Radiology & Medical Imaging

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lecture 1

WHAT IS RADIOLOGY?

- Radiology represents a branch of medicine that deals with radiant energy in the diagnosis and treatment of diseases by using imaging technologies (Modalities),

- This field can be divided into two broad areas
  - Diagnostic radiology
  - Interventional radiology

DIAGNOSTIC RADIOLOGY

Diagnostic radiologists use medical images such as

- X-rays,
- ultrasound,
- CT scans
- MRI scans

to diagnose diseases anywhere in the body

DIAGNOSTIC RADIOLOGY

- Neuroradiology
- Pediatric radiology
- Breast imaging
- Cardiovascular radiology
- Chest radiology
- Gastrointestinal radiology
- Genitourinary radiology
- Musculoskeletal radiology
- Emergency radiology
- Nuclear radiology

INTERVENTIONAL RADIOLOGY

- A subspecialty of radiology that focuses on the diagnosis and treatment of patients utilizing minimally invasive interventional techniques (non-surgical procedures)
- These include
  - Imaging & treatment of blood vessels (angiography)
  - Biopsy procedures,
  - Cardiac Catheterization,
  - Angioplasty (balloon dilation of blood vessels)
  - Stents
  - laser treatment of varicose veins
  - fluid abscess drainage

WHAT IS MEDICAL IMAGING?

- Medical imaging is the visualization of body parts, tissues, or organs, for use in clinical diagnosis, treatment and disease monitoring.

- Imaging techniques encompass the fields of

✓ radiology,

✓ nuclear medicine

✓ optical imaging

✓ image-guided intervention

RADIOLOGY TECHNIQUES (MODALITIES)

- X-ray radiography
- Fluoroscopy
- CT - computer tomography
- MRI - magnetic resonance imaging
- PET - positron emission tomography
- SPECT - single photon emission computed tomography
- Ultrasound


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x-rays

Discovery of x-rays

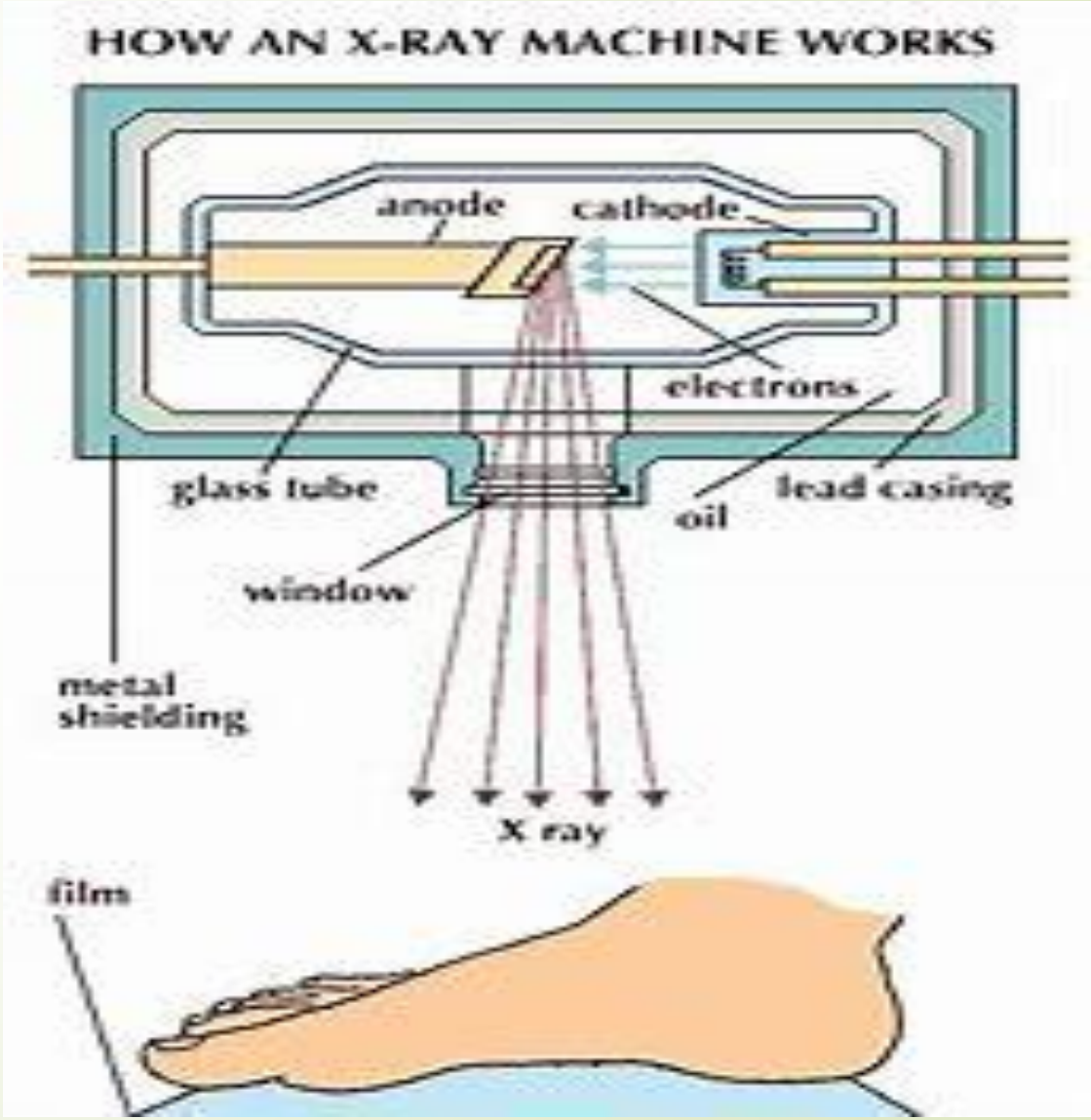
- Discovered in 1895 by German physicist named Wilhelm Roentgen.
- He found shadow of his bone on fluorescent screen.
- X-rays are a form of electromagnetic radiation similar to visible light but with short wave length.

Properties of x-rays

- Are electromagnetic radiations composed of small packets of energy . called photons.
- Travel at speed of light.
- Travel in straight lines.
- Highly penetrating.
- Invisible.
- Blacken radiographic films.
- Produce scatter.

PARTS OF X-RAY MACHINE

- 1. X-ray tube
- 2. Transformer
- 3. Tube stand
- 4. Control pane



How radiographs are produced

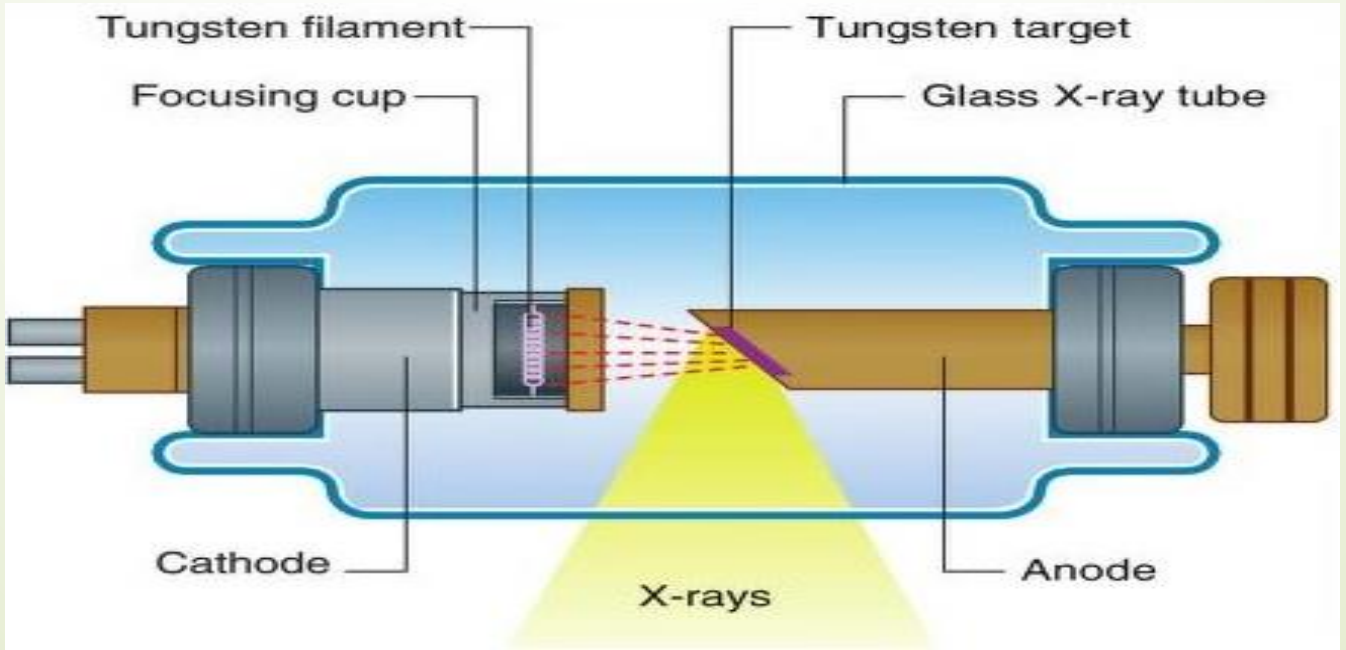
Production of radiograph

- X-ray are produced in the machine.
- X-ray interact with the patient.
- Image is recorded in the x-ray plate.

Production of the x-ray radiations the machine.

Steps in x-ray production:-

- Filament is heated and gives off cloud of electrons.
- A large electrical charge is placed in the cathode/anode space causing the electrons to race toward the anode.
- When they crush into the anode it causes x-ray to be given off.



Control panel

- Higher kv attract the electrons toward the anode by greater force.
- They smash the anode harder and produce x-ray with higher energy and greater tissue penetrating power.
- Increasing mA increase the number of electrons cloud around the filament. Result in higher number of x-ray produced per second.

3. CONTROL PANEL

X-ray tube head

Stationary anode.

- Found in smaller machines.
- The target is fixed in block of copper.
- Only capable of low output.
- mA to 30m

Rotating anode.

- Found in large machines.
- The target is rotate in The tungsten disc.
- Higher output producing.
- mA up to 300m

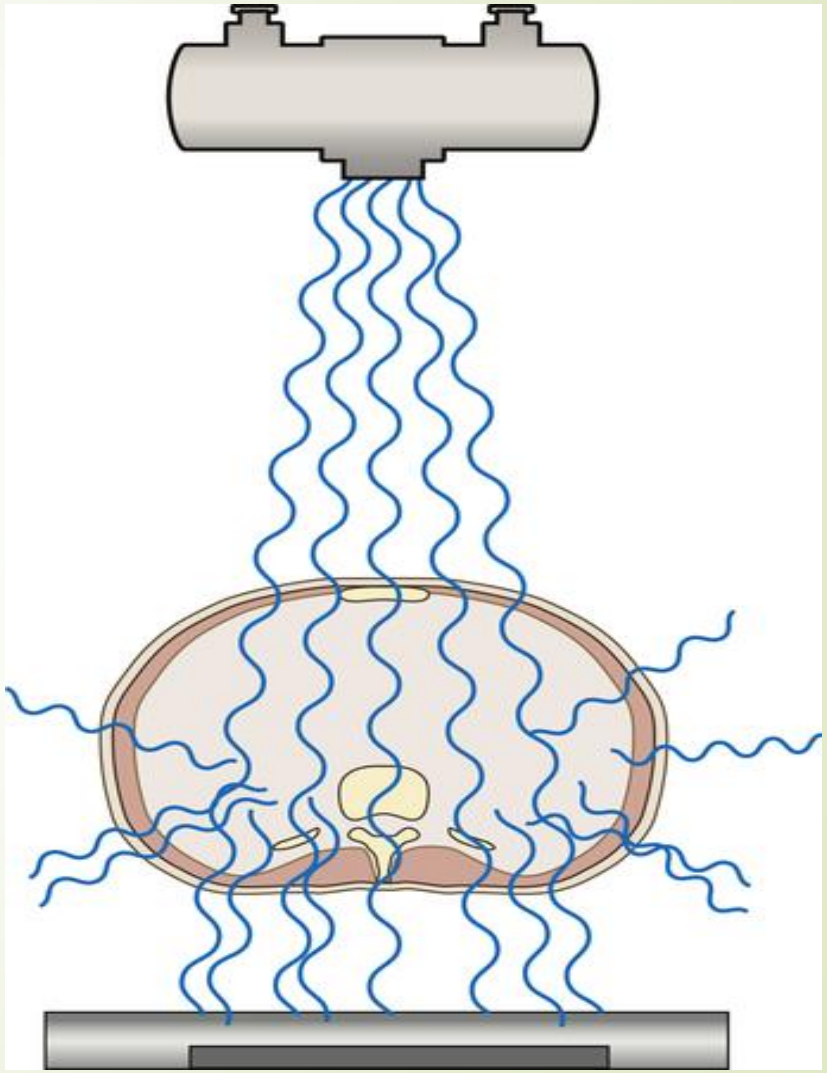
How x-ray interact with patients.

Three things occurred:

- Some x-rays absorbed.
- Some pass straight through the patient.
- Some scattered

Depend on three things

- X-ray energy. In high kv most of x-rays pass to the film through the patient.
- Atomic number of the absorber.
- Thickness and density of the object.



How image is formed

- As an x-ray beam leave the tube head, it fans out and become weaker.
- As the distance double, the strength is reduced.

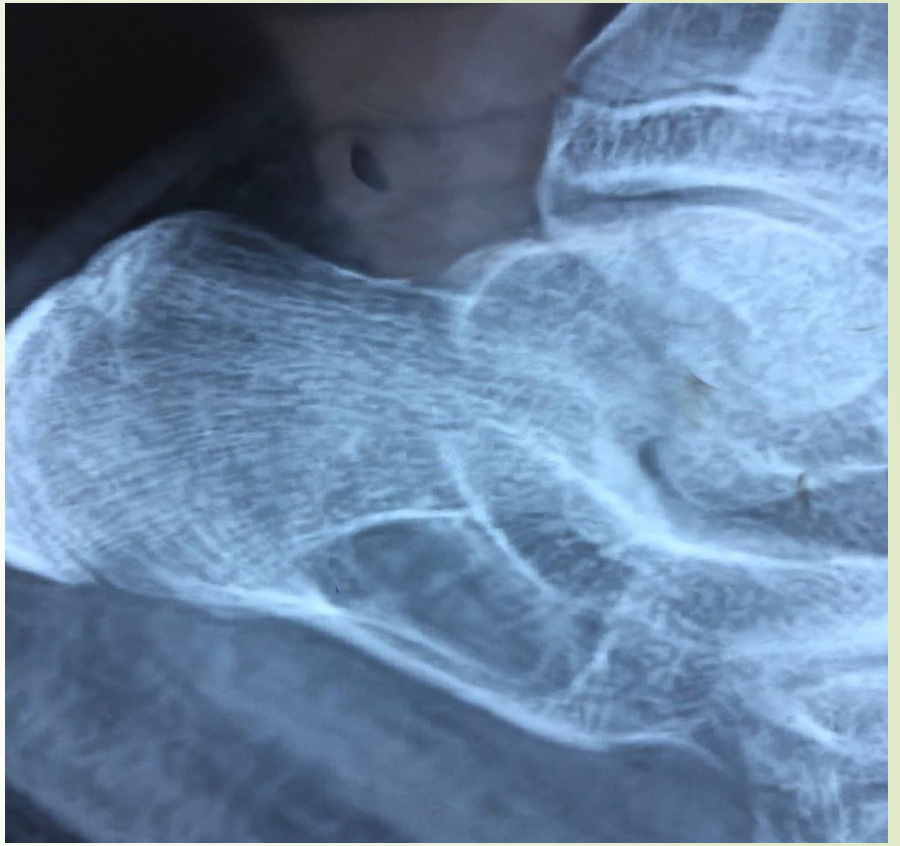
. Formation of the image:

- The distance from the anode target to the film is called the film focal distance.
- Changing the distance affect the quantity of the x-ray reaching the film.
- Increasing the distance means that less x-rays reaches the film

Processing films

- There are five steps:
  - Developing.
  - Rinsing,
  - Fixing.
  - Washing.
  - Drying.

ADVANGTAGE



Good bone resolution

Can be used on a wide range of people

Widely available

Quick imaging

DISADVANGTAGE

Uses ionising radiation can be harmful- cause cells to mutate and cause cancer

Poor images of soft tissues

Limit to the number of X-rays you can have in any given time frame due to the ionising radiation

FLUOROSCOPY

- Fluoroscopy is a type of medical imaging that shows a continuous X-ray image on a monitor, much like an X- ray movie.
- During a fluoroscopy procedure, an X-ray beam is passed through the body. The image is transmitted to a monitor so the movement of a body part or of an

instrument or contrast agent ("X-ray dye") through the body can be seen in detail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CT - computed tomography

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CT scan

is a diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce images of the inside of the body.

It shows detailed images of any part of the body, including the bones, muscles, fat, organs and blood vessels.

CT scans are more detailed than standard X-rays.

Computed : use of computer

Tomography: Greek word tomos means "slice",

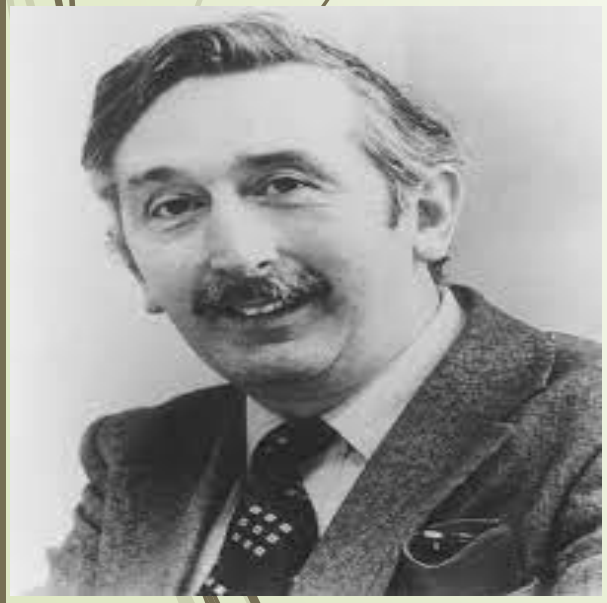
graphy means "write".

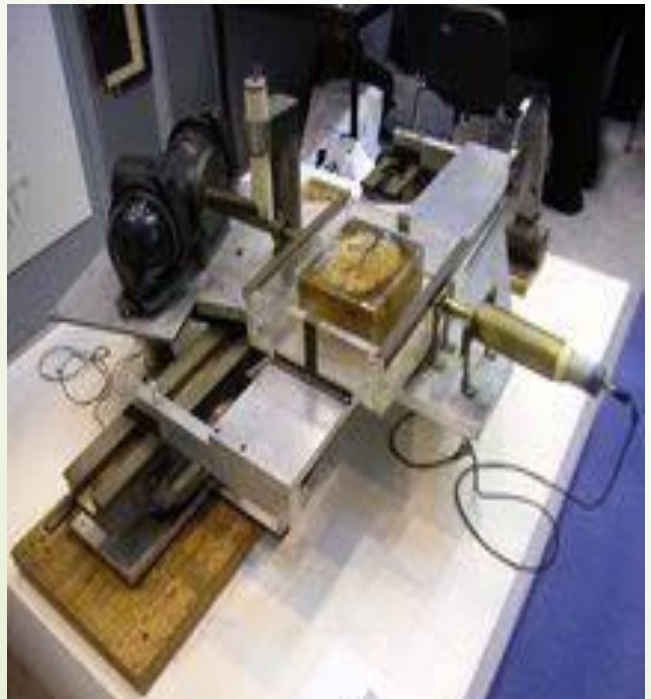
 Computed Tomography is the process of generating a two-dimensional image of a slice or section through a 3-dimensional object (a tomogram)

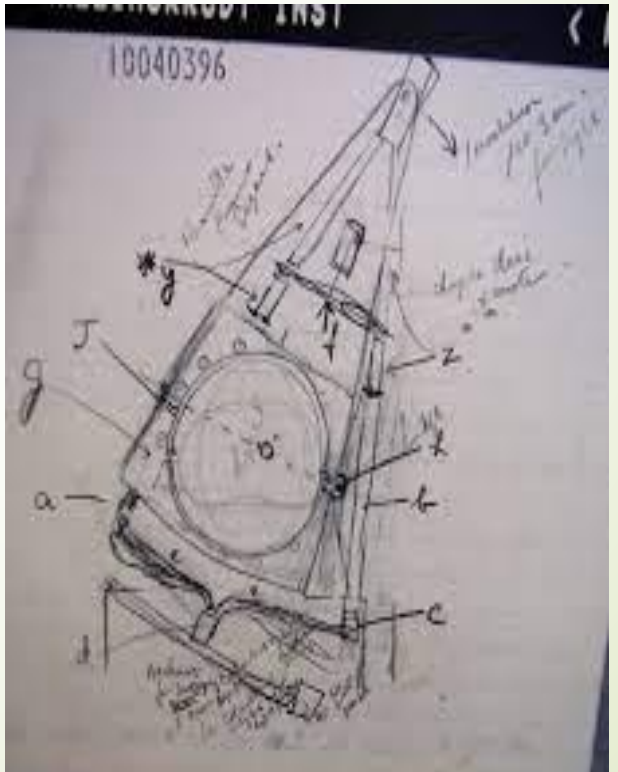
The first commercially CT scanner was invented by Sir Godfrey Hounsfield using X-rays

The first EMI-Scanner was installed in Atkinson Morley Hospital in Wimbledon, England

 The first patient brain-scan was done on 1 October 1971.





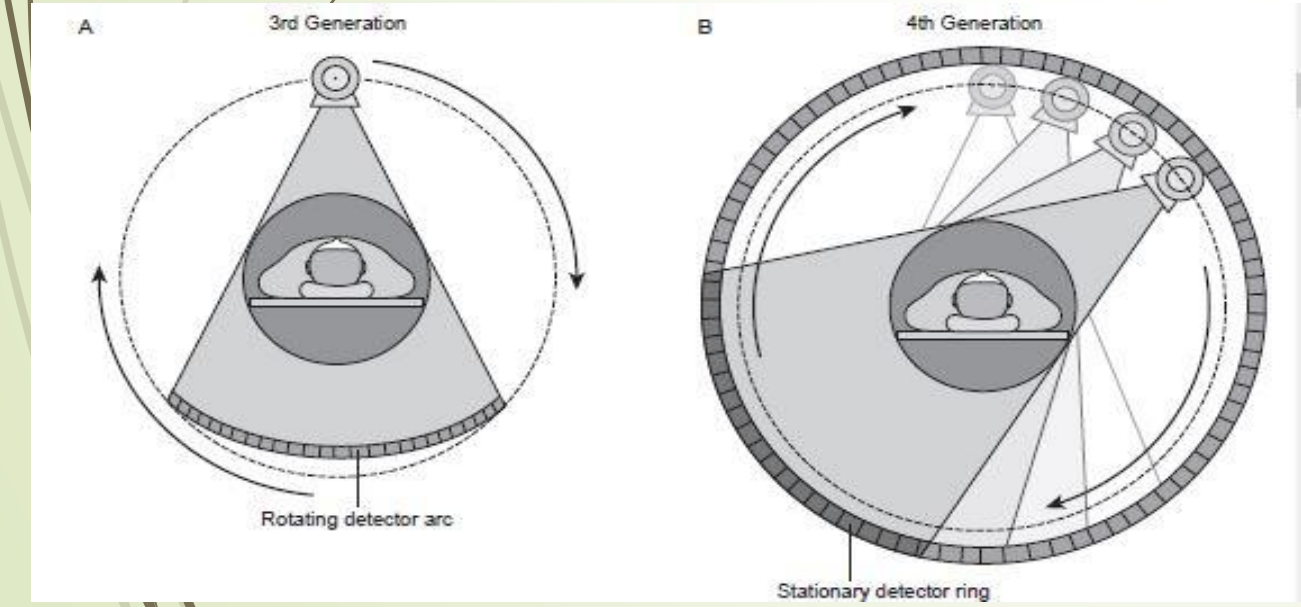


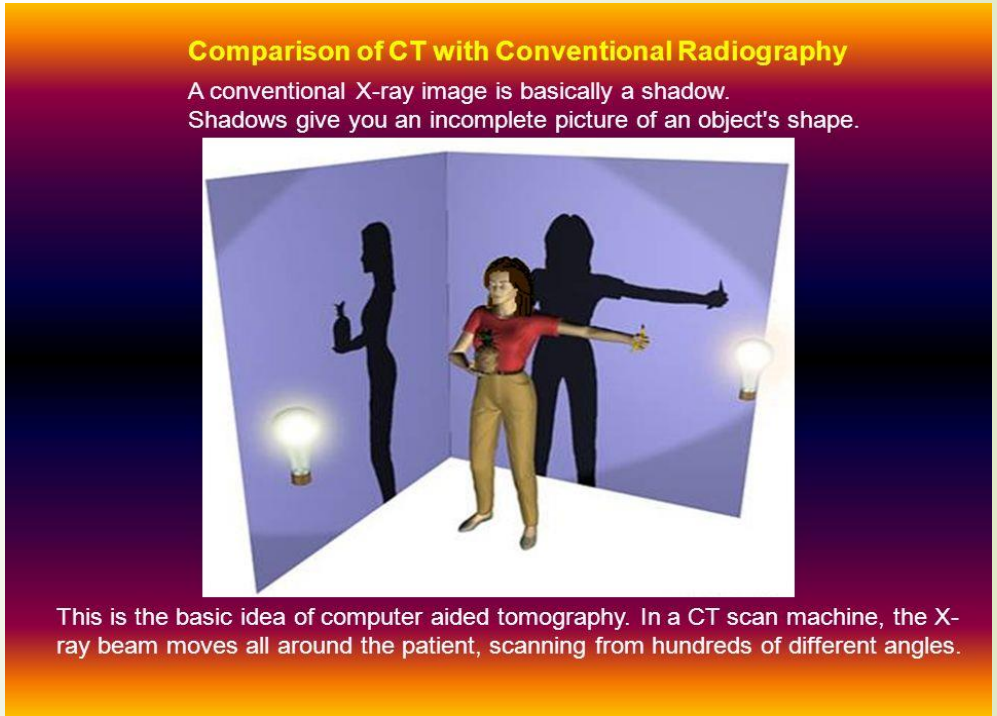
Introduction •

- Computed tomography (CT) is a medical imaging method employing tomography.
- A large series of two-dimensional X-ray images (slices) of the inside of an object are taken around a single axis of rotation.
- Digital geometry processing is used to generate three-dimensional images of the object from those slices.

CT-The basics

- • The x-rays are produced in a part of the ring and the ring is able to rotate around the patient.
- • The target ring contains an array of detectors and is internally cooled so the to reduce electronic noise and to cool the anode.
- • The patient is put into the system using a precise high speed couch.





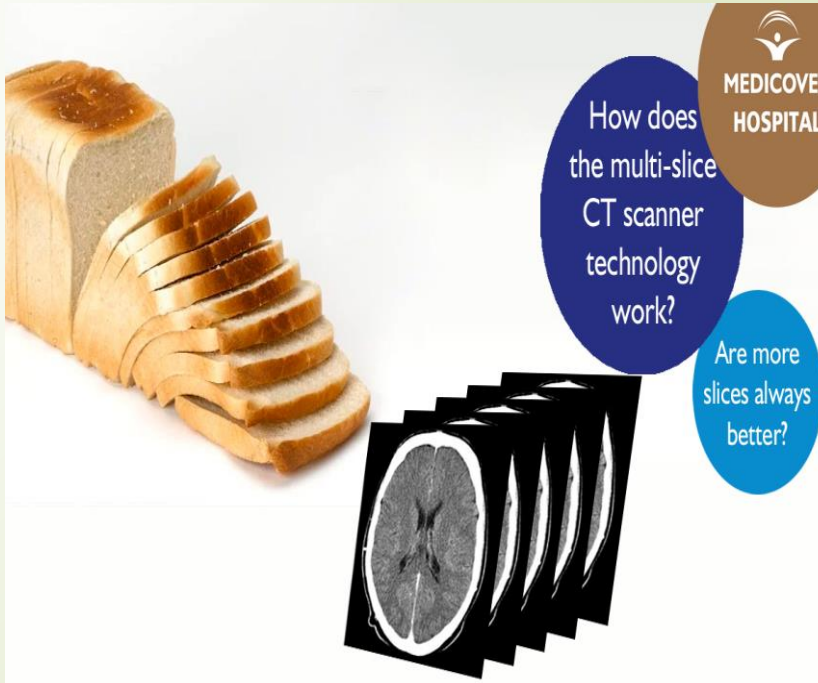
CT Scan: What is it?

- •A noninvasive medical procedure that helps diagnose medical conditions
- • In the past only seen through surgery or autopsy
- • Internal organs, bones, soft tissue and blood vessels
- • Greater clarity, more detail Than X-ray

VARIOUS PARAMETERS OF CT

- SLICE
- MATRIX
- PIXEL
- VOXEL
- CT NUMBER
- WINDOWING
- WINDOW WIDTH
- WINDOW LEVEL
- PITCH

- 1. SLICE/CUT
- The cross section portion of body which is scanned for production of CT image is called Slice.
- The slice has width and therefore volume.
- The width is determined by width of the x rays beam



CT Scan: How does it work?

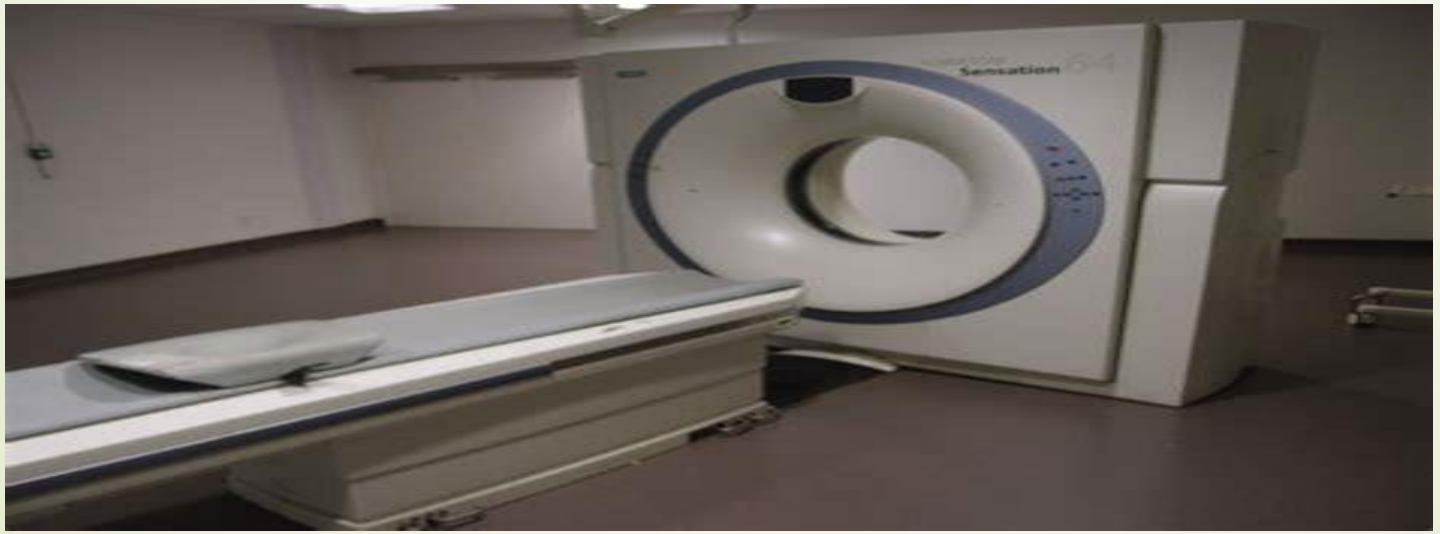
- • 2D cross sectional image
- • Electromagnetic energy from all angels
- • Different body parts absorb beams differently
- • Contrast material (dye) enhances images

CT Scan: Used For Diagnose

- cancers.
- CV disease.
- infectious disease.
- Appendicitis.
- Trauma.
- muscular-skeletal disorders.

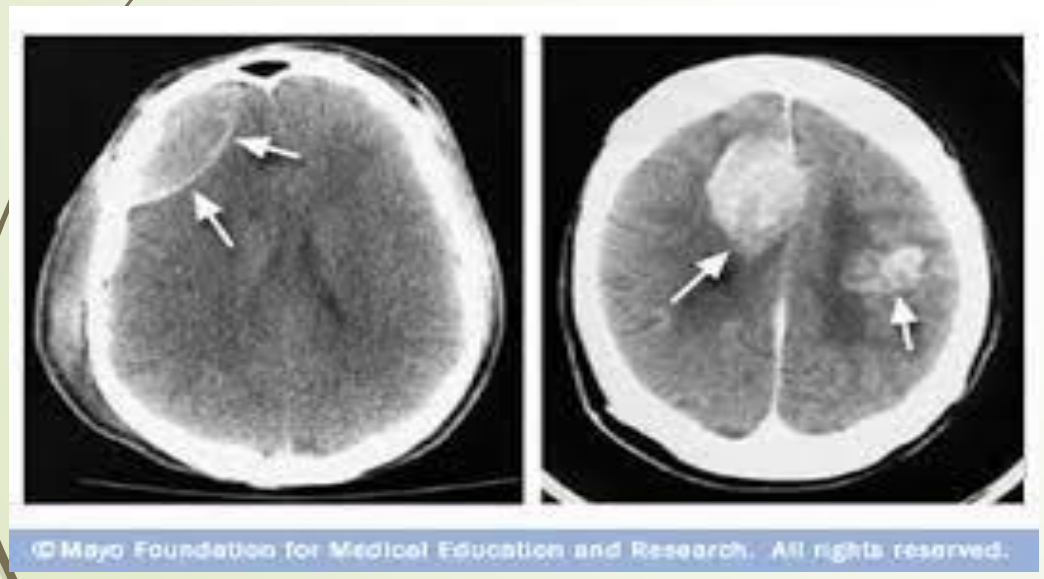
CT scan: Equipment

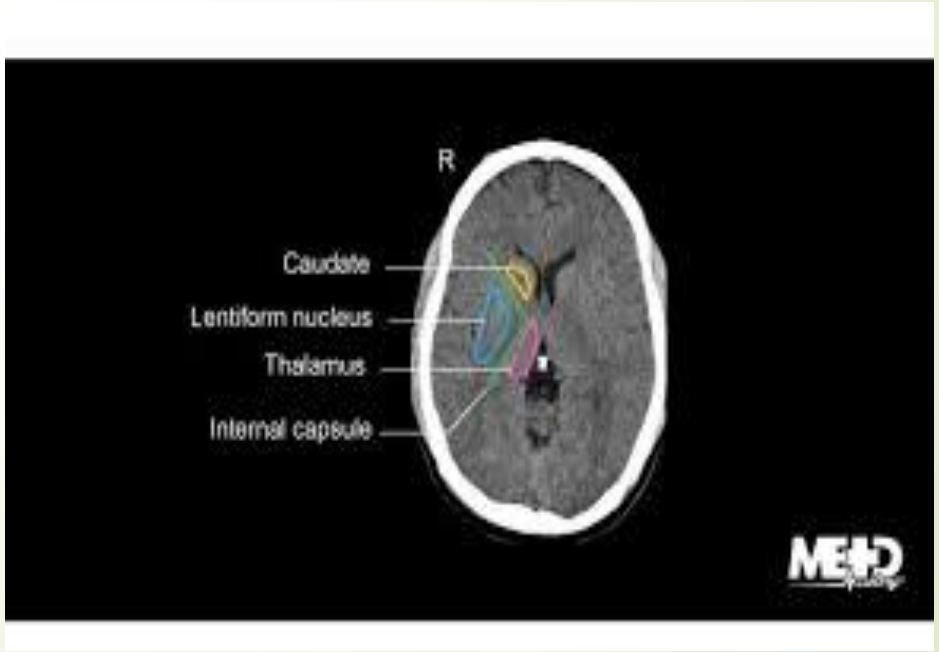
- Large box-like machine with hole in the middle.
- Pt. lies on narrow table that slides in and out of this hole.
- X-ray tube and electronic x-ray detectors rotate around you (gantry).
- Computer processes the information and is operated by a technologist who works scanners and monitors the exam.



CT- Image Quality Contrast Resolution

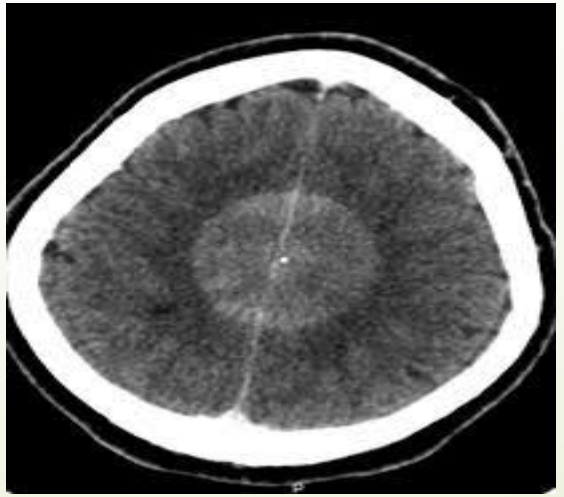
- – The ability to differentiate between different tissue densities in the image
- High Contrast - Ability to see small objects and details that have high density difference compared with background.
- Low Contrast - Ability to visualize objects that have very little difference in density from one another.





CT- Imaging Artifacts

- • Artifacts can degrade image quality and affect the perceptibility of detail.
- - Streaks – due to patient motion, metal, noise, mechanical failure.
- - Rings and bands – due to bad detector channels.
- - Shading - can occur due to incomplete projections.



CT Scan: Not for

- … Pregnant women.
- nursing mothers If dye is used, … should wait 24h before resuming feedings.
- Allergies to iodine.
- a very large person may not fit in the scanner and the table has a limit of 450 lbs.

What Is Bright on CT?

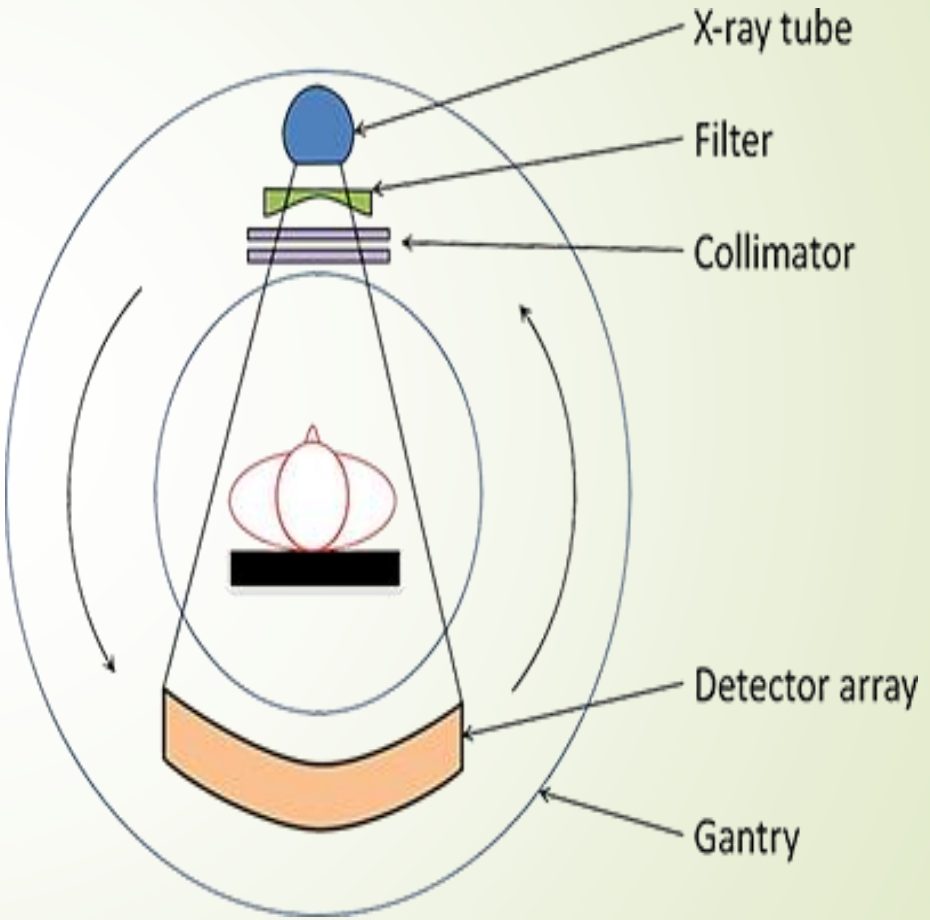
- Blood.
- Contrast.
- Bone.
- Calcium.
- Metal.

What Is Dark on CT?

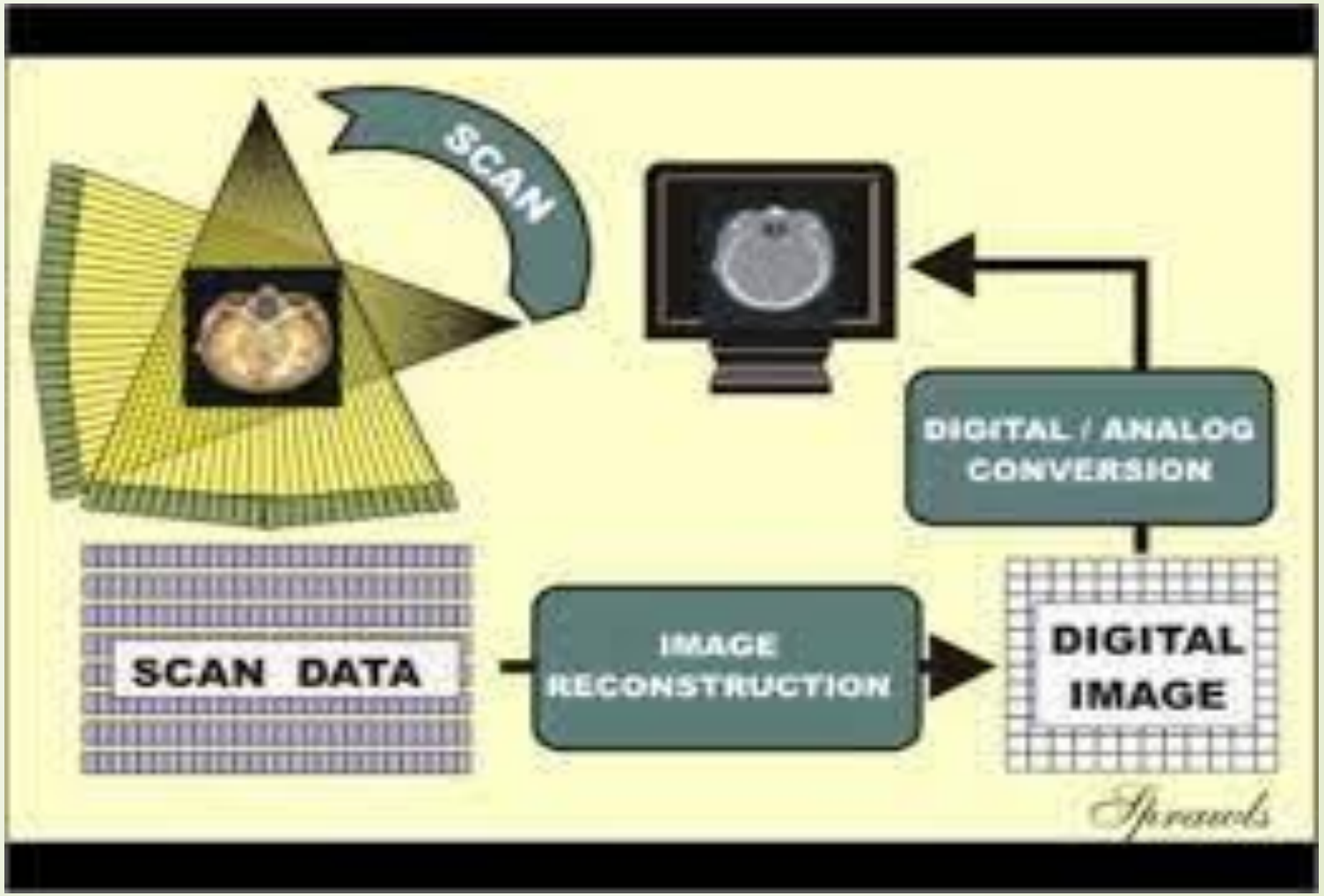
- Air .
- CSF
- H20 .

Basic CT scanner components

- Gantry
- X-Ray Tube
- Detector
- ControlConsole

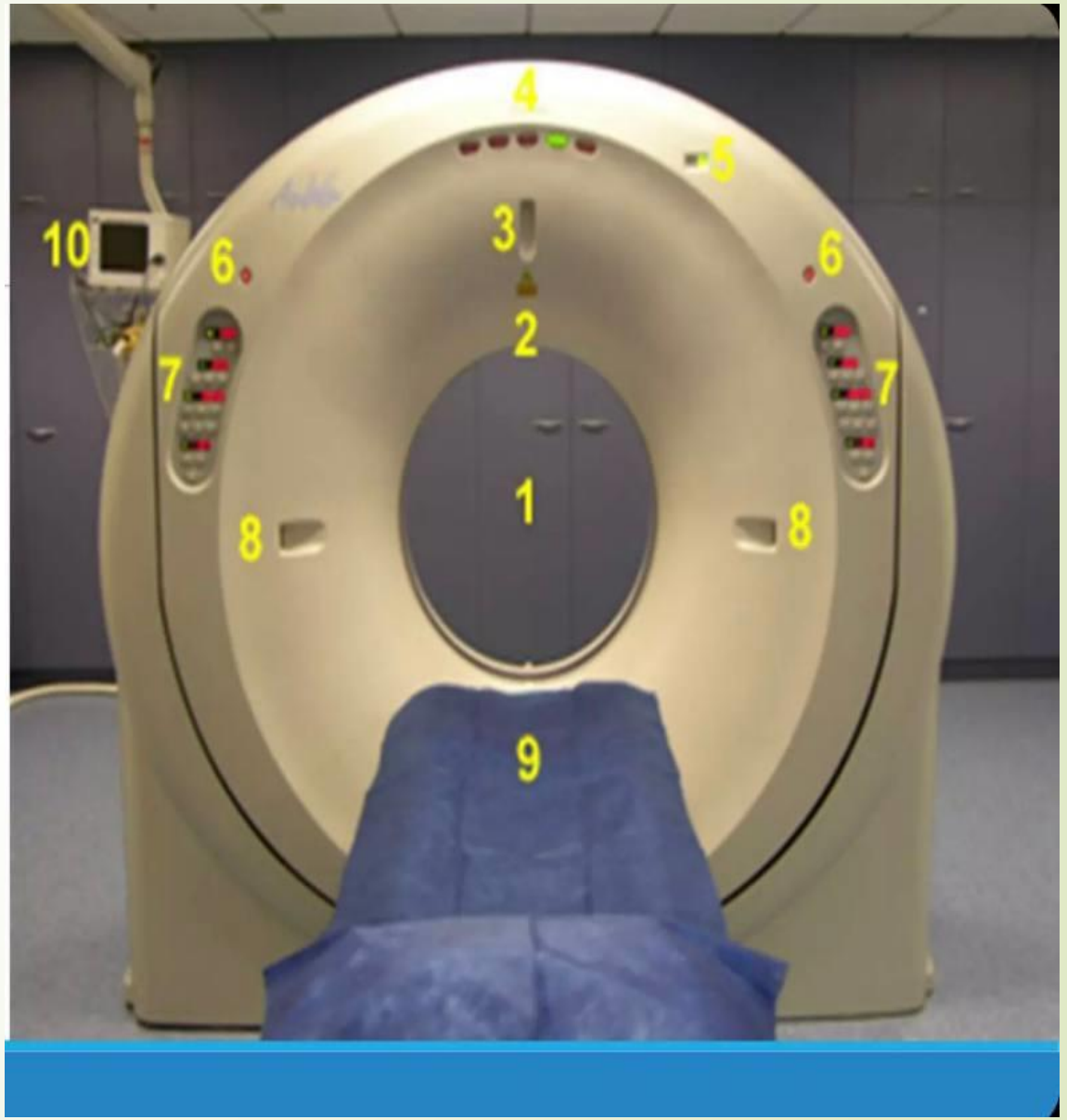


STEPS OF CT IMAGE FORMATION



CT scanner

- 1-gantry aperture (720mm diameter)
- 2-microphone
- 3-sagittal laser alignment light
- 4-patient guide lights
- 5-x-ray exposure indicator light
- 6-emergency stop buttons
- 7-gantry control panels
- 8-external laser alignment lights
- 9-patient couch
- 10-ECG gating monitor

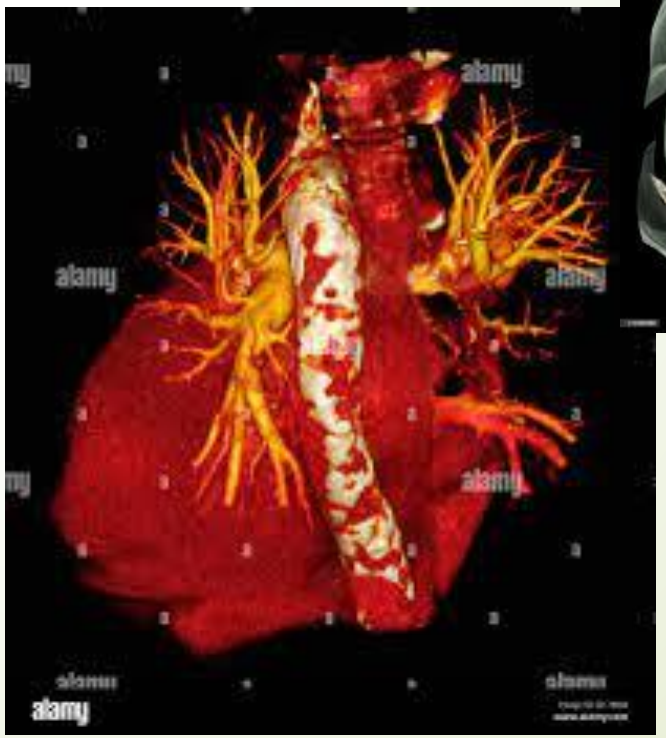


Advantages to CT

- Desired image detail is obtained.
- Fast image rendering.
- Filters may sharpen or smooth reconstructed images.
- Raw data may be reconstructed post-acquisition with a variety of filters.

Disadvantages to CT

- Multiple reconstructions may be required if significant detail is required from areas of the study that contain bone and soft tissue.
- Need for quality detectors and computer software.
- X-ray exposure




THANK YOU

MRI:
MAGNETIC RESONANCE IMAGING

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DEFINITION
Magnetic resonance imaging (MRI)

- is a technique that uses a magnetic field and radio waves to create detailed images of the organs and tissues within your body

HISTORY

- Nikola Tesla discovered the Rotating Magnetic Field in 1882 in Hungary.
- In 1956, the "Tesla Unit" was proclaimed.
- All MRI machines are calibrated in "Tesla Units".
- The strength of a magnetic field is measured in Tesla or Gauss Units
- In 1973, Paul Lauterbur, a chemist, produced the first NMR image.
- On July 3, 1977, the first human scan was made as the first MRI prototype. (The process took 5 hours).

- 1 Tesla = 10,000 Gauss
- Low-Field MRI= Under 0.2 Tesla (2,000 Gauss)
- Mid-Field MRI= 0.2 - 0.6 Tesla (2,000 - 6,000 Gauss)
- High-Field MRI= 1.0 - 1.5 Tesla (10,000 - 15,000 Gauss)

MECHANISM OF ACTION

- Magnetic field temporarily realigns hydrogen atoms in your body.
- Radio waves cause these aligned atoms to produce signals
- Signals used to create cross-sectional MRI images

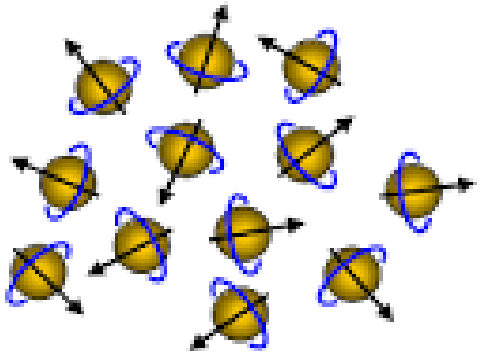


Figure 1

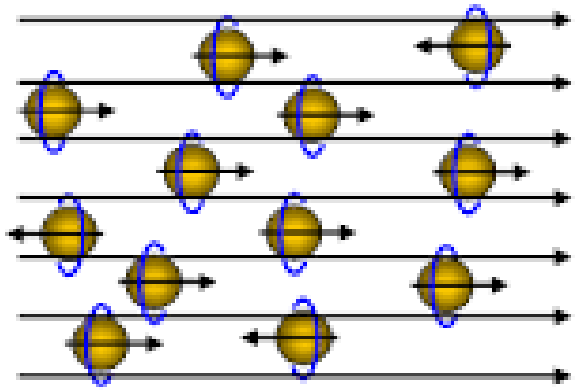
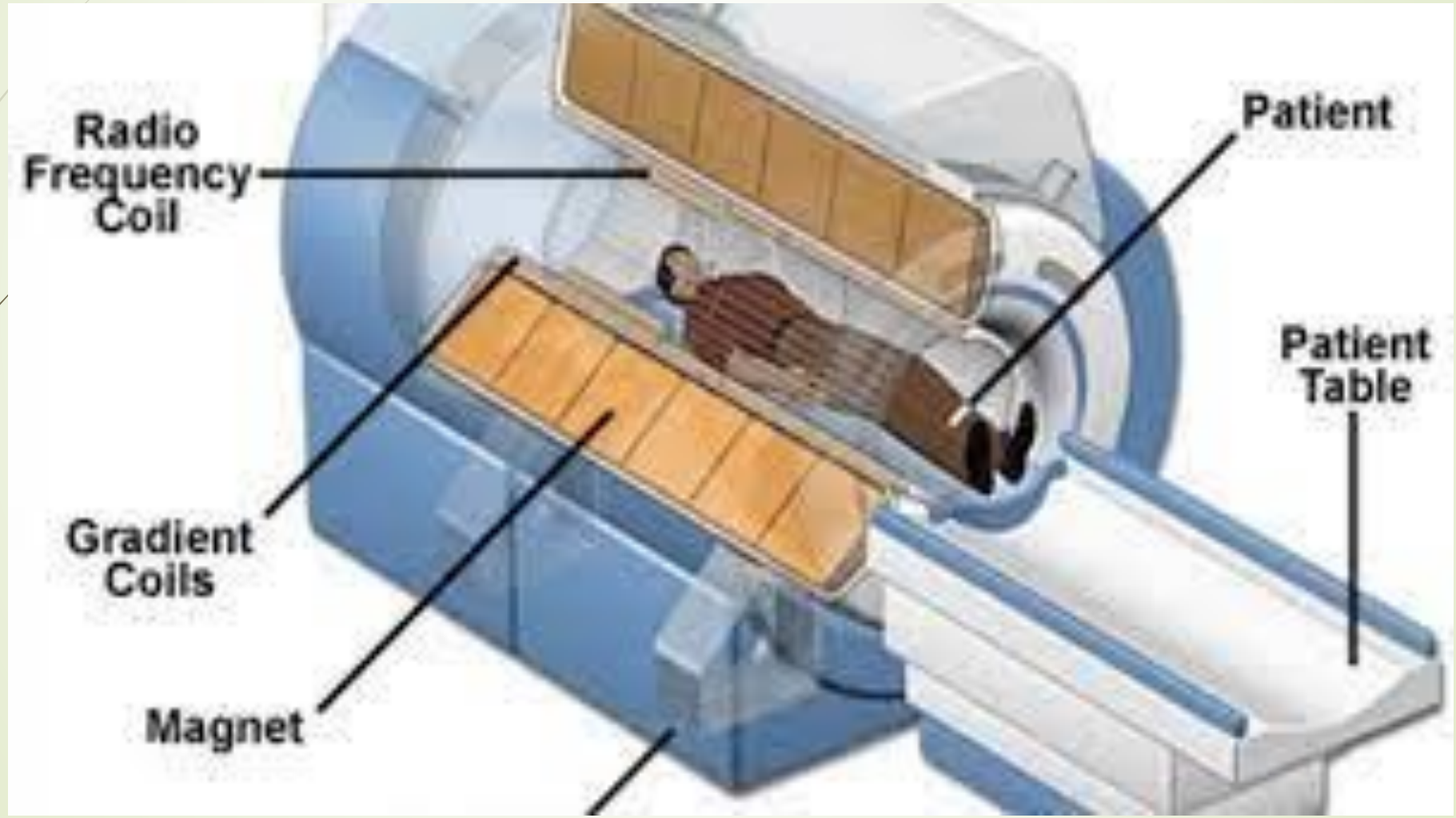


Figure 2

COMPONENTS OF MRI MACHINE



MAIN COMPONENTS OF MRI

- • Scanner
- • Computers
- • Recording hardware

- SCANNER

  An MRI scanner is a large tube that contains powerful magnets.

  • Main components of scanner

  – Static magnetic field coils

  – Gradient coils

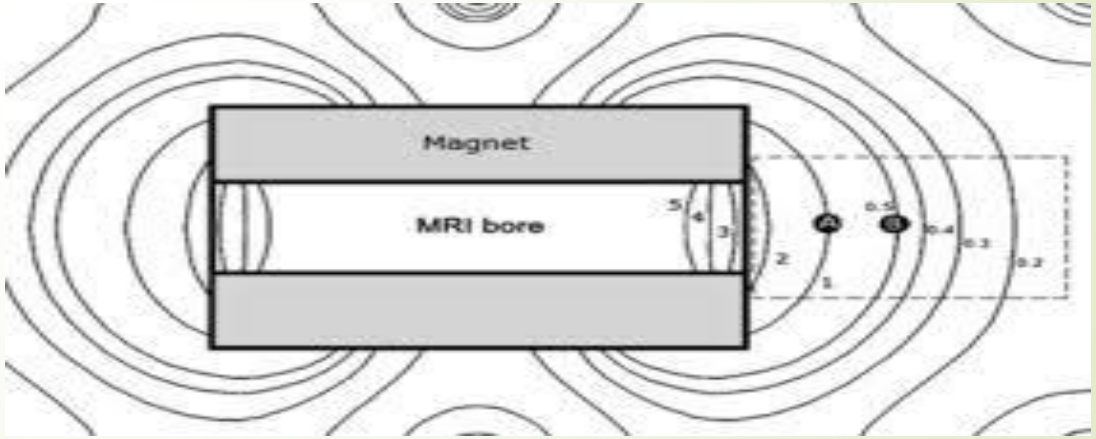
  – RF (radiofrequency) coils

Static Magnetic Field Coils

- • Three methods to generate magnetic field
- 1. Fixed magnet
- 2. Resistive magnet
- 3. Super conducting magnet
- • Fixed magnets and resistive magnets are generally restricted to field strengths below 0.4t
- • 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

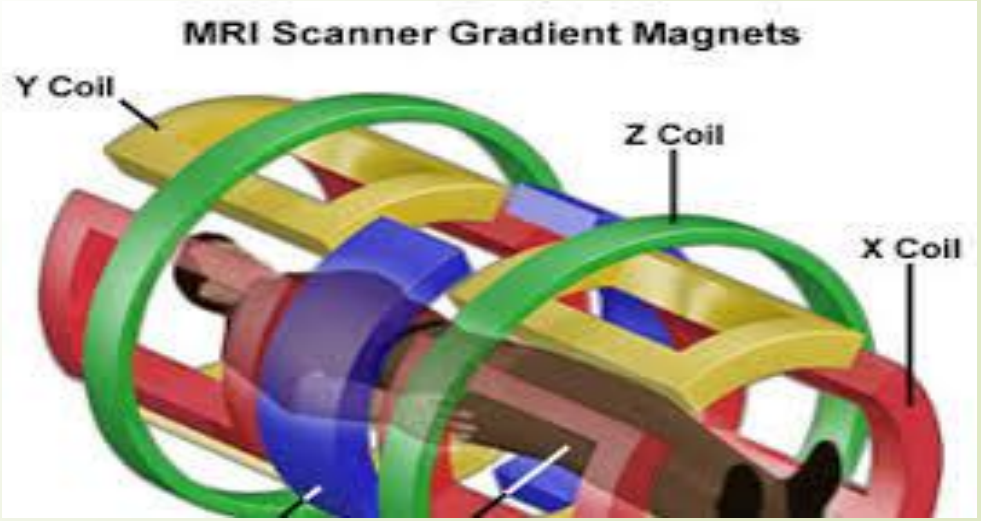
COMPONENTS OF MRI MACHINE

- Magnet There is a horizontal tube that runs through the magnet and is called a bore.
- Most MRI magnets use a magnetic field of 0.5 to 2.0 tesla. (Earth's magnetic field is only 0.5 gauss.)
- The magnetic field is produced by passing current through multiple coils that are inside the magnet.



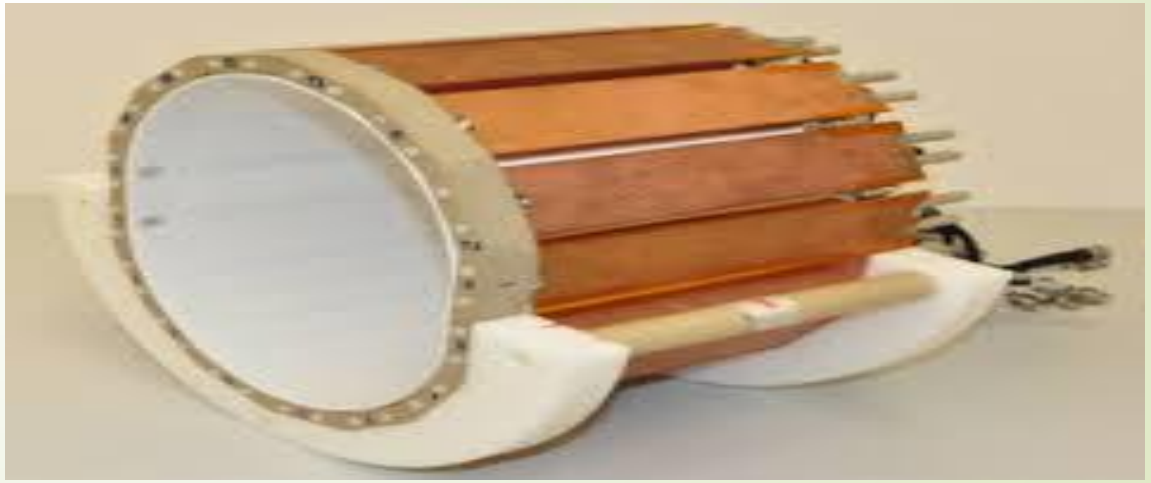
Gradient Coils

- There are three different gradient coils located within the main magnet.
- Each one of these produce three different magnetic fields that are each less strong that the main field.
- The gradient coils create a variable field (x, y, z) that can be increased or decreased to allow specific and different parts of the body to be scanned by altering and adjusting the main magnetic field.



Radio Frequency (RF) coils

- Transmit radio frequency waves into the patient's body.
- There are different coils located inside the MRI scanner to transmit waves into different body parts.
- If a certain area of the body is specified, then all the RF coils usually become focused on the body part being imaged to allow for a better scan.



COMPONENTS OF MRI
Patient Table

- This component simply slides the patient into the MRI machine.
- The position at which the patient lies down on the table is determined by the part of the body that is being scanned.
- Area under examination is placed in the exact centre of the magnetic field (isocentre).

COMPONENTS OF MRI Antenna/Computer System

- The antenna detects the RF signals emitted by a patient's body and feeds this information into the computer system.
- The computer system: function is to receive, record, and analyze the images of the patient.
- It interprets the data produce an understandable image

WHAT CAN BE DIAGNOSED BY AN MRI SCAN?

- • Most ailments of the brain, including tumours
- • Sport injuries
- • Musculoskeletal problems
- • Most spinal conditions/injuries
- • Vascular abnormalities
- • Female pelvic problems
- • Prostate problems
- • Some gastrointestinal tract conditions
- • Certain ear, nose and throat (ENT) conditions
- • Soft tissue and bone pathology/conditions

WHO CAN'T HAVE AN MRI SCAN?

- • A cardiac pacemaker
- • Certain clips in head from brain operations
- • A cochlear implant
- • A metallic foreign body in your eye
- • surgery in the last 8 weeks
- • pregnancy

ADVANTAGES

- scanning and detection of abnormalities in soft tissue.
- There is no involvement of any kind of radiations in the MRI
- MRI scan can provide information about the blood circulation
- Painless
- images may be acquired in multiple planes (Axial, Sagittal, Coronal, or Oblique) without repositioning the patient
- MRI images demonstrate superior soft tissue contrast than CT scans and plain films making it the ideal examination of the brain, spine, joints and other soft tissue body parts
- functional MRI allows visualization of both active parts of the brain during certain activities and understanding of the underlying networks

DISADVANTAGES

- MRI scans are considered to be a safe procedure providing you do not have any implants or objects on you that must not go in the scanner.
- The powerful magnetic fields generated by the MRI scanner will attract metal objects
- The magnetic field of the MRI scanner can also pull on any metal-containing object in your body, such as medicine pumps and aneurysm clips. Medical implants may heat up during the scan as a result of the technology.
- MRI scans can cause heart pacemakers, defibrillation devices and cochlea

Comparison between X-ray CT system and MRI system

	X-ray CT system	MRI system
Principle of imaging	Absorption of X-ray	Magnetic resonance phenomenon
Radiation exposure	Yes	No
Tissue resolution	Good (physical information)	Excellent (scientific information)
Dynamic diagnostic information	Difficult	Easy
Influence by bone, air	Yes	No
Image plane	Transverse plane	Arbitrary section plane
Examination noise	Comparatively quiet	Large
Examination time	Short (5~10 min.)	Long (15~30 min.)
Preferred area	Lung, abdomen, bone, etc.	Brain, spinal cord, junction, etc.

MRI VS. CT

Radiation exposure

- CT Scan The effective radiation dose from CT ranges from 2 to 10 mSv, which is about the same as the average person receives from background radiation in 3 to 5 years.

  None. MRI machines do not emit ionizing radiation

- **Cost**

CT Scan costs they usually less than MRIs (about half the price of MRI).

which is usually more expensive than CT scans and X- rays, and most examining methods.

Time taken

for complete scan Usually completed within 5 minutes. Actual scan time usually less than 30 seconds. Therefore, CT is less sensitive to patient movement than MRI.

Depending on what the MRI is looking for, and where it is needing to look, the scan may be quick (finished in 10-15 minutes) or may take a long time (2 hours).

Effects on the body

CT Effects on the body Despite being small, CT can pose the risk of irradiation. Painless, noninvasive.

MRI No biological hazards have been reported with the use of MRI. However, some may be allergic to the contrast dye

- CT Comfort level for patient

Seldom creates claustrophobia,

MRI Anxiety especially anxiety caused by claustrophobia, is common, as is tiredness or annoyance over having to stay still on a hard table for a long period of time

- A person who is very large (e.g. over 200 kg) may not fit into the opening of a conventional CT scanner or may be over the weight limit for the moving table.

mri -- Patient over 160 kg may be over table's weight limit.

MRI Limitation for Scanning patients with metal implants

- Patients with Cardiac Pacemakers, tattoos and metal implants are contraindicated due to possible injury to patient or image distortion (artifact).

can get CT scan

DIFFERENT DESIGNS OF MRI MACHINE

- CLOSED MRI

- OPEN-BORE MRI: Typically, an open MRI will have two flat magnets positioned over-and-under with a large space between them for the patient to lay in.

This configuration keeps the space open on two sides and alleviates much of the claustrophobia many patients experience.

The clarity in this magnetic range is less than closed-bore

.

- WIDE-BORE MRI: MORE THAN 60 CM
- UPRIGHTE MRI

THANK YOU,,