BASIC CONCEPTS IN DIAGNOSTIC IMAGING

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OBJECTIVES & GOALS

- Introduce the various Medical Imaging Modalities
- Understand the basics of image generation
- Appreciate constraints and limitations
- Relate imaging to gross anatomy
- Develop imaging vocabulary in the interpretation

WHAT IS RADIOLOGY?

- ✓ Medical specialty that supervises, perform and interprets imaging studies.
- ✓ Reports findings to referring physicians to help in the patients management.
- ✓ Medical specialty that use medical imaging technologies to diagnose and treat patients.
- ✓ Information technology (IT) and artificial intelligence (AI) promote the productivity of radiology department through assistant in the management of workflow, interpretation of images, treatment decision-making and communication with clinicians and patients

WHAT ARE THE DIAGNOSTIC MODALITIES UTILIZED IN RADIOLOGY?

- PLAIN X-RAY
- COMPUTED TOMOGRAPHY (CT)
- MAGNETIC RESONANCE IMAGING (MRI)
- ULTRASOUND (US)
- NUCLEAR MEDICINE (NM)
- ANGIOGRAPHY (ANG)

Which of these modalities use ionizing radiation?

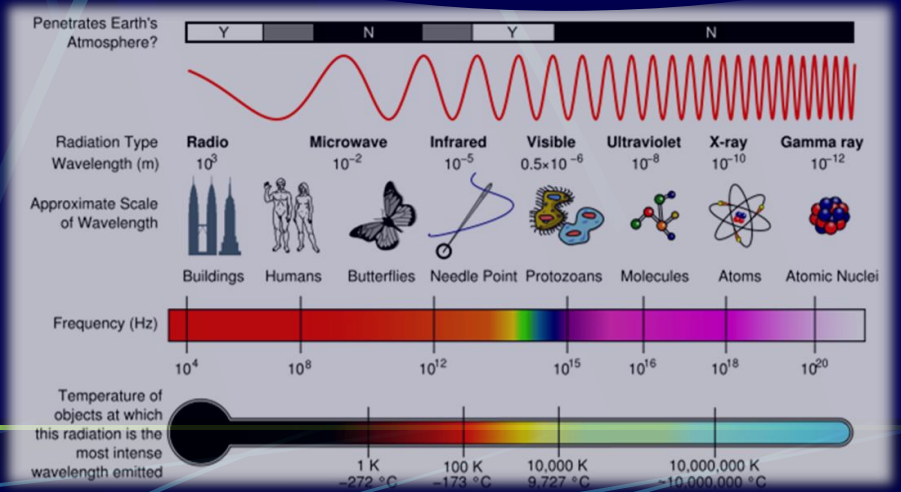
Ionizing radiation can be carcinogenic / to the fetus → mutagenic or even lethal (x-ray)

WHAT IS X-RAY?

- ✓ It is a form of electromagnetic energy that travel at the speed of light
- ✓ Discovered and named by Dr. W. C. Röentgen at University of Würzburg, 1895
- ✓ Electromagnetic energy wave spectrum

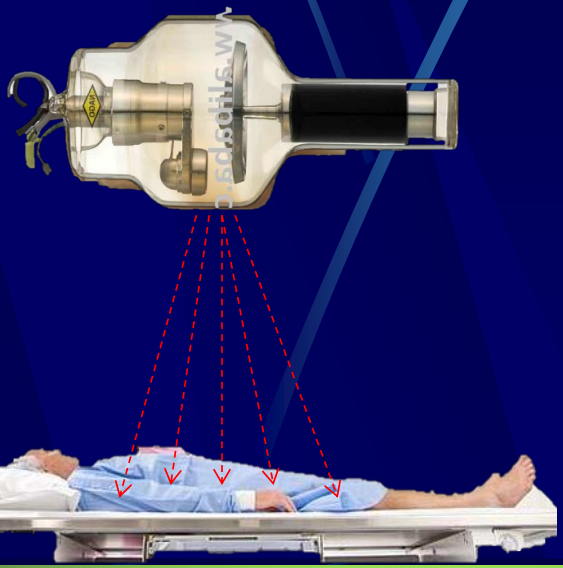
- Gamma Rays
- X-rays
- Visible light
- Infrared light
- Microwaves
- Radar
- Radio waves

Produced when high energetic electrons interact with matter. Kinetic energy of electron is converted in to electromagnetic energy by atomic interaction



WHAT IS X-RAY?

- X-RAY
- VISIBLE LIGHT



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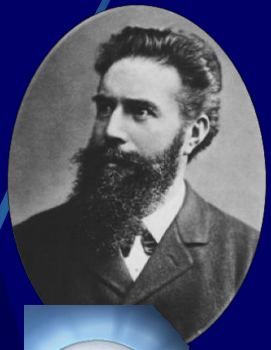
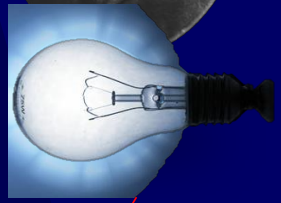


- X-RAY

- VISIBLE LIGHT



WHAT IS X-RAY?

- X-rays are emitted and detected in cassette which generate either a hard copy film or a digital image
- X-ray beam interaction with body tissue can:
  - Pass all the way through the body → render the film dark (black)
  - Be deflected or scattered
  - Be absorbed

  } → render the film light (white)

Image key = shades (Densities)
Air
Fat / Soft tissue/fluid
Metal / Mineral

  - Air = low atomic # → x-rays get through → image is dark
  - Metal = high atomic # → x-rays blocked → image is light (white)

- Projections (views) are usually described by the path of the x-ray beam.
- Thus, the term PA (poster anterior) view designates that the beam passes from the back to the front. *(standard projection for a routine chest film).*

Q: Where on this image have x-rays passed through the body to the greatest degree?

PLAIN X-RAY

Pros

- Widely available
- Inexpensive
- Doesn‘t require advanced technologist knowledge
- Can be performed quickly
- Portable

Cons

- Ionizing Radiation
- Relatively insensitive
- Requires patient cooperation

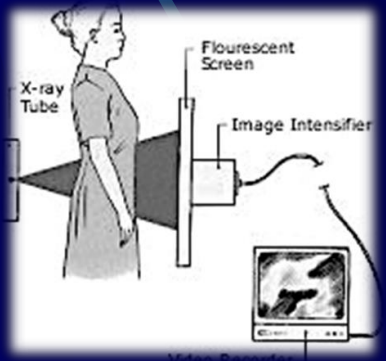
FLUOROSCOPY

- ✓ Utilizes X-Rays
- ✓ Real-time imaging (Dynamic)
- ✓ Utilizes image intensifier
- ✓ Involves use of contrast agents

FLUOROSCOPY

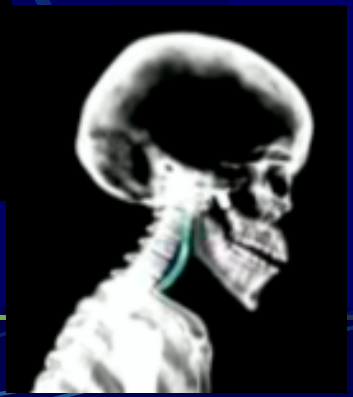
A modality utilized in evaluation of Gastrointestinal Tract:

Dynamic Contrast Studies



FLUOROSCOPY

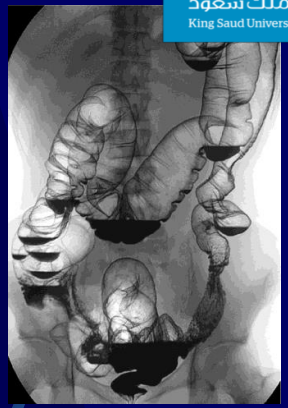
Dynamic Contrast Studies

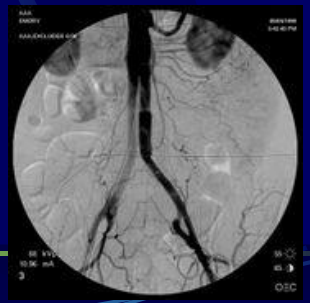


FLUOROSCOPY

Main Uses of Fluoroscopy

- Gastrointestinal Imaging
- Genitourinary Imaging
- Angiography
- Other:
  - Intraoperative
  - Foreign body removal
  - Musculoskeletal





FLUOROSCOPY

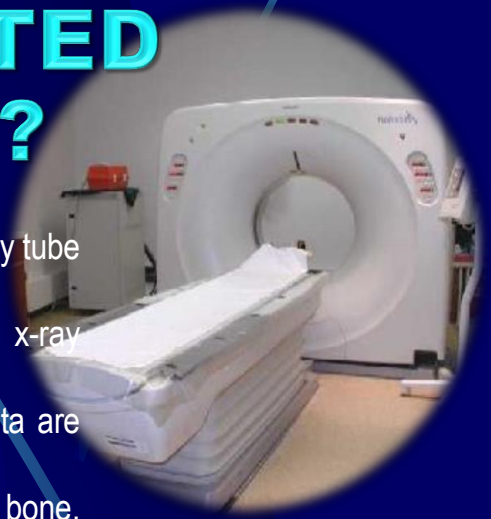
Pros

- Widely Available
- Inexpensive
- Functional and Anatomic
- No sedation required

Cons

- Requires ingestion/injection of contrast medium
- Patient cooperation
- Time consuming

WHAT IS COMPUTED TOMOGRAPHY?



- ✓ Relies on x-rays transmitted through the body through mobile X-ray tube that rotates around a patient. (Cross Sectional imaging modality).
- ✓ Differs from conventional radiography in that a more sensitive x-ray detection system is used.
- ✓ Images consist of sections (slices) through the body, and the data are manipulated by a computer.
- ✓ Data displayed in multiple window settings (lungs parenchyma, bone, etc.)
- ✓ Density measurements analyze chemical component of tissue "Hounsfield Unit (HU)" :

Image key = shades (Densities)

Fat	= -150	Soft tissue	= 20-80
Air	= -1000	Blood	= 45-75
Water	= 0	Bone/calcium	= >100- >1000

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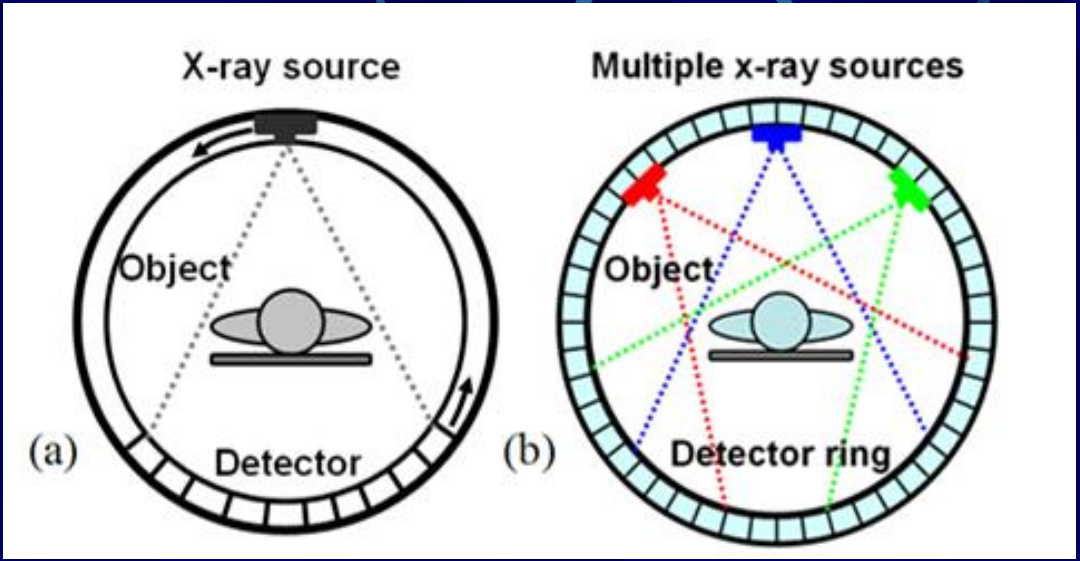

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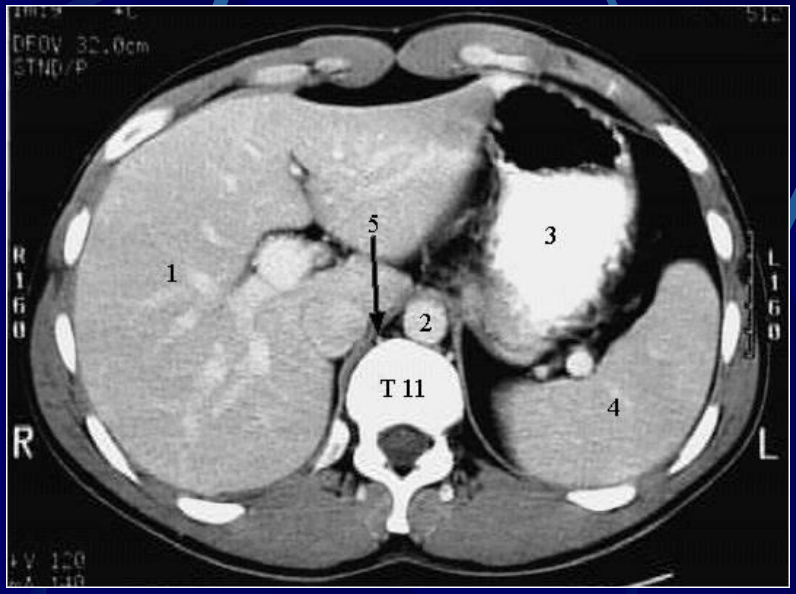

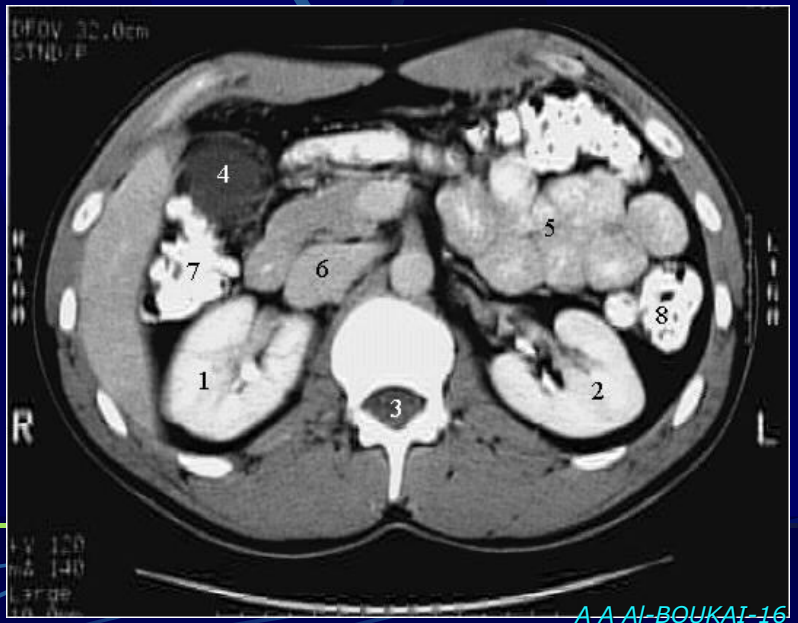

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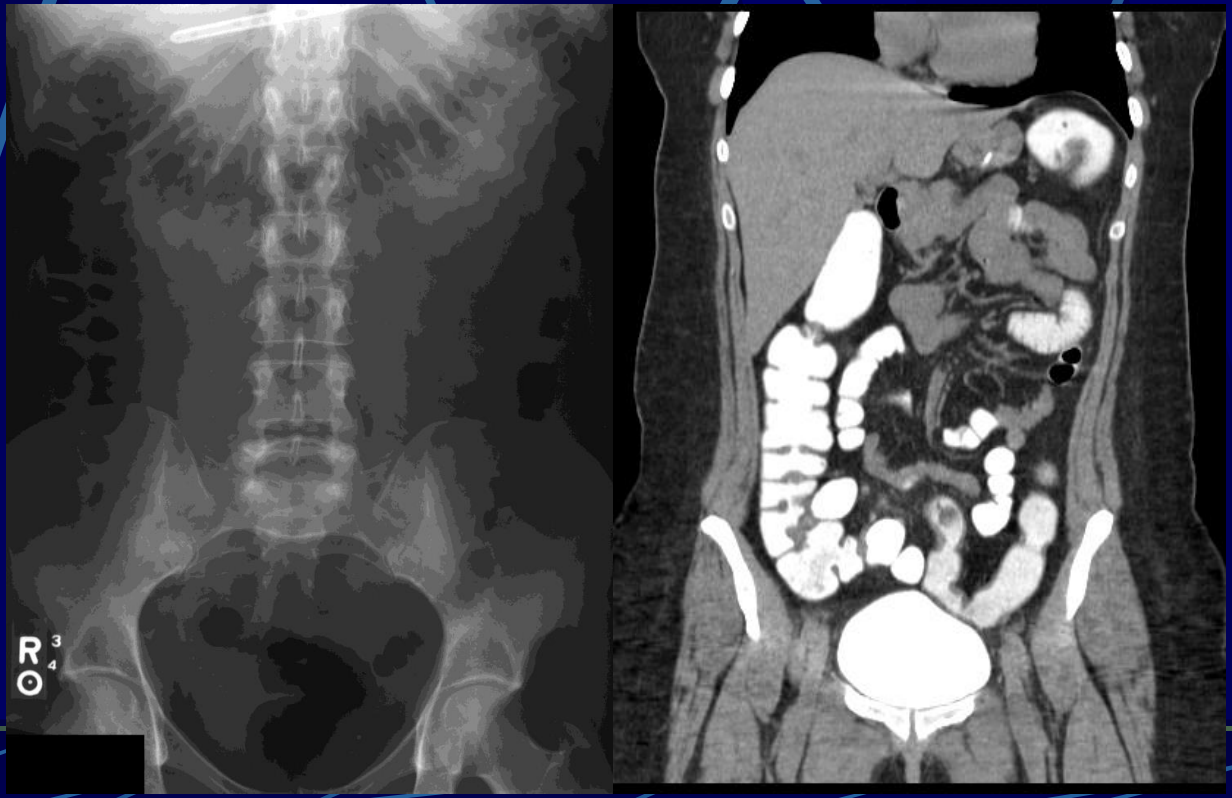
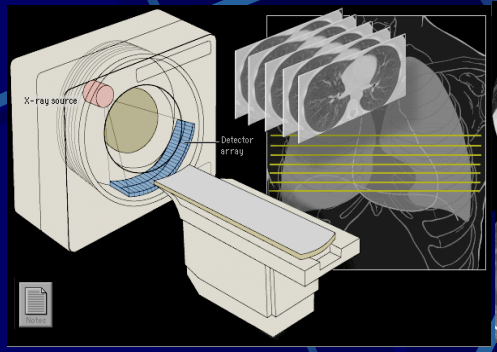
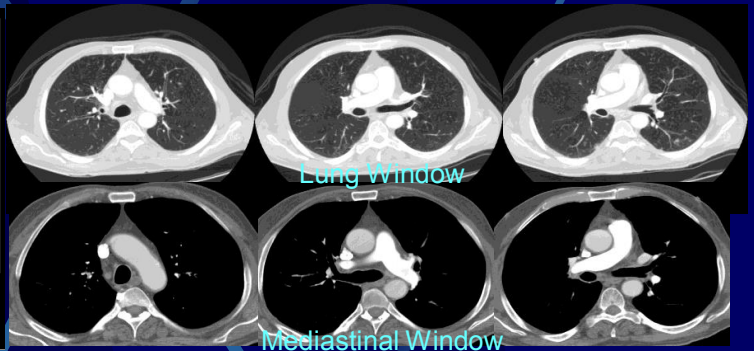


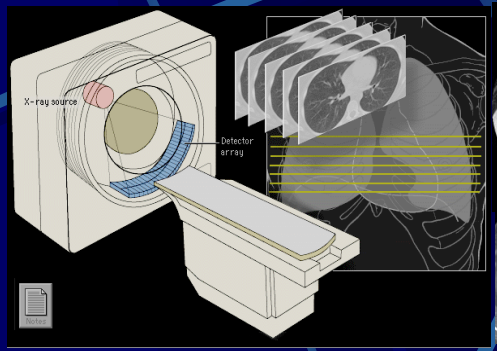
COMPUTED TOMOGRAPHY?

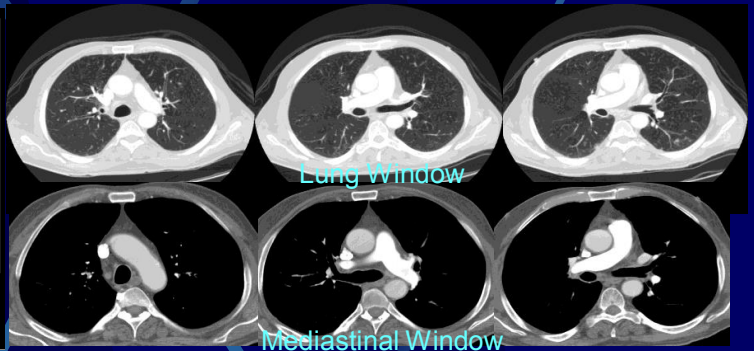




- Has very small differences in x-ray absorption values compared with conventional radiography; the range of densities recorded is increased approximately 10-fold.
- The major risk behind the CT is exposure (1 brain CT scan radiation is almost 200 X-ray and 1 pelvis CT is 400 x-ray which means do not request Ct scan unless it is needed and we can not do it for pregnant women unless it is necessary

COMPUTED TOMOGRAPHY?





- So gradations of density within soft tissues can be recognized, e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.
- There is major risk behind CT scan, 1 Brain CT scan radiation = 200 x-ray radiation , pelvic CT radiation = 400 x-ray radiation which means don't request a CT scan unless it is needed and we can't use it for a pregnant women unless it is necessary
- Wide window to visualize more structure within certain organ such as bronchi, vessels and alveoli in the lung (Lung window).
- Narrow window to visualize certain structures within certain region such as major vessels and heart in mediastinum (Mediastinal window).

- BONE

to visualize cortex, medulla and trabeculae → Wide window

COMPUTED TOMOGRAPHY APPLICATIONS

- NEURO-IMAGING

  -Acute head trauma, acute intracranial hemorrhage

  -Low sensitivity for early ischemic stroke, intracranial metastatic disease, white matter degenerative disease

- HEAD AND NECK IMAGING

  -Soft tissue of neck, paranasal sinuses, temporal bone imaging, orbital wall imaging

COMPUTED TOMOGRAPHY APPLICATIONS

- BODY IMAGING

  - Chest, Abdomen, Pelvis (with enteric and IV contrast)

  - Pulmonary nodules, Renal Calculi (without contrast)

  - Acute appendicitis (with enteric and IV contrast)

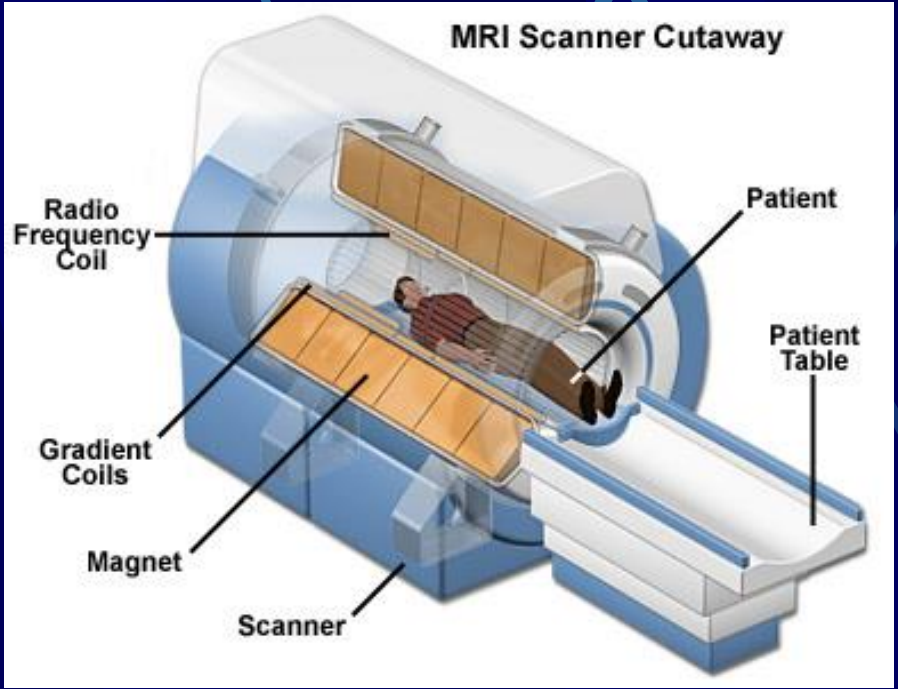
- SPECIALIZED PROTOCOLS:

  -Liver masses, pancreatic tissue, renal masses, adrenal masses

COMPUTED TOMOGRAPHY APPLICATIONS

- ACUTE ABDOMEN
  -decrease rate of false laparotomy procedures
- TRAUMA SPINE IMAGING (cervical, thoracic, lumbar)
- OTHER OSSEOUS STRUCTURES (pelvis, extremities)
- VASCULAR IMAGING
  -CT angiography--- i.e. coronary arteries

MAGNATIC RESONANCE IMAGING



MAGNATIC RESONANCE IMAGING

T1weighted (T_1WI). Fat → white / Fluid → dark / Subacute hemorrhage → white

T2 weighted (T_2WI). . Fluid → white, Fat less white compared to T1 weighted

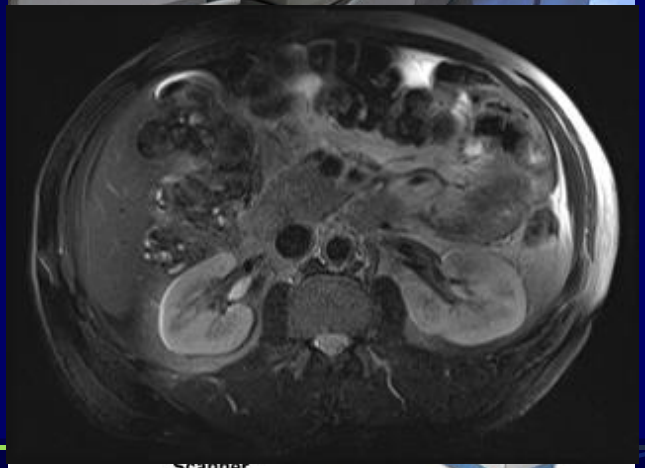
Bone appear black on all sequences

Air also appear black on all sequences.

On Flair fluid appear jet black. Very good for detection of demyelination plaques and haemorrhages

MRI contrast agent. Gadolinium DTPA(Ethylene Triamine Penta acetic acid) is used as contrast agent. It is used with T1W images only.

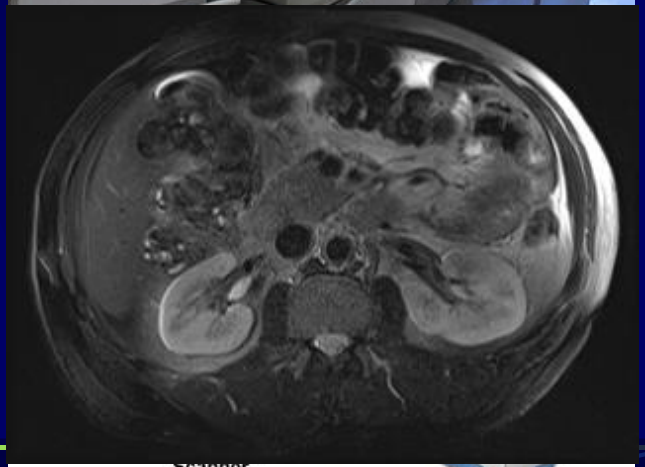
Image key = shades (Intensities)



Scanner

MAGNATIC RESONANCE IMAGING

- Simply, hydrogen atoms (protons) in water molecules and lipids >> magnetism affects all protons causes them to line up in one direction >> magnets can be switched on and off to change the direction of the magnetic field >> whenever the water molecule spin around they give a light radio wave >> MRI machine can detect it >> show it as images
- So gradations of density within soft tissues can be recognized, e.g. brain substance from cerebrospinal fluid, or tumor from surrounding normal tissues.



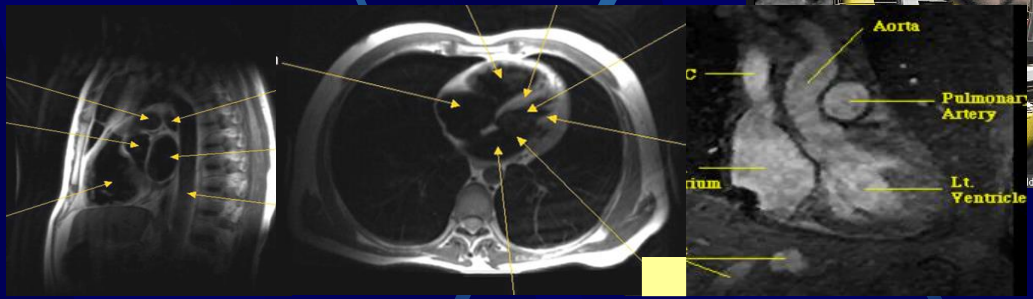
Scanner

Image key = shades (Intensities)

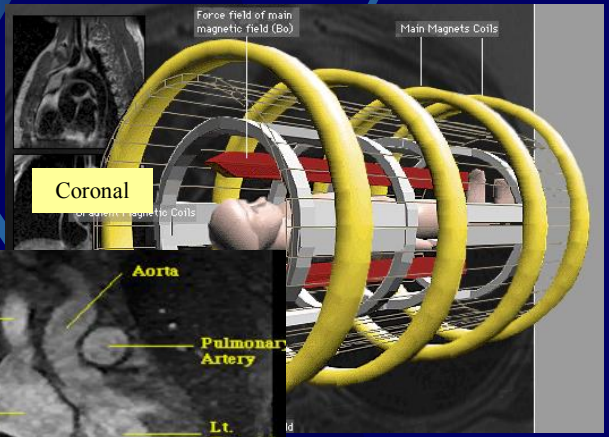
MAGNATIC RESONANCE IMAGING

Sagittal

Axial



Coronal



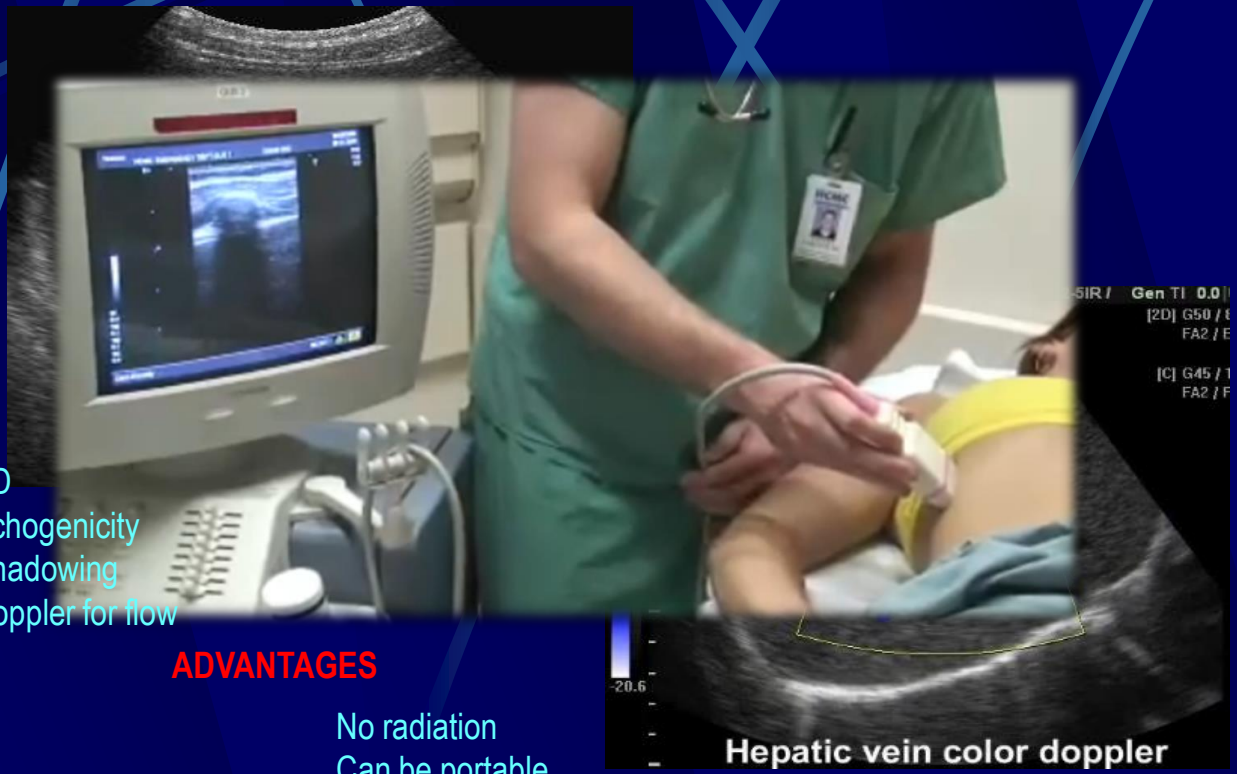
ADVANTAGES

- ✓ Best for soft tissue imaging (Better contrast resolution and tissue discriminations)
- ✓ No ionization
- ✓ Can be done for pregnant women
- ✓ Images can be obtained in any plane without changing the position of the patient
- ✓ Useful for soft tissue pathology (Tumor, infection) MSK
- ✓ Multisequence play with characteristic abnormal tissues
- ✓ MR angiogram can be perform wit out introducing contrast media

DISADVANTAGES

- ✓ Eexpensive
- ✓ Time consuming
- ✓ Phobia (narrow place)
- ✓ No metals allowed
- ✓ Motion
- ✓ Since it is magnetic no metal can be allowed
- ✓ Patient has to keep still during the producer.

ULTRASOUND



ULTRASOUND

Echogenicity
Shadowing
Doppler for flow

ADVANTAGES

No radiation
Can be portable
Relatively inexpensive

NUCLEAR MEDICINE

- ✓ Uses gamma rays to produce an image (Counts or Activity).
- ✓ Radioactive nuclide given IV, per os, per rectum etc.
- ✓ Rays emitted from the patient
- ✓ Physiologic imaging (Abnormal function, metabolic activity).
- ✓ Poor for anatomical information.
- ✓ Radioactivity stays with the patient until cleared or decayed

CONTRAST MEDIA

Natural contrast in the body

- Air
- Fat
- Bone

Added contrast in the body

- Barium sulfate
- Iodine (Water Soluble)

CONTRAST MEDIA

- Barium sulfate

- Iodine (Water Soluble)


THANKS