Lecture 1:

Introduction to Radiology

Radiology Team
Med433

Sources:
Slides + 432 team

● Slides ● Explanation ● Notes ● Additions ● Important

Objectives

- ✓To learned different type of radiology modalities.
- ✓To have the principle of the indication and contra- indication for different radiology investigation .
- ✓Usage of different type of contrast.

X-ray Wilhelm Röntgen in 1895

✧ Remember:
- Radiation can cause mutations.
- Bone absorbs more rays that air that's why it appears white (radio-opaque).

What is X-Ray?

- A high energy electromagnetic radiation causing ionization in the body.
- Radiation produced when highly energetic electrons interact with matter.
  - Travels at speed of light.
  - Travels in a straight line.

Major usage of X-Ray

- Medical Imaging (Diagnostic X-ray machine)
- Industrial Imaging (Airport Baggage Screening)

Terms Related to Image Production:

Attenuation
- The process by which primary radiation is changed or absorbed as it travels through the patient.

Radiolucent
- Material that allow x-ray photons to pass through easily (air).

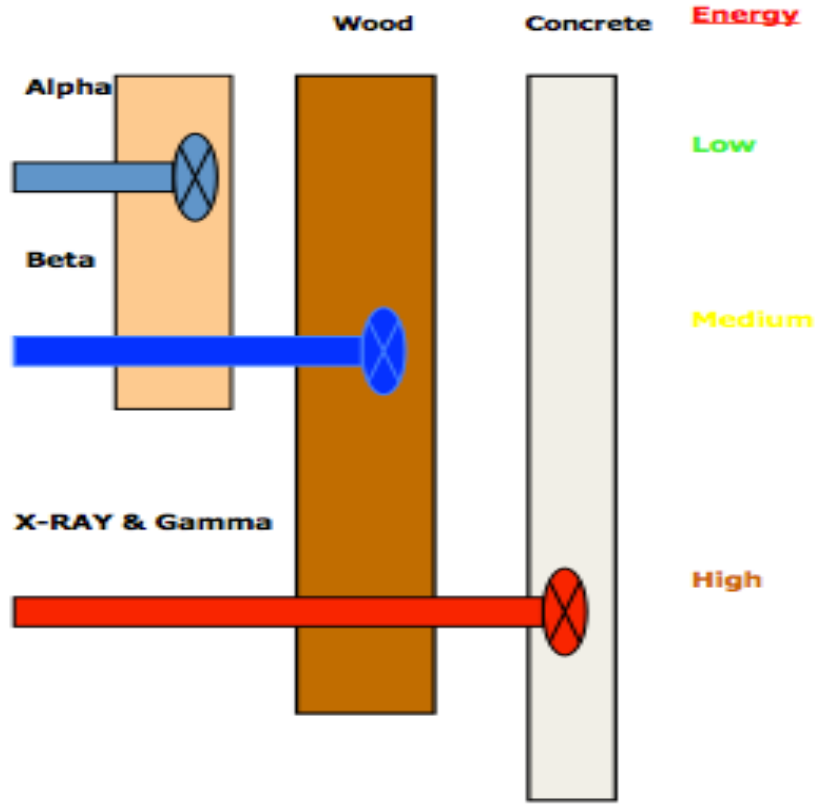
Radiopaque
- Materials that **do not** allow x-ray photons to pass through easily, (bone) can be seen on plain film.

X-ray Wilhelm Röntgen in 1895

Ionizing Radiation

- Sources:
  - Ultraviolet light
  - Visible light Microwaves
  - Infrared radiation
  - Radio & TV

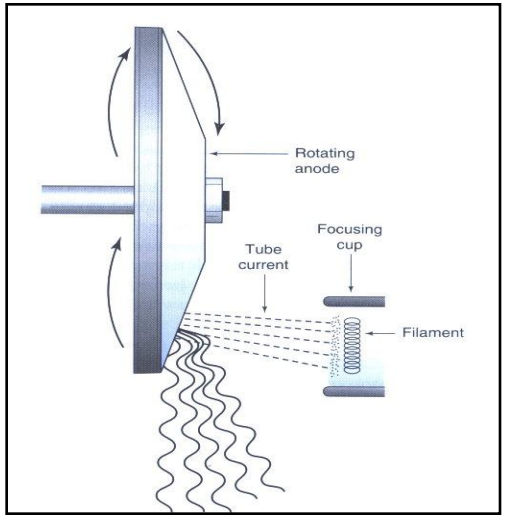
Nonionizing Radiation

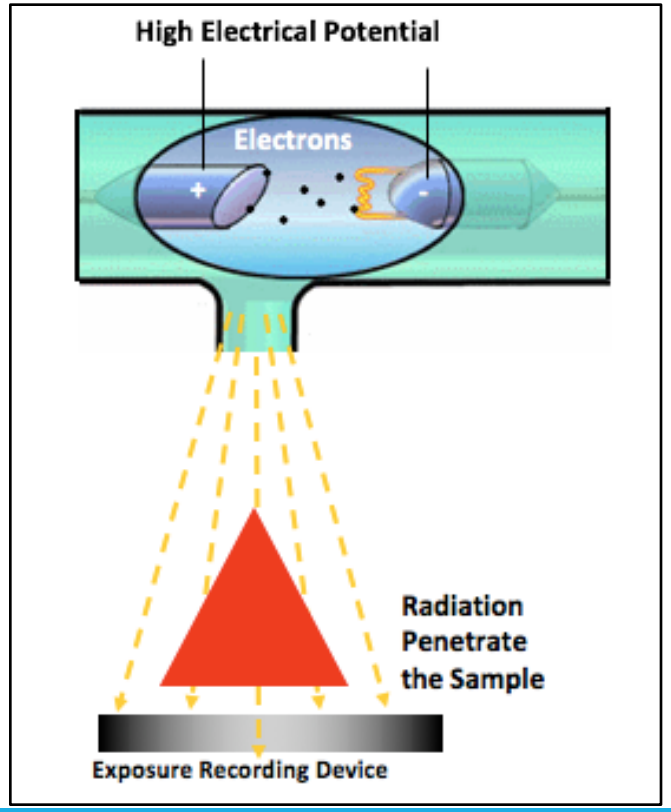


Structure	Appearance
Air	X-ray that pass through air are the least absorbed (the most blackening of the radiograph)
Bone & other calcified tissues	Calcium absorbs the most and virtually white.
Soft tissues (except fat)	Various shades of grey *depending on how dens they are *
Fat	Absorbs slightly fewer x-ray and appears a little blacker than other tissues.
In x-ray : black coloration (Radio-lucent) is called (Lucency), white coloration (Radio-opaque) is called (opacity)	

X-ray Production

- Push the "rotor" or "prep" button
  - Charges the filament – causes thermionic emission (e- cloud)
  - Begins rotating the anode.
- Push the "exposure" or "x-ray" button
  - e-'s move toward anode target to produce x-rays
- The cathode contains a small filament much the same as in a light bulb.
- Current is passed through the filament which heats it. The heat causes electrons to be stripped off.
- The **high voltage** causes these "free" electrons to be pulled toward a target material (usually made of tungsten) located in the anode.
- The electrons hit the target. This causes an energy exchange which causes x-rays to be created.





X-ray

THE X-RAY TUBE PARTS:

- **Cathode (-)**: Filament made of tungsten
- **Anode (+)**: target Tungsten disc that turns on a rotor
- **Stator**: motor that turns the rotor
- **Port**: exit for the x-rays

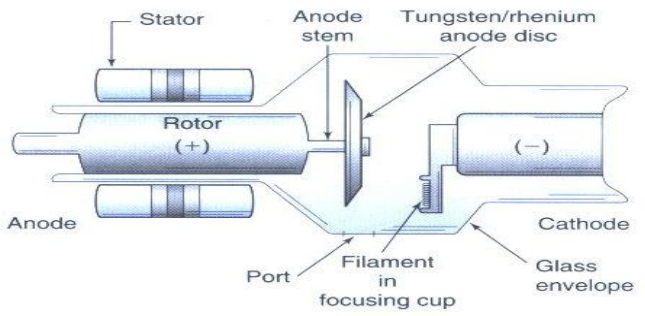
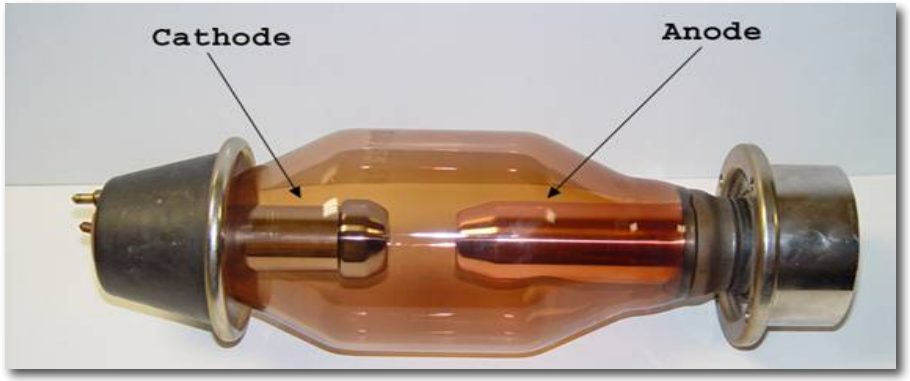


FIGURE 2-5 Structure of a typical x-ray tube, including the major operational parts.

X-RAY PRODUCTION

- X-rays are produced by establishing a very high voltage
- between two electrodes, called the anode and cathode.
- To prevent arcing, the anode and cathode are located inside a vacuum tube, which is protected by a metal housing.



X-RAY GENERATOR

- x-rays are produced by an X-ray generator system.
- These systems typically include a high voltage generator, and a control console.

Filtration

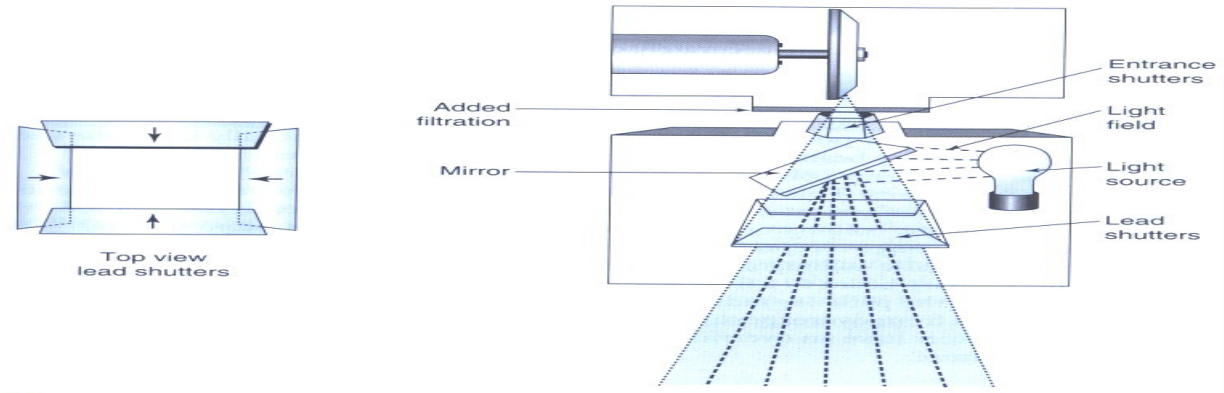


FIGURE 6-9 Collimators have two sets of lead shutters that are used to change the size and shape of the primary beam.

- Beam filtration modifies the quantity and quality of the x-ray beam by removing low-energy (softer) photons in the spectrum.

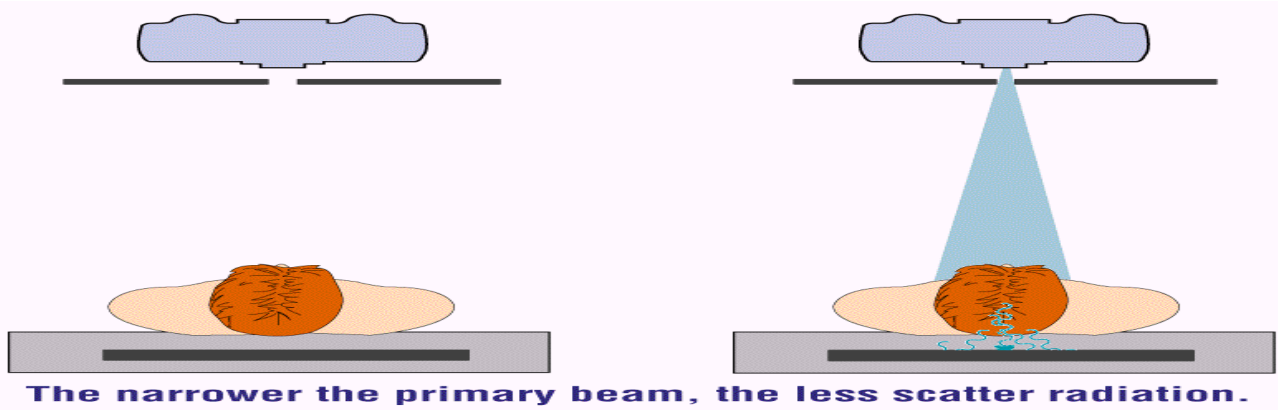
Three kinds of filtration:

- **Inherent**: due to tube housing, insulation, etc.
- **Added:** aluminum shielding that blocks low energy x-rays. (2 - 2.5mm) AL filter .
- **Special:** used to image body parts that have varying thickness or density. (like wedge filters)

- Filtration is measured in terms of "half-value layer" (HVL)

Collimation

Effects of collimation (beam restriction) on scatter

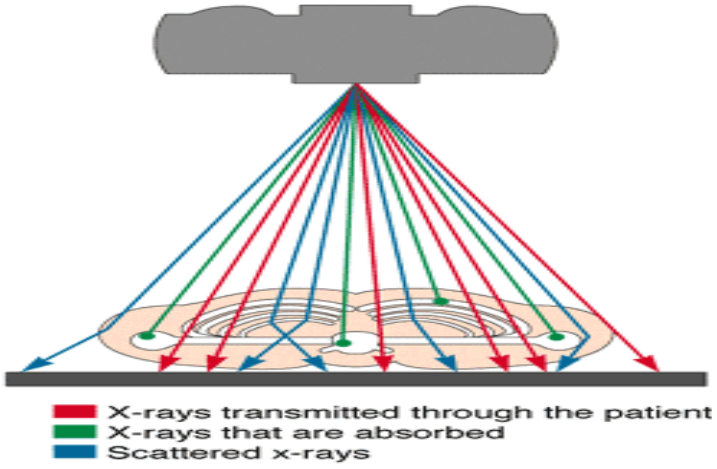


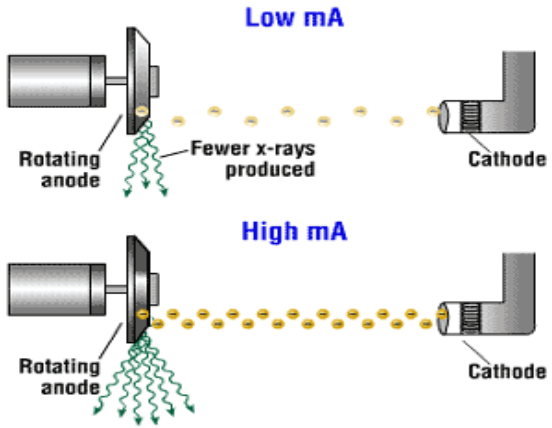
- Is located under the port of the X-ray tube.
- Has a light in it for radiographer to see where x-rays would hit the patient.
- **Advantages:**
  - ↓ patient dose
  - ↓ scatter radiation (↑contrast)
  - Always use the minimum acceptable field size
- Collimation should be visible on a minimum of three sides of the film.

X-ray

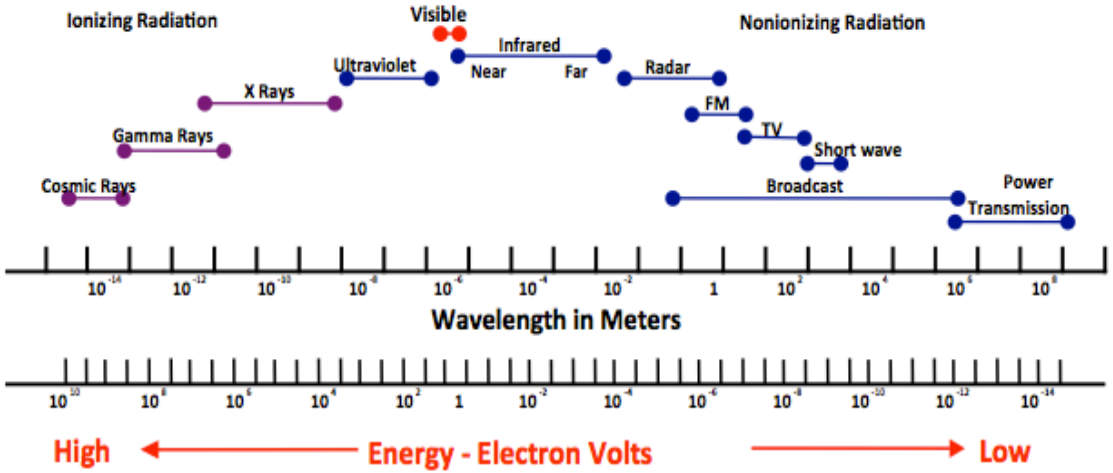
INTERACTIONS IN THE BODY:

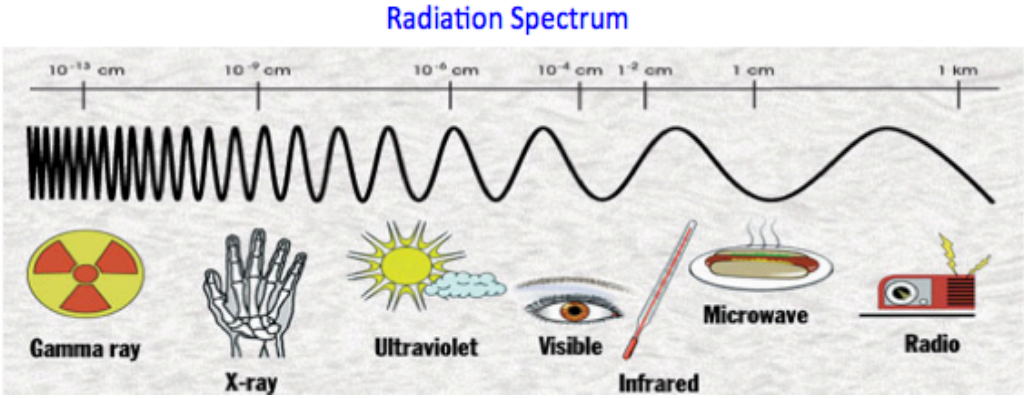
- Three things can happen to x-rays as they hit the body:
  - **Absorption (photoelectric effect):** x-ray is absorbed by tissues – does not contribute to image.
  - **Scattered.**
  - **Transmission:** penetrates through body to hit radiographic film or detectors.





ELECTROMAGNETIC SPECTRUM





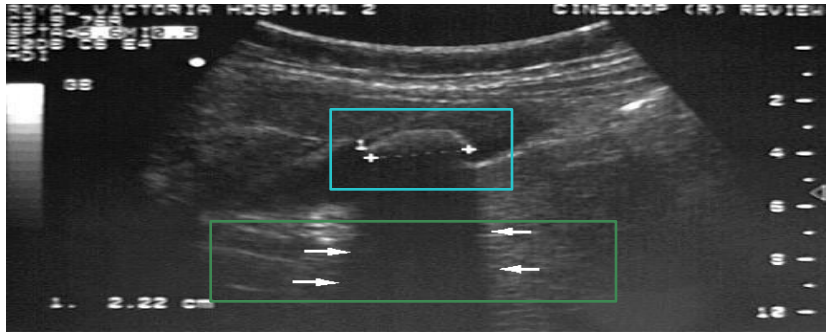
CT (Computerized Axial Tomography)

- There is a large amount of radiation in CT examination.
- It can penetrate the skull. Thus, it is indicated in a stroke or hemorrhage (shows location and complications). "Hemorrhage always hyper dense"
- IV contrast is used with precaution.
  (Because of the possible side effects, e.g. allergic reactions and extravasation: leakage of contrast into surrounding tissues)
- Oral contrast is safe.

Ultra Sound. True or false:
The normal liver is **hyper-echoic** to the kidney?
True

US (Ultra Sound) (1)

- Ultrasound is often used to **determine whether a structure is solid or cystic**:
- Cysts or other fluid-filled structures produce large echoes from their walls but no echoes from the fluid contained within them.
- More echoes than usual are received from the tissues behind the cyst, an effect known as **acoustic enhancement**.
- With a calcified structure, e.g. **a gall stone (important)**, there is a great reduction in the sound that will pass through, so a band of reduced echoes, referred to as **an acoustic shadow**, is seen behind the stone.



Gallstone size is shown between the two crosses (2.22 cm), arrows identify the acoustic shadow behind the stone.

US Advantages	US disadvantages
Non-invasive	Organ limitation (it can't penetrate air nor bone so we can't use it for **brain** or **lung**)
No ionizing radiation (safe for pregnant)	
Determine whether a lesion is cystic or solid	Operator dependent

(1) Fluid is a good conductor of sound, and ultrasound is, therefore, a particularly good imaging modality for: 1- Diagnosing cysts. 2- Examining fluid-filled structures such as the bladder and biliary system. 3- Demonstrating the fetus in its amniotic sac.

MRI Magnetic Resonance Imaging

Used in radiology to visualize internal structures of the body in details.

How does it work?

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.

MRI advantages	MRI disadvantages
Best for soft tissue imaging	Expensive
There is no ionization	Time consuming
it can be done for pregnant women with caution (after the 1st trimester)	Some people might be claustrophobic (fear of enclosed or narrow spaces)
Creates more detailed images of the body compared to X-ray.	Contraindication: metals. E.G. pacemakers.

Contraindications:

- Metallic Cardiac Piece makers
- Intracranial vascular clip
- Neuro stimulators of any sort
- Intraocular metallic foreign bodies
- Ossicular implantation
- metallic implants: metal plates, pins, rods, cardiac pacemaker
- Hair pieces
- Any prosthetic devices
- Heart failure
- Surgical clips on the arteries and wire sutures (as in post lap chole)
- Heart valve , Pregnancy , Shrapnel , Metallic/silver eye liners
- Total knee replacement

•Note: now mostly metals are MRI compatible (we can do MRI in that case)

Can we do MRI For a pregnant patient?
Yes, but only after the first trimester

Very Important

	X-ray	US	CT	MRI
Black coloration	Radiolucent	Hypo-echoic	Hypo-dense	Hypo-intense
White coloration	Radiopaque	Hyper-echoic	Hyper-dense	Hyper-intense

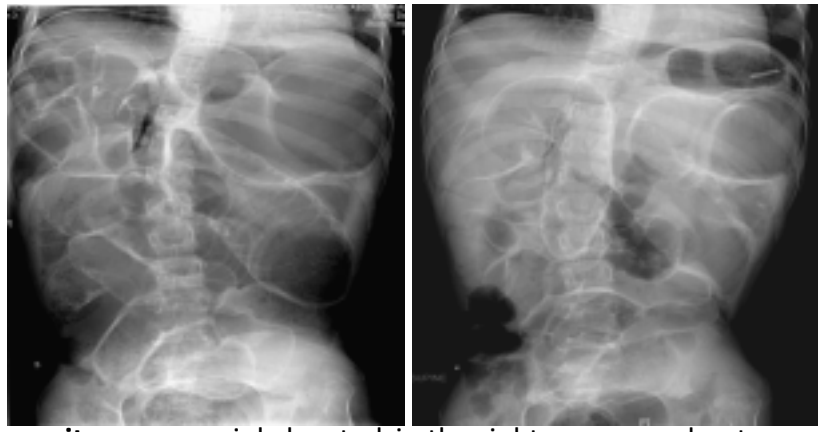
	Test	Organ
Said by the doctor	Myogram	For muscular contractions
	Sialogram	Salivary gland , carotid, submandibular ducts
	Mamogram	Breast
	Myelogram	Spinal cord
From 432 team	Sinogram	Sinuses
	Magnetic resonance cholangio-pancreato-graphy (MRCP) (no radiation)	Bile and pancreatic ducts
	Endoscopic retrograde cholangio-pancreato-graphy (ERCP) (with radiation)	
	Intravenous urography	Kidneys
	Ductogram	Breast duct

Note: it's **important** to know the different between the procedure's name & the picture's name & the organ.
Example: Mamogram is imaging for breast (procedure), Mamography is the name of the image.

Reducing Exposure (protection):

Time: reduce the spent near the source of radiation.
Distance: increase the distance from the source of radiation.
Shielding: place shielding material between you and the source of radiation.
* Most sensitive organs to radiation are: Thyroid, Gonads, Lens.

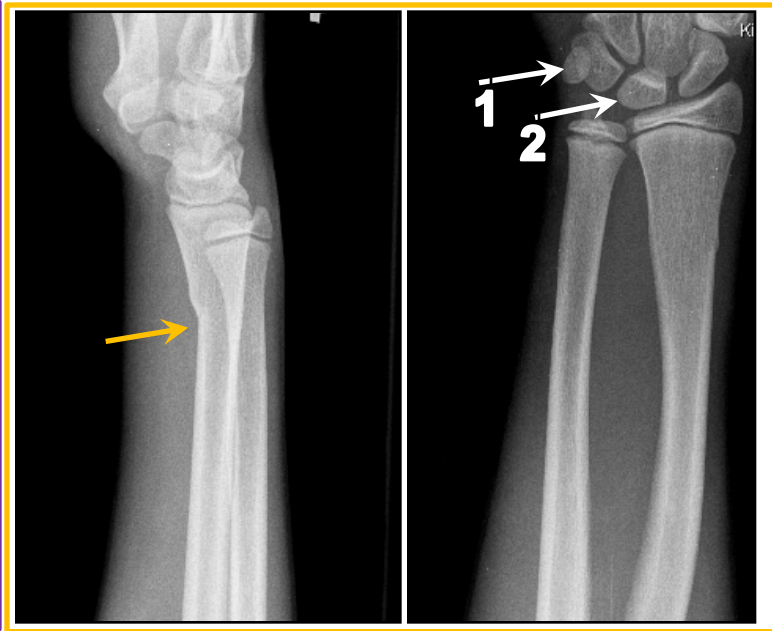
X-ray



Pneumoperitoneum mainly located in the right upper quadrant.

* Pneumoperitoneum is the presence of air or gas in the abdominal (peritoneal) cavity.

- Gas outside the bowel is abnormal.
- US patients are advised to fast to reduce gas.



1.Pisiform. 2. Lunate.

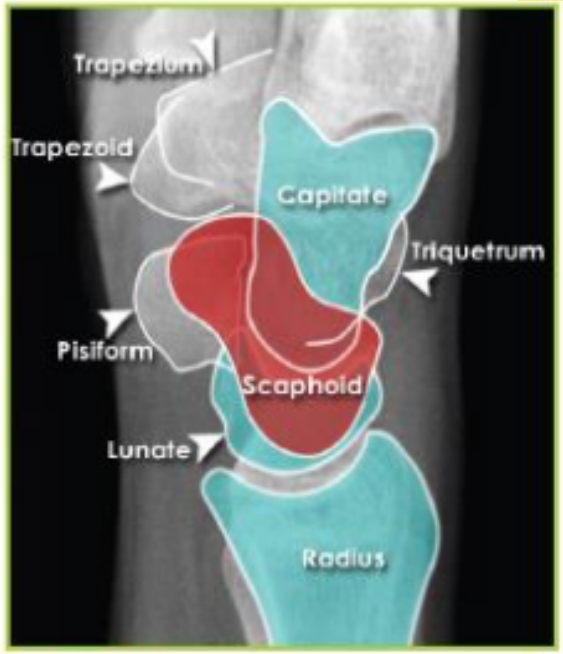
Is this image for an adult or pediatric?

Pediatric. Because bones are not fused (we can see growth plate)

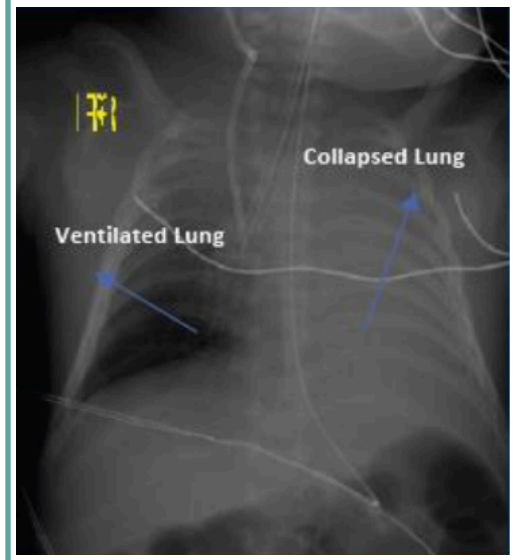
What type of fracture and where?

Torus (Buckle) fracture in the distal radius. (arrow)

1) Trapezoid 2) Scaphoid 3) Hammate 4) Triquetrum
5) Distal phalanx 6) Proximal phalanx 7) Metacarpal bone
*R means right hand



Later view: This view is essential to check for alignment of the radius, lunate and capitate



Chest X-ray (Pediatric)

Where is the endo-bronchial tube allocated?

In the right lung.

How do you know the right lung is normal?

It's translucent. (black)

What happened to the left hemi-thorax?

Collapsed lung. (endo-bronchial tube is ventilating the right lung)

What should you do?

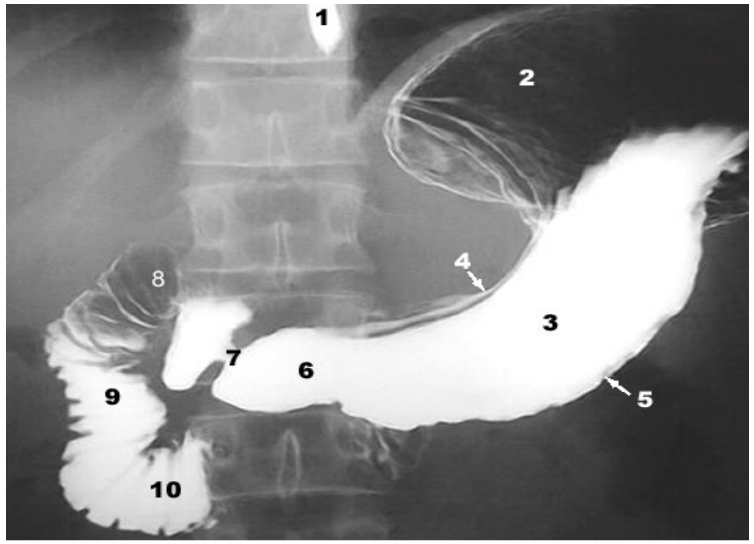
You have to pull the endo-trachial tube 5cm so both lungs will be ventilated.

Contrast

N.B. Contrast is radio-opaque.

- **Oral**
  - Barium swallow (Esophagograpgy) → to examine the upper GI tract
  - Barium meal → to examine the esophagus, stomach & duodenum
  - Barium enema → lower GI examination, colon
- **IV**
  - Angiogram (arteriography): a medical imaging technique used to visualize the inside (lumen) of blood vessels
  - Aortic (Abdominal) Angiogram
  - Cerebral Angiogram

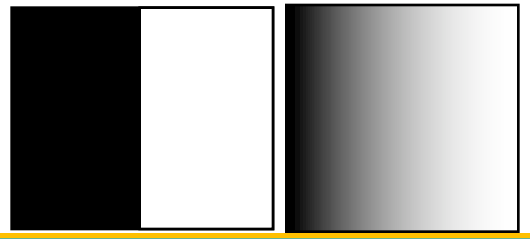
NORMAL ANATOMY OF THE UGI (BARIUM MEAL)

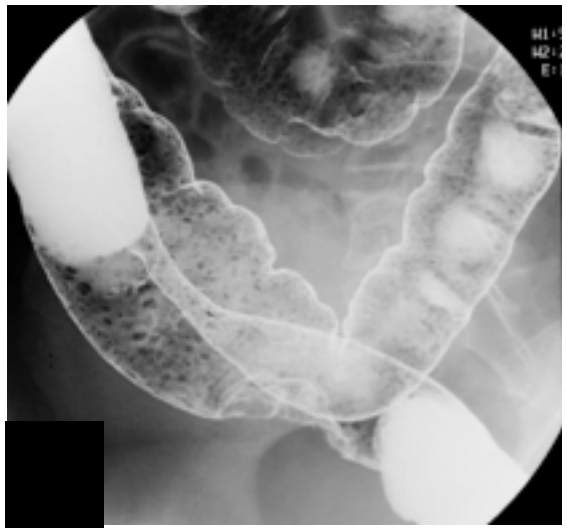


1 esophagus 2 fundus of the stomach 3 body of the stomach
4 lesser curvature 5 greater curvature 6 pyloric antrum
7 pylorus 8 duodenal bulb (1st half of 1st stage of duodenum)
9 2nd stage of duodenum 10 3rd stage of duodenum

Contrasts:

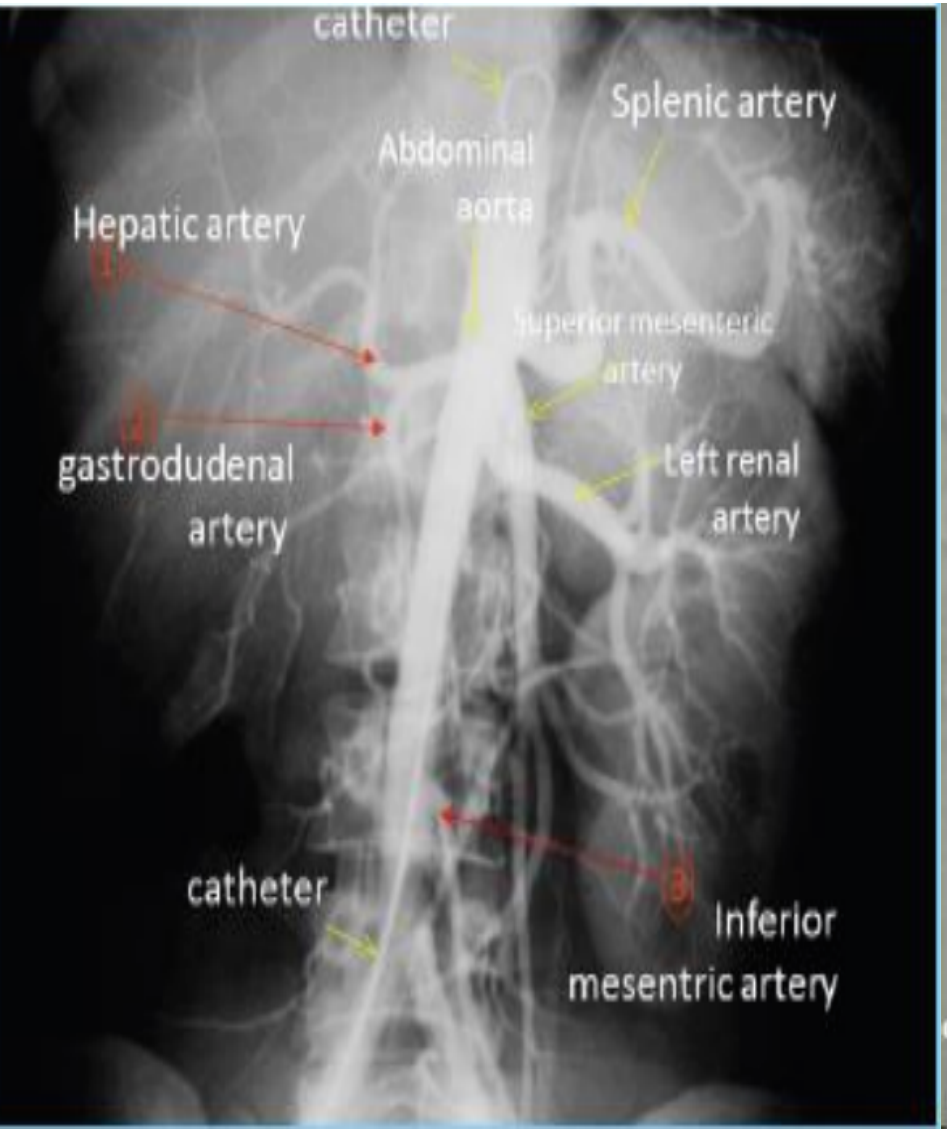
- ↑contrast = short scale = more black and white (less detail)
- ↓contrast = long scale = mores shades of grey (more detail)
- Controlling factor → kVp (↑kVp = ↓ contrast (more shades of grey)



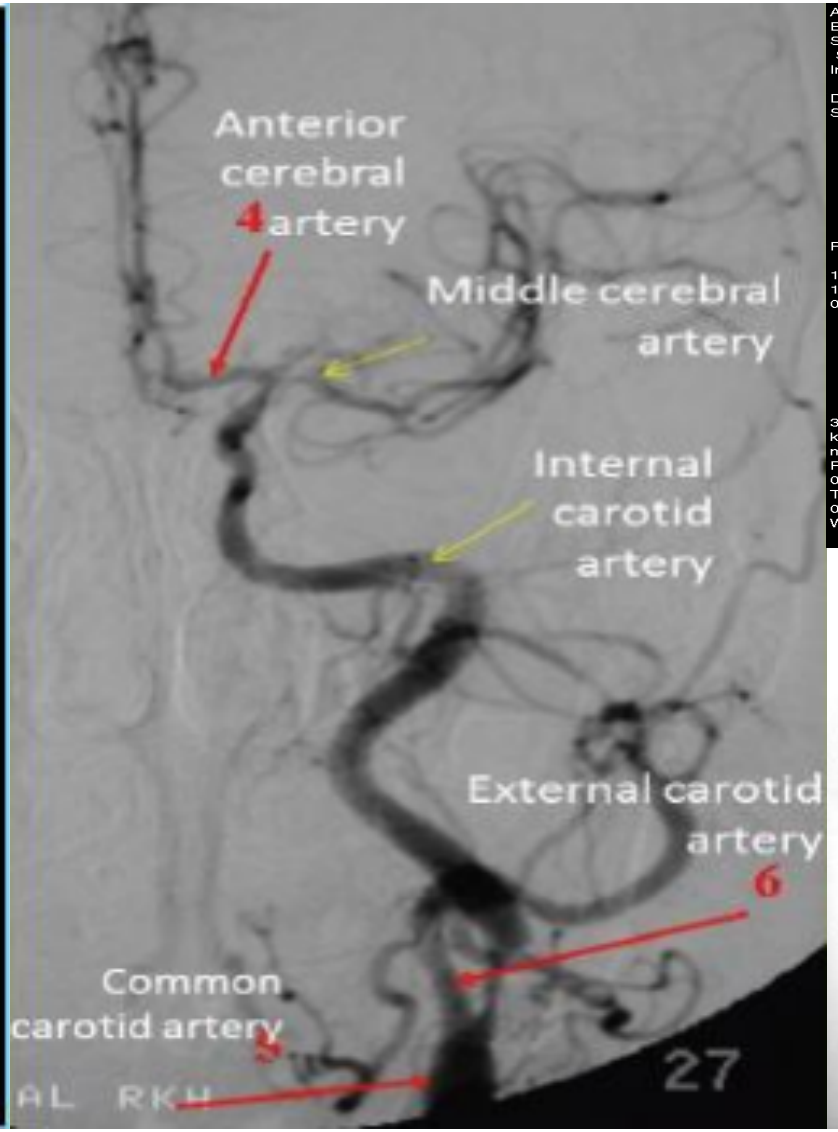


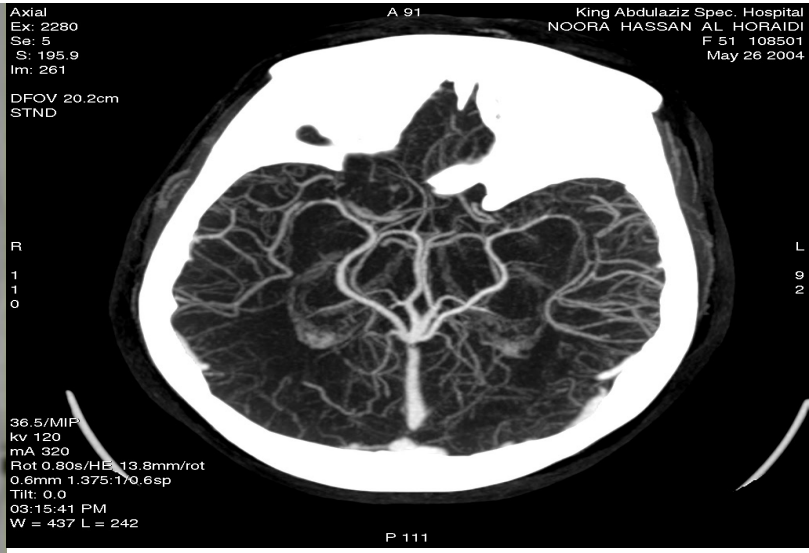
BARIUM ENEMA. DOUBLE CONTRAST (CONTRAST & GAS)

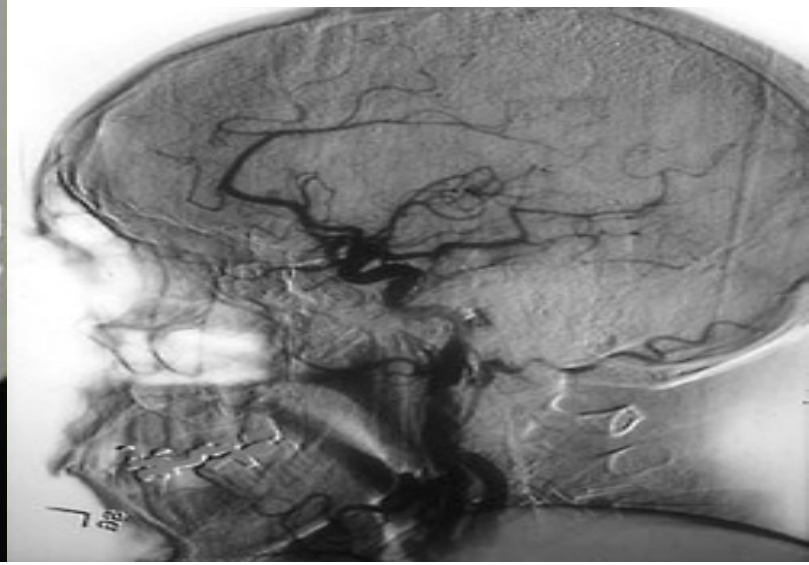
ABDOMINAL ANGIOGRAM

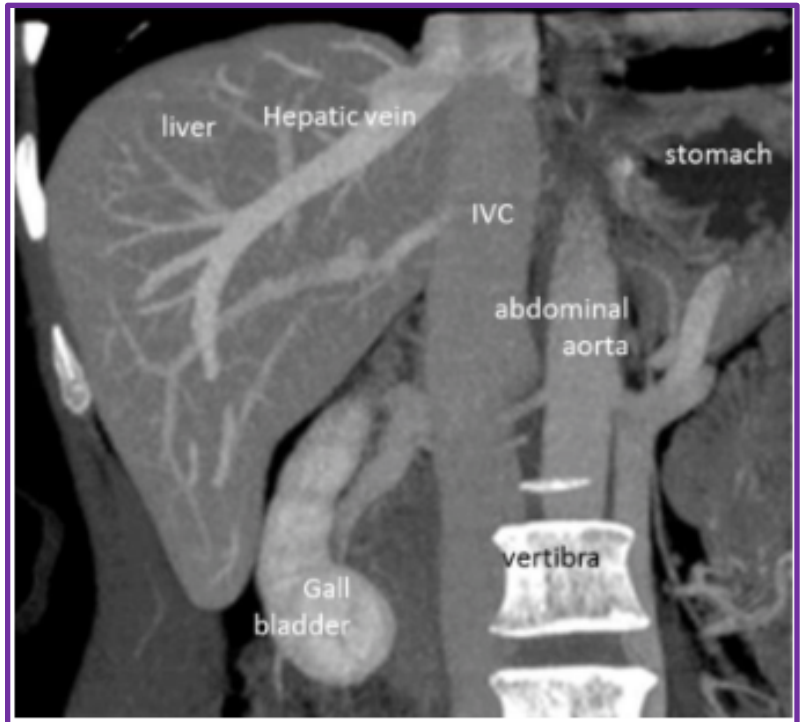


CEREBRAL ANGIOGRAM

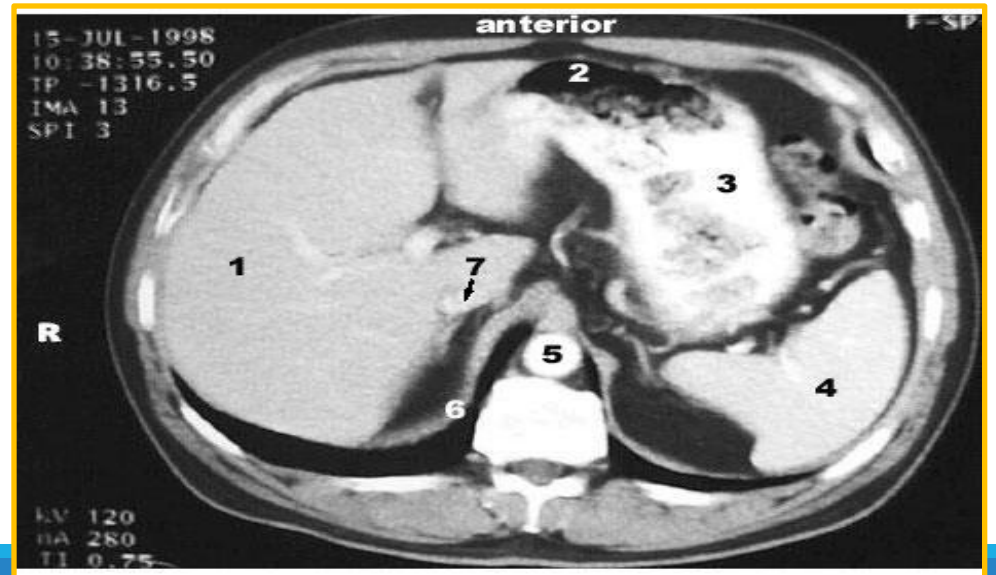




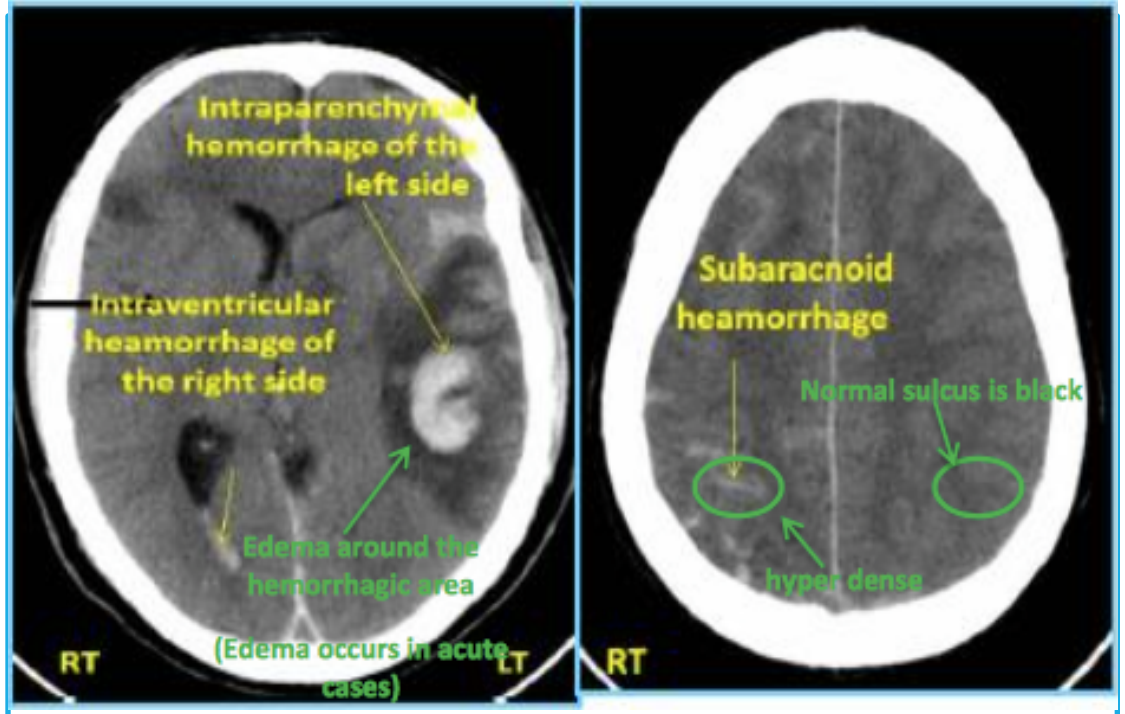




Coronal image of the abdomen (CT with contrast)



1 liver 2 gas in the stomach 3 stomach 4 spleen 5 aorta
6 crus of the diaphragm 7 inferior vena cava



CT scan of the brain

- Patient with right side hemiplegia: left side lesion
- Patient with left side hemiplegia: right side lesion.
- Ventricles are hypo-dense (If high atomic number: appears white)
- Internal hemorrhage on the left, temporal (x-ray will only show the skull)
- Mass effect: midline shift, compression

Leukocoria

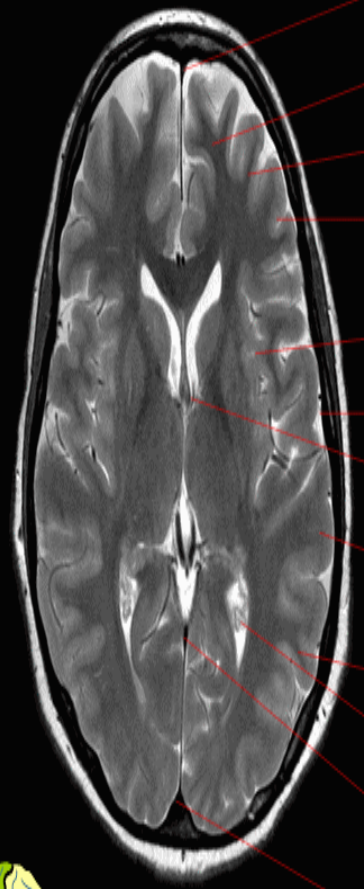
CT scan, an axial cut of the orbit, abnormality (mass) in the temporal aspect of the left globe partially calcified.

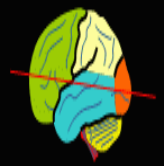
- The disease in the globe is: retinoblastoma

Brain
Axial T2

- Caudate nucleus
- Internal capsule (anterior limb)
- Putamen
- Extreme capsule
- Column of fornix
- Claustrum
- External capsule
- Internal capsule (genu)
- Globus pallidus
- Internal capsule (posterior limb)
- Third ventricle
- Thalamus
- Retropulvinar cistern
- Posterior commissure
- Quadrigeminal cistern

Brain
Axial T2



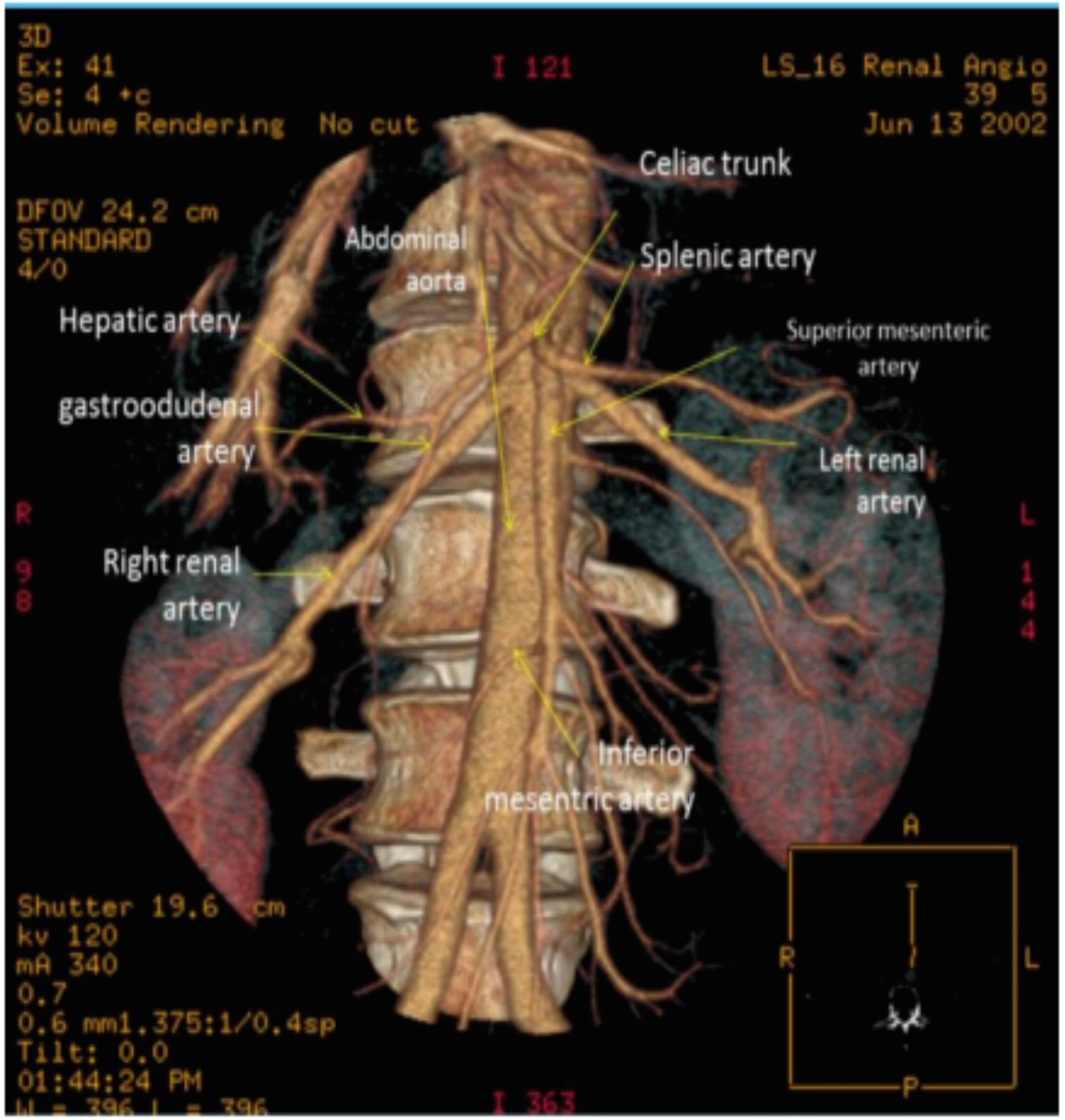


- Superior sagittal sinus
- Superior frontal gyrus
- Middle frontal gyrus
- Inferior frontal gyrus
- Insula
- Lateral sulcus
- Foramen of Monro
- Superior temporal gyrus
- Middle temporal gyrus
- Choroid plexus
- Straight sinus
- Superior sagittal sinus

Brain
Sagittal T1

- Superior sagittal sinus
- Frontal lobe
- Parietal lobe
- Corpus callosum
- Precuneus
- Parieto-occipital fissure
- Cuneus
- Calcarine sulcus
- Lingual gyrus
- Straight sinus
- Cerebellum
- Brainstem
- Straight gyrus
- Spinal cord

3D abdominal angiogram

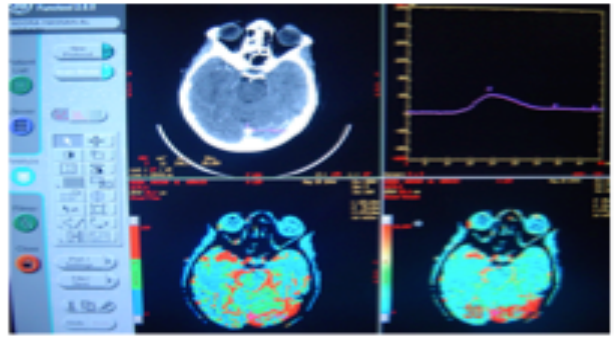


The Knee (X-ray & MRI)

X-Ray: Only bone is seen
Ligament is NOT seen

MRI: Soft tissue better visualized

PROPOSED - KAASH "BRAIN ATTACK" IMAGING PROTOCOL



WORK STATION POST PROCESSING

CTP : 2 - 4 MINUTES
CTA : 8 - 10 MINUTES

TIME
- ACQUISITION & POST PROCESSING = 16 - 20 MINUTES
- INTERPRETATION = 12 - 20 MINUTES
- TOTAL TIME = 28– 40 MINUTES

Doctor's cases:

- A 25 years old male came to the ER limping, you as a doctor suspected **acetabulum fracture**, what is the radiological investigation for this case?

  1-Head CT scan 2-Elbow CT scan 3-Chest CT scan **4-Hip CT scan** (Pelvic CT is also right)

- A 30 years old male came to the ER, you as a doctor suspected **coracoid process fracture** after an RTA, what is the radiological investigation for this case?

  Shoulder joint x-ray

- A patient with an odontoid fracture, what is the radiological investigation for this case?

  Second cervical vertebrae X-ray/CT/MRI

- A pregnant lady came with a bone fracture, is x-ray scan a safe approach?

  No, that is because x-ray's Ionized radiation is scattered, therefore it can reach the fetus leading to the absorption of these radiations

- 25 years old female came to ER with jaundice (he might said pregnant as well). Ultrasound showed intrahepatic dilation. Which technique should've been used?

  Magnetic resonance cholangio-pancreato-graphy (MRCP)

- Note: Fracture of the **Odontoid process** of C2, also known as **dens fracture.**

Thank You!

We hope you found this helpful and informative.

Done by:

- Layan Altawil
- Felwah Alharthi

Reviewed by:

- Abdullatif Alahassan
- Ghaida Alawaji

You can always contact us at Radiology433@yahoo.com