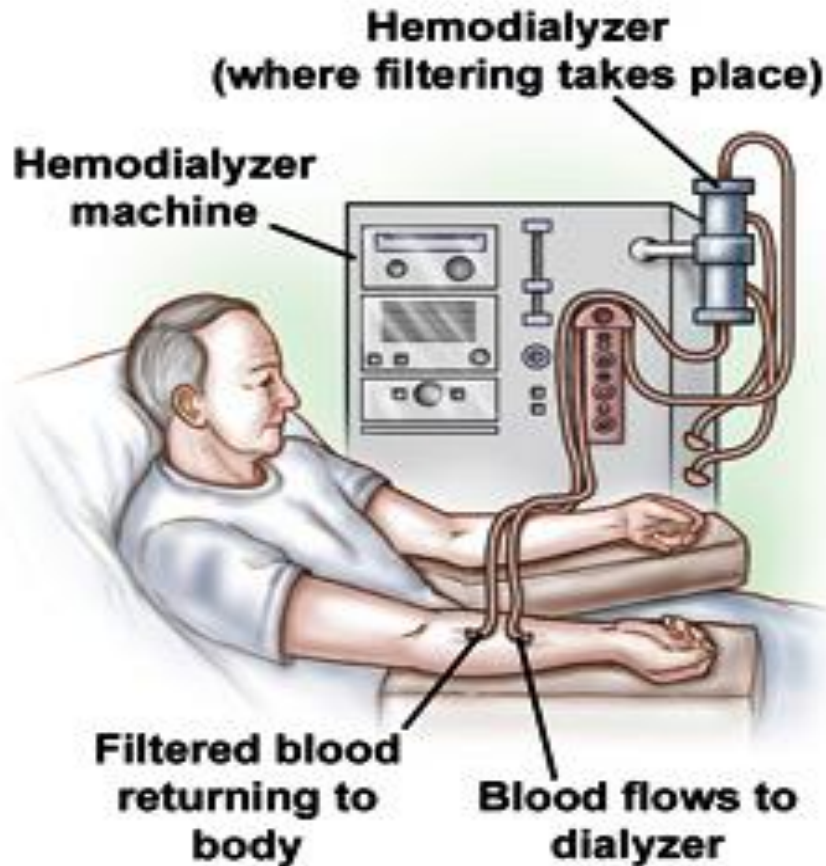
- In medicine dialysis is a process for removing waste and excess water from the blood, and is used primarily to provide an artificial replacement for lost kidney function in people with renal failure.
- Kidneys maintain the body's internal equilibrium of water and minerals (sodium, potassium, chloride, calcium, phosphorus, magnesium, sulfate).
- The kidneys also function as a part of the endocrine system, producing erythropoietin (RBC) and calcitriol (Bone formation).



# Dialysis machines



# Dialysis machines...



# Medical monitors

- In medicine, monitoring is the observation of a disease, condition or one or several medical parameters over time.
- It can be performed by continuously measuring certain parameters by using a medical monitor and by repeatedly performing medical tests.

# Classification of Monitors

- Cardiac monitoring
- Hemodynamic monitoring
- Respiratory monitoring
- Neurological monitoring
- Blood glucose monitoring
- Body temperature monitoring



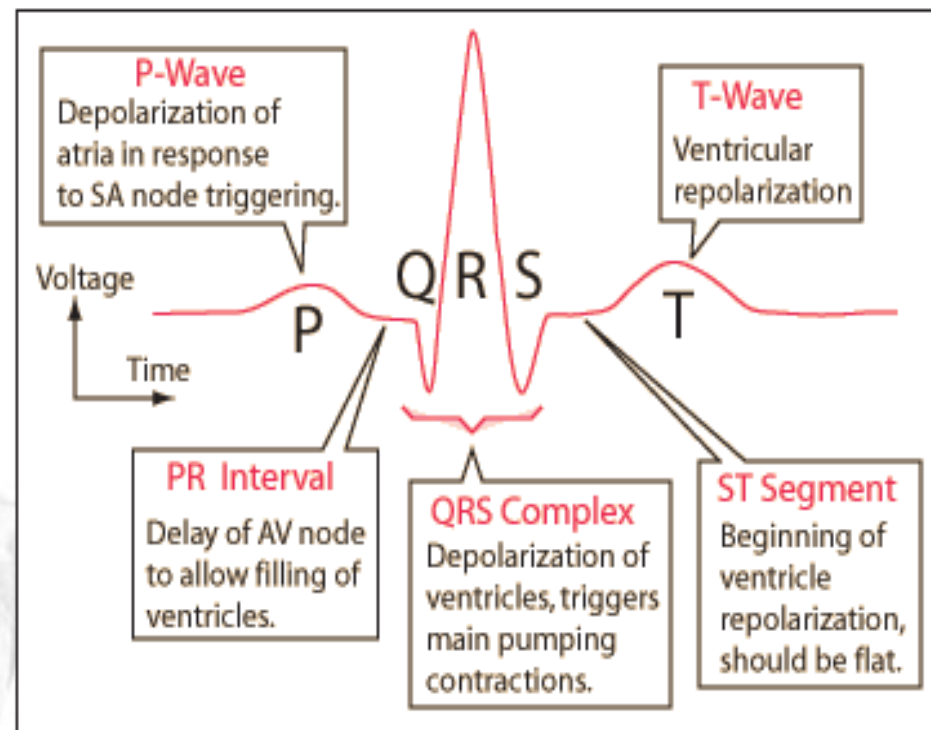
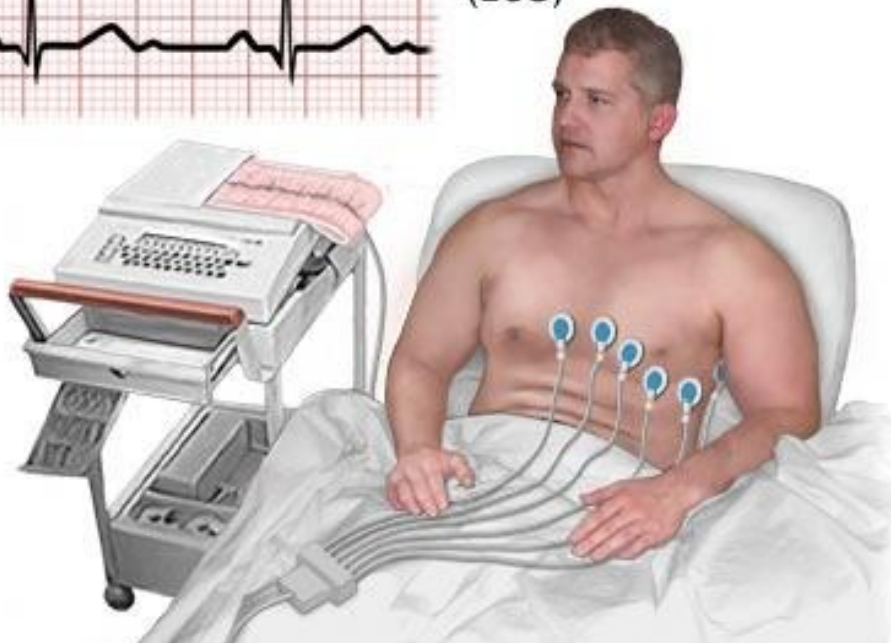
# ECG (Electrocardiography)

- Electrocardiography (ECG or EKG from Greek: *kardia*, meaning heart) is a transthoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body.
- The recording produced by this noninvasive procedure is termed an electrocardiogram (also ECG or EKG).

# ECG...



Electrocardiogram (ECG)



# ECG...

## Application of ECG

- To measure the rate and regularity of heartbeats,
  - To detect the size and position of the chambers,
  - To detect the presence of any damage to the heart, and
  - To detect the effects of drugs or devices used to regulate the heart, such as a pacemaker.
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- ECGs are performed for diagnostic or research purposes on human hearts, but may also be performed on animals, usually for diagnosis of heart abnormalities or research.

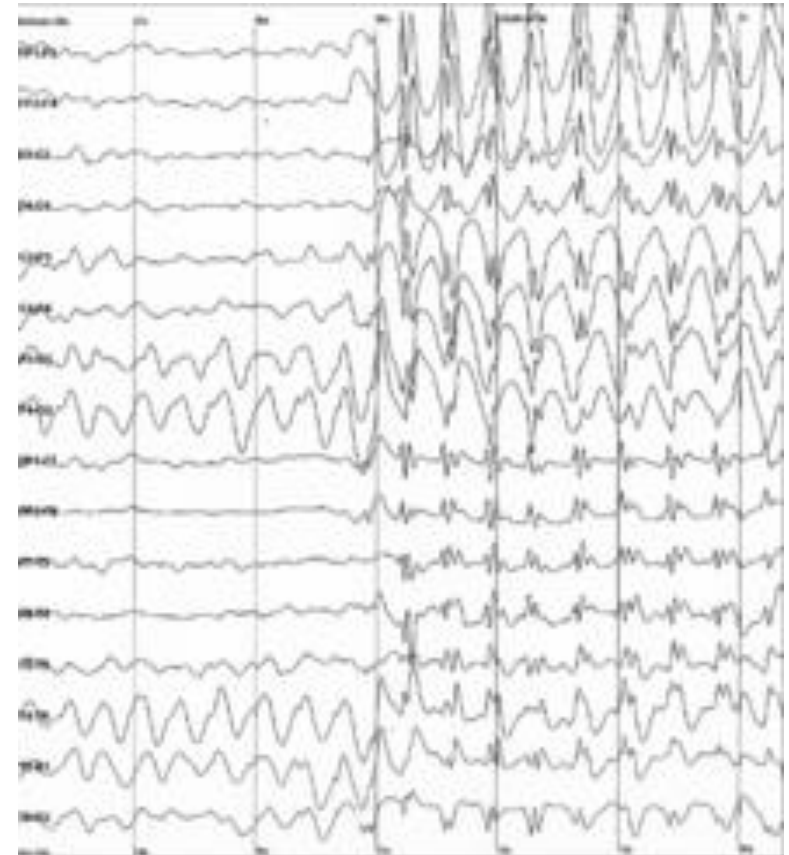
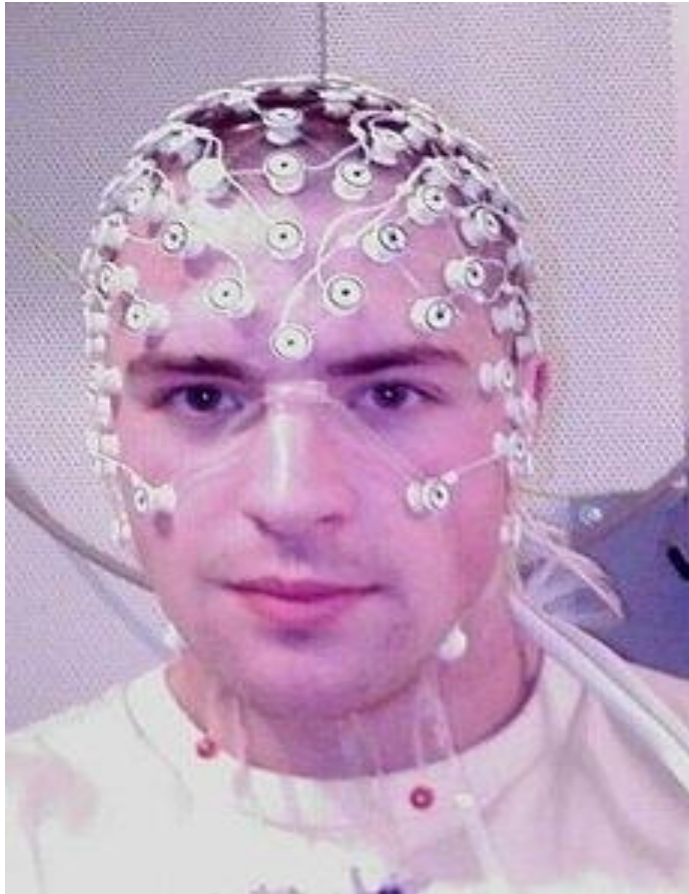


# Electroencephalography (EEG)

- Electroencephalography is the recording of electrical activity along the scalp.
- EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain.
- In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes, as recorded from multiple electrodes placed on the scalp.



# EEG Recording



# Applications of EEG

- Diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations that can be observed in EEG signals.
- In neurology, the main diagnostic application of EEG is in the case of epilepsy, as epileptic activity can create clear abnormalities on a standard EEG study.
- A secondary clinical use of EEG is in the diagnosis of coma, encephalopathies, and brain death.
- A third clinical use of EEG is for studies of sleep and sleep disorders where recordings are typically done for one full night, sometimes more.