

# X RAY FUNDAMENTALS

## Clinical scenarios

00:01:10

Q. A 32 year old patient undergoes a CXR for fitness. Later that day her UPT comes as positive. USG reveals a 6 week pregnancy. Extremely anxious, she comes to you for consultation. Best advice you can give her is?

- A. Immediate termination of pregnancy.
- B. Mandatory invasive testing for genetic defects.
- C. Counselling, reassuring advice to continue with the pregnancy.
- D. Obstetric MRI.

60c6b3eaa8ded0e4e7e5ea7

Radiation exposure occurring during a CXR : 0.02.

Permissible exposure limit in a pregnant woman : < 1 mSv.

Q. A child with ALL undergoes prophylactic irradiation prior to autologous hematopoietic stem cell transplant. Which of the following will be the least affected by radiation?

- A. Spermatogonia.
- B. Intestinal epithelial cells.
- C. Neurons.
- D. Bone marrow/ erythrocyte precursor cells.

Concept : Law of radiobiology.

Q. Laurel & Hardy were brought in for a CXR. Laurel's Xray was done using at 80KV and 6mAs.

Considering Hardy's body habitus which of the following would be the most appropriate changes in exposure factors that is required to be done?

- A. Decrease KV, Decrease mAs.
- B. Increase KV, Increase mAs.
- C. Decrease KV, Increase mAs.
- D. Increase KV, Decrease mAs.



In obese individual, increase penetration by increasing Kvp and the resulting decrease in image contrast is compensated by increasing mAs.

Active space



## Discovery of X rays

00:04:31

**Willhelm Rontgen** : Discovered X rays and was given the title of 'Founding father of Radiology'.

He discovered X-rays by accident on 8<sup>th</sup> November 1895 while he was working on cathode ray tube and photographic plates.

So, 8<sup>th</sup> November is celebrated as International Radiology day every year.

He also coined the term X-rays (X denoting unknown) because he speculated that some unknown rays that were originating from the cathode ray tube, hit the photographic plate and is making the plate glow.

First X-ray image to be documented in history was the image of Mrs Bertha Rontgen's hand.



Willhelm Rontgen



First X-ray image of Mrs. Bertha Rontgen

## Electromagnetic spectrum : Energy components

60c6b3eeaa8ded0e4e7e5ea7

00:08:29

X-rays are a part of electromagnetic spectrum.

Various components of electromagnetic spectrum :

Radio-waves    microwaves    IR    Light UV    X-rays    Gamma



Increasing order of frequency and energy

Least frequency and energy : Radiowaves.

Highest frequency and energy : Gamma rays.

X-ray wavelength : 0.01 - 10 nm.

Energy content of X-rays : 100 eV to 100 KeV.

Electromagnetic spectrum is comprised of energy components and not particles.



The properties of electromagnetic spectrum :

- They do not have mass.
- They travel at the same velocity i.e., the speed of light  $3 \times 10^8$  m/s.
- Type of wave : Crests and trough type.

## Atomic terms

00:15:11

**Isotopes** : Same number of protons but different number of neutrons.

**Isotones** : Same number of neutrons but different number of protons.

**Isobars** : Different protons and neutrons but have same atomic mass number (total number of nucleons which is the sum of protons and neutrons).

**Isomers** : Different/ unique nuclear energies in spite of having same atomic number and atomic mass number.

**Tungsten (W)** :

It is a very important component of the X-ray tube.

Classified in the periodic table as a **transition metal**.

Atomic number : 74.

Atomic mass number : 184.

**Radiation units** :

**Radiation exposure** :

- Conventional unit : Rontgen.
- SI unit : Coulomb/ Kg (charge/ weight).
- The energy of X-rays deposited in the body, causes ionization resulting in the production of ions which have charge (SI unit is Coulomb). The amount of charge liberated in the body gives the idea about the radiation exposure.

**Absorbed Dose** :

- Determines adverse effects on the body.
- Conventional unit : **RAD** (Radiation Absorbed Dose)
- SI unit : Gray.



madam marie curie

arankitindia1@gmail.com

Active space



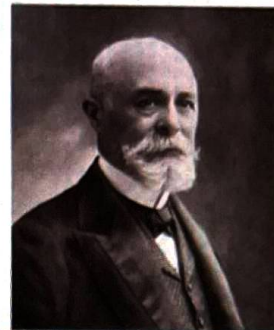
### Absorbed dose equivalent :

- Takes into account the radiosensitivity of different tissues.
- Conventional unit : Rem (Radiation Equivalent in man).
- SI unit : Sievert.

### Radioactivity :

Sir Henri Becquerel discovered radioactivity for the first time.

Madam Marie Curie worked extensively with radioactive elements and elucidated the various properties of radioactive elements. Was awarded Nobel prize twice for her work in the field of radioactivity.



Sir Henri Becquerel

- Conventional unit : Curie.
- SI unit : Becquerel.

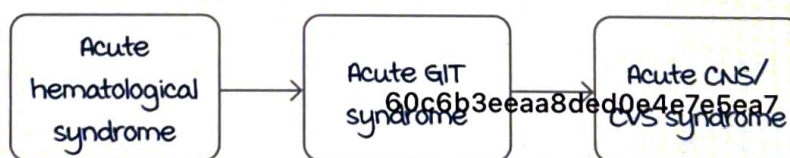
## Acute radiation syndromes

00:30:59

After a radiation exposure, all the tissues in the body will not be affected to a similar extent.

Radiosensitive tissues will be affected earlier and to a larger extent and radio resistant tissues will be affected to a lesser extent.

This creates some clinical syndromes :



Law of Radiobiology/ Law of Bergonie and Tribondeau : Tells about the radiosensitive and radioresistant tissues.

**Radiosensitive tissues** : Tissues which have maximum number of undifferentiated cells/ cells in active mitosis. Example :

- Bone marrow (acute haematological syndrome).
- GI mucosal cells (acute GIT syndrome).

Acute CNS/CVS syndrome is the last syndrome which occurs because CNS cells are **radio resistant**.



Stage 1/ prodromal stage/ nausea, vomiting, diarrhoea stage

: Few minutes to hours.

Stage 2/ latent stage : Few hours to days.

Stage 3/ manifest illness stage : Few days to weeks.

Stage 4/ recovery/ death stage : Few weeks to years.

Acute haematological syndrome :

Threshold dose:  $2-6 \text{ Gy}$

Results in pancytopenia.

Recurrent infections and recurrent haemorrhages are the causes of death in these patients.

Acute GIT syndrome :

Threshold dose :  $6 - 10 \text{ Gy}$ .

Radiation enteritis (mucosal layer is shed off) usually presents as diarrhoea (1<sup>st</sup> symptom).

Other symptoms : malaise, severe diarrhoea, electrolyte imbalance.

Acute CNS/ CVS syndromes :

Threshold dose :  $20 \text{ Gy}$ .

Death usually occurs due to circulatory collapse or raised ICT.

Q. True statement regarding acute radiation syndrome is ?

- A. It presents in 3 stages.
- B. GI suppression occurs at a lower dose than that required for Bone marrow suppression.
- C. Bone marrow suppression occurs earlier than neurological effects.
- D. Bone marrow suppression occurs at  $7.4 \text{ Gy}$ .

This is based on the law of radiobiology.



## Radiation effects

00:40:03

Parameters	Deterministic	Stochastic
Examples	Acute radiation syndromes. Radiation induced cataract, skin effects, sterility.	Radiation induced cancer, genetic mutations, chromosomal aberrations.
Onset	Acute onset because radiosensitive tissues are affected immediately.	Subacute-chronic onset. Example : Survivors of Hiroshima and Nagasaki continued to report malignancies many years after the atomic event. And higher incidence of developing thyroid/ breast cancers in patients with past h/o head and neck radiation.
Threshold dose	Yes	No
Severity	Severity increases with the dose of exposure.	Severity is not affected by dose.
Risk-dose relationship (risk of occurrence of the effect)		

## ALARA principle (As Low As Reasonably Achievable)

00:48:53

It is a principle which deals with radiation safety.

This principle should be followed whenever there is requirement of the radiation exposure to the patients i.e., as low as reasonably possible.

And not very low, because image quality would be compromised which results in misdiagnosis.

### 10 day rule :

It was an empirical rule which was followed in the olden days i.e., in young women of reproductive age group, all X-ray based investigations should be done in the first 10 days of the

Active space



menstrual cycle to prevent the inadvert irradiation of the embryo.

Nowadays, all technicians are trained to enquire with the patient the possibility of a pregnancy before taking an x ray, instead of following the 10 day rule.

Ideal time to do a hysterosalpingography (HSG) : 6<sup>th</sup> - 10<sup>th</sup> day.  
Injection of contrast is avoided in the 1<sup>st</sup> 5 - 6 days to prevent the risk of infections.

## Radiation exposures (mSv) in various modalities

00:53:03

The unit of absorbed dose equivalent is used here instead of Rontgen because it is important to equate the radiation exposure in different radiosensitive tissues to know about the radiation induced adverse effects.

Role of colours in radiology : Provide additional diagnostic information. For example :

- In colour doppler ultrasound, colour indicates the direction of flow (red is towards the probe and blue is away from the probe).
- In PET scans, it indicates the metabolic status of the cells (blue= low metabolism, red/ yellow= high metabolism)

Classification of radiation exposure in various modalities :

1. **Green zone/ safe zone/ spot radiographs :**  
Patient is exposed to radiation only once or twice.
  - In CXR PA view, patient is exposed only once.
  - In X ray wrist, patient is exposed twice.
2. **Yellow zone/ warning zone/ diagnostic procedures :**  
Patient is exposed to the radiation multiple times.
  - In IVU (intravenous urogram), patient is exposed to the radiation : Before injection of the contrast (plane film), and after injection of the contrast at; 0 minutes, 5 minutes, 10 minutes, 15 minutes, 30 minutes, 1 hour (full bladder), post voidal exposure which is done to trace the contrast as it comes to the kidneys and opacifies the kidney.

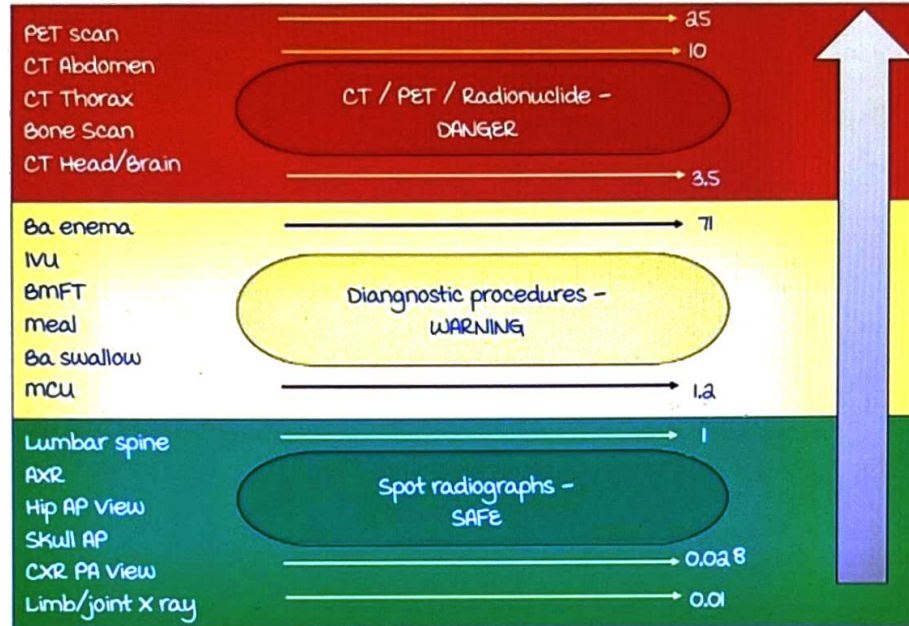


- In mcv (micturating cystourethrogram), X ray is taken while the patient is micturating after the injection of the contrast.

3. Red zone/ danger modalities :

Radiation exposure is very high. For example :

- CT head/ thorax/ abdomen.
- PET scan.
- Bone scan.



ICRP/ ICRU radiation exposure guidelines

01:02:21

ICRP : International Commission on Radiological Protection.

ICRU : International Commission on Radiation Units.

	Public exposure	Occupation exposure
Effective dose overall	1 mSv/ year	20 mSv / year averaged over 5 years (<100 mSv in 5 years) or 50 mSv in any one year provided that total dose over 5 years is <100 mSv
Annual equivalent dose to lens of eye.	15 mSv	150 mSv
Annual equivalent dose to skin	50 mSv	500 mSv
For pregnant radiation workers	Dose of 1 mSv should not be exceeded	

Active space



**AERB** (Atomic Energy Regulatory Board) :

Indian guidelines for radiation exposure.

Same as ICRP except that maximum exposure that can be allowed in 1 year is **30 mSv**, provided that in 5 years is  $< 100$  mSv.

## Exposure factors

01:06:38

1. **kVp (kilo voltage peak)** :

It is the potential difference which is applied across the anode and cathode of the X ray tube (Tube potential difference).

It affects :

- Penetration of the X ray beam is affected directly :

Low kVp : Low penetration.

High kVp : High penetration.

- Image contrast is affected inversely :

Low kVp : High contrast.

High kVp : Low contrast.

2. **mAs (milli Ampere second)** : It is the current which is passed through the cathode filaments/ X ray (Tube current).

This determines film blackening and the number of X ray photons in the X ray beam.

It affects the image contrast directly.

- Low mAs : Low contrast film.

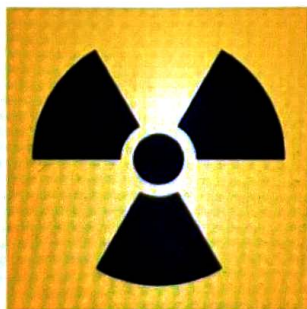
- High mAs : High contrast film.

## Important symbols

01:10:31

**IAEA** : International Atomic Energy Agency.

**ISO** : International Organization for Standardization.



International radiation symbol  
"The trefoil"



High level sealed source  
ionizing radiation symbol  
IAEA & ISO - 2007

kumarankitindia1@gmail.com

Active space



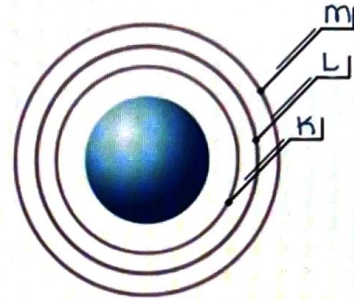
# X-RAY PRODUCTION AND INTERACTIONS

## Structure of atom

00:01:38

- Proposed by Neils Bohr.
- Atom has a central nucleus, surrounded by shells.
- Each shell contains a particular number of electrons.

Atomic Structure- Basic concepts



K → 2

L → 8

M → 18

N → 32

**Stable atom** → All shells are filled with complete set of electrons.

Tungsten atom :

K shell electron → Bound electron.

In free electron total energy level equals 0.

To make the K shell electron of tungsten atom, a free electron.



Energy of 70 eV spent.

If 'x' was original level of energy,

$$x + 70 = 0 \rightarrow x = -70$$

Each shell has its own fixed energy level at which all the electrons lie.

Energy for K = -70 eV

L = -12 eV

M = -2 eV

On removing a K shell electron, an electron void is created.



Atom becomes unstable.



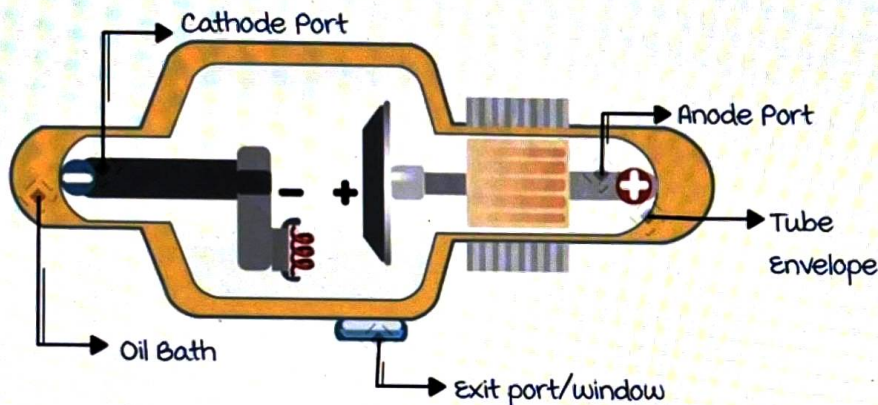
↓  
Outer shell electron jumps into inner shells  
& free electron jumps into outer shell.  
↓  
Atom becomes stable.

When outer shell electron jumps to inner shell → It has to lose energy.

Amount of energy lost = Difference in energy levels of two shells.

## X-ray tube

00:10:19



Tube housing → Lead lined material to prevent radiation leakage.

Oil bath present inside the tube housing → Surrounds tube envelope and helps dissipate heat.

Tube envelope made of ceramic.

Tube envelope has cathode and anode port.

Exit port :

Port from where the x ray beam comes out, it restricts the primary x ray beam.

It is placed in the tube envelope.

Filters are attached which block the low energy x rays and allow x rays of diagnostic strength.

Collimators : Placed at the exit port , it closes or opens up to allow narrow or wide beams of x ray.

Inside the tube envelope is vacuum, in which , 2 electrodes, Cathode ( high negative charge) and anode ( high positive charge) are placed.



High potential difference present between the cathode and anode, plays an important role in production of X rays.

**Cathode** : Cathode filament is made of tungsten-helical wire (length of about 10-20 mm & width of 2-5mm).

Small electric current passed through filament.

Tungsten filament gets heated up due to high resistance. When heated at very high temperature.



**Thermionic emission** : Emission of electrons.

kumarankitindia1@gmail.com

Electrons accumulates around the cathode as a cloud of electrons.

These electrons will be accelerated towards the anode with high kinetic energy.

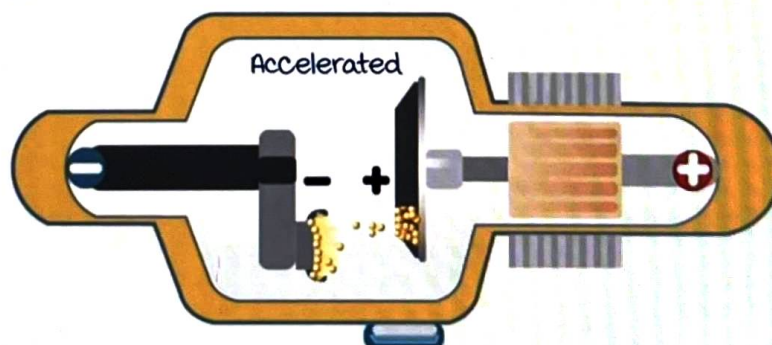
**Anode** : metal that has a very high heat tolerating capacity. Alloy of Tungsten (90%) and Rhenium (10%).

mammogram → molybdenum used

Anode rotates, hence preventing electrons from hitting the same

target thereby giving high heat tolerance and a long life.

X-rays are produced when electrons hit the anode.



## Production of X-rays

00:21:39

1. Continuous spectrum. (A.K.A Bremsstrahlung)
2. Characteristic spectrum.

**Continuous spectrum/white radiation/braking radiation** :

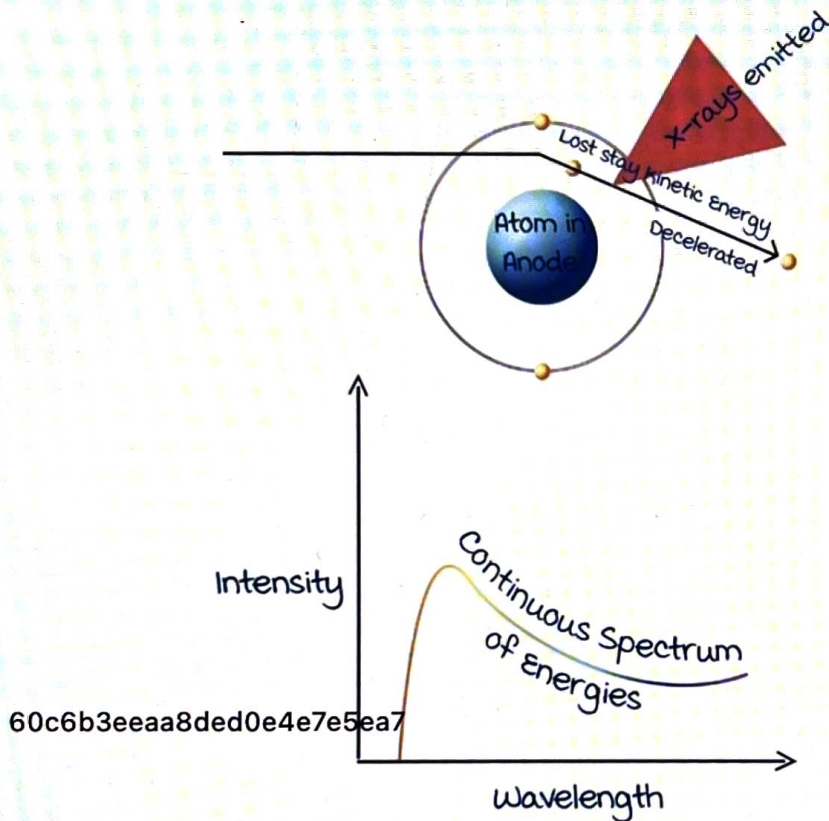
- most common mechanism, 70-80% X-rays produced by this.



- When electron accelerates towards the anode, it gets decelerated and deviated from its path due to the opposite positive charge of the anode nucleus.

When decelerated the electron loses its kinetic energy, this is emitted out as X-rays.

Based on the principle of law of thermodynamics, energy can neither be created nor can it be destroyed, but can be converted from one form to another.

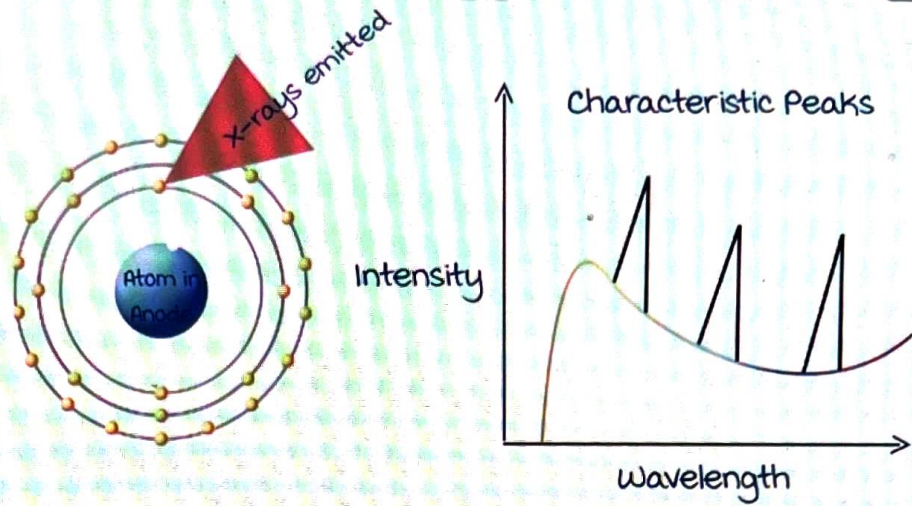


- Beams of variable energies produced in continuous spectrum.

**Characteristic spectrum :**

- 20-30 % of x ray production.
- Used in mammography.
- The travelling electron hits & throws out the inner shell electron.
- Atom becomes unstable, the energy lost to gain stability is emitted out as X-rays.
- When plotted on graph shows, characteristic peak depending on the movement of the shell electron, hence it is called characteristic spectrum





## Interaction of X-rays with matter

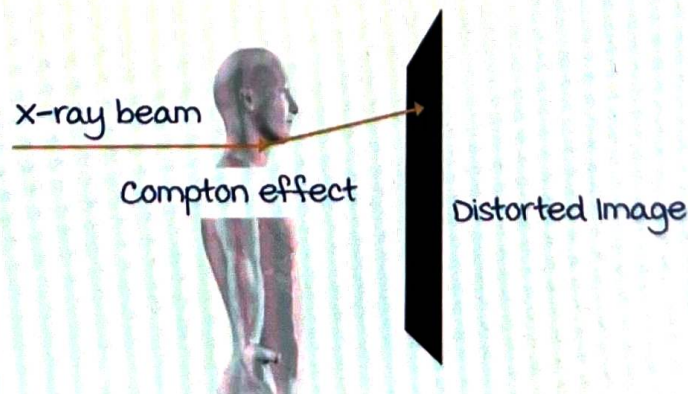
00:30:42

manner in which X-ray beam interacts with the body tissues.

- Compton effect.
- Photo electric effect.
- Coherent scattering.
- Photo-disintegration.
- Pair production.

### Compton effect :

- Most common interaction.
- Also called mid-energy phenomenon.
- X-ray beam hits outer shell electron → Requires small energy.
- The electron which is thrown out is called Compton electron.
- X-ray beam deviates from original path due to collision.
- Deviation of X-ray beam gives distorted image → Scatter radiation
- Compton effect is minimized by using high energy X-rays





**Photoelectric effect :**

- Less common.
  - Low energy phenomenon.
  - X ray photon hits an inner shell electron.
  - X ray beam gives all energy to this electron and disappears  $\rightarrow$  No scattering. This improves image quality.
  - Maximise photo electric effect by relatively low energy levels or target of high atomic number.
- Low energy used matches the binding energies of inner shells of atoms in human body (C/H/O).

**Coherent scattering/classical scattering:**

kumarankitindia1@gmail.com

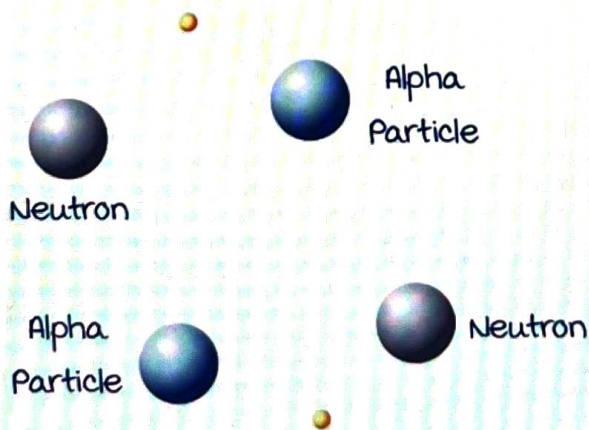
Also called Thompson scattering/Rayleigh scattering.

- X ray photon hits electron and gives all energy & disappears.
- Electron gets excited & vibrates releasing an X ray photon, identical to the hitting a photon but in a different direction.
- No ionisation occurs  $\rightarrow$  Only direction changes.
- If only one electron is involved  $\rightarrow$  Thomson scattering.
- If all electrons are involved  $\rightarrow$  Rayleigh scattering.

Not commonly seen in routine practice.

**Photo disintegration :**

- Nucleus of an atom breaks  $\rightarrow$  Alpha particle or neutron is produced.
- Occurs only if high energy involved ( $> 7$  mev)
- Not used in clinical practice.



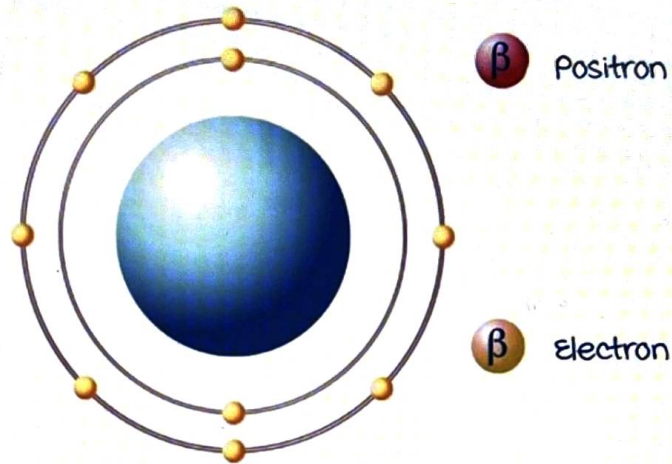
Nucleus dis-integrates releasing an  
 $\alpha$ -particle / Neutron



**Pair production :**

- X-ray photon hits nucleus  $\rightarrow$  This energy of X ray photon converted into particles  $\rightarrow$  A pair of positron & electron are produced.
- Incident X-ray beam strength  $> 1$  mev
- Not commonly used.

A pair of Positron & Electron is emitted



60c6b3eaaa8ded0e4e7e5ea7



# CT BASICS

## Basics of CT

00:00:43

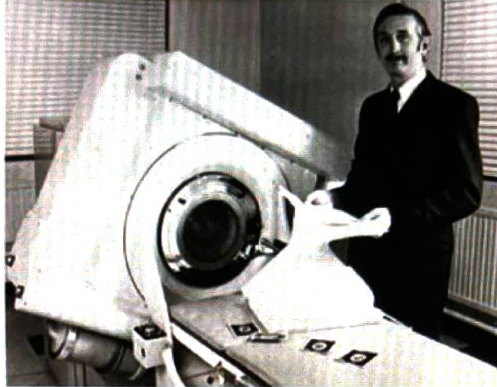
**Sir Godfrey Hounsfield :**

Invented CT.

1<sup>st</sup> generation CT : Aka **EMI scanner** (Electrical and musical instruments).

Devised **Hounsfield unit** (HU) scale or CT value scale .

Awarded noble prize jointly with Allan Cormack in 1979.

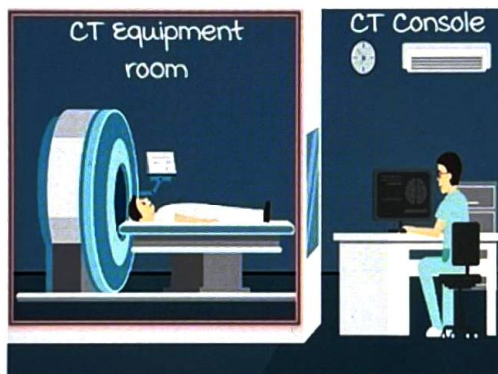


Computed tomography :

Tomography = Cross sectional imaging.  
uses X rays.

CT scan department :

Equipment room is lined by **Lead** to prevent leakage of radiation.



Lead sheath of  $(1/16)^{\text{th}}$  inch thickness or around (4-6) inches of standard density concrete wall.

**Glass window** between equipment room and console room → **Lead containing glass.**

CT scan machine :

Outer ring : **Gantry.**

CT table is where patient lies down.



Active space



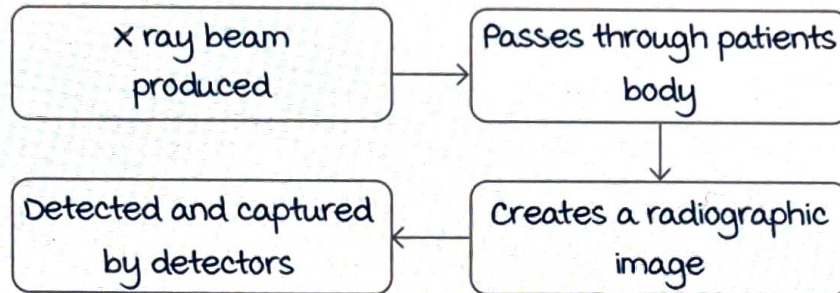
## CT basic principles

00:07:10

Internal structure of an object can be reconstructed from multiple projections of that object.

Inside gantry :

X ray tube on one side and X ray detector on other side.



60c6b3eaa8ded0e4e7e5ea7

Detectors : **Electronic device.**

Data collected by detectors are called as **projections.**

All the collected data are transmitted to computers.

Both X-ray tube and the detectors move to new positions, another image is created.

This procedure is repeated until 'n' number of projections are produced from patient's body at different angles.

All data is fed to the computer and processed together → Produce and display a cross sectional image.

The image showed from 'n' number of projections → Internal structures.

## CT scan generations

00:11:50

1<sup>st</sup> generation : Aka **Translate-Rotate scanner.**

Pencil shaped X-ray beam from X-ray tube.

To cover entire body cross section using pencil beam X ray :  
Swipe pencil shape X ray beam entirely across from one side of patient's body to another : **Translation.**

**1 Translation = 1 projection.**

After 1 translation → Entire setup is rotated by a small angle  
→ **Rotation** → Translation → 2<sup>nd</sup> projection.

Rotate → Translate → 3<sup>rd</sup> projection → Repeated 'n' no. of times → Cross sectional image.

Slower working machine.



2<sup>nd</sup> generation : Aka **Translate-Rotate scanner**.

Fan shaped X ray beam (Single row of detectors).

Similar procedure but due to fan shape X ray beam degree of translation is less.

But slightly faster than 1<sup>st</sup> generation.

3<sup>rd</sup> generation : Aka **Rotate-Rotate scanner**.

Wide fan shaped X ray beam → Translation not required.

Disadvantage : **Detector instability** → Due to rotation of detectors continuously.

4<sup>th</sup> generation : Aka **Rotate-Fixed scanner**.

Complete 360° ring detectors.

Faster working machine.

5<sup>th</sup> generation : **Fixed-Fixed scanner**.

Electron beam is used.

One end : Electron emitter/gun.

High velocity stream of electrons → Electron directing coils →

Hits Tungsten target rings → X ray passed through patient

→ Detectors.

[kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)

Fastest CT machine technology but still in experimental phase (for cardiac imaging).

Helical or spiral CT :

Peculiar problem with 3<sup>rd</sup> and 4<sup>th</sup> generation CT is X ray tubes with high voltage wires are attached.

During rotation, high voltage wire might get entangled and get cut → Short circuit → machine may explode.

Hence only one rotation was possible at a time.

Tube turned on → 1 rotation → Table moves inside → Tube turned off → Tube brought back to position.

And then the procedure is repeated.

**Slip ring technique :**

High voltage attached to outer ring and the inner ring is mobile. Electrical supply via brush contractors are fixed to inner tube.

Patient's table moves simultaneously when tube is rotating :

Spiral or helical CT.



multi detector CT :

Fan shaped beam (Single slice in one cut) → unidetector CT.

3 dimension cone shaped : multiple slices in one cut (8 slice/16 slice/64 slice/128 slice).

### Hounsfield unit or CT value

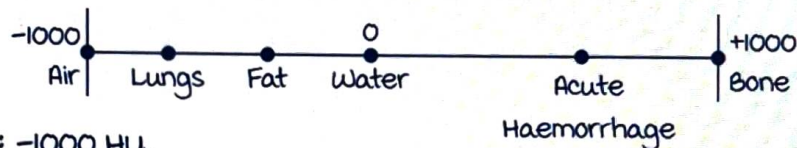
00:23:24

Every tissue is given a numerical value in CT scan : Hounsfield unit value.

$$HU_x = 1000 \times \frac{\mu_x - \mu_{\text{water}}}{\mu_{\text{water}}}$$

$\mu$  : Linear attenuation coefficient → Determined by density.

$$HU_{\text{water}} = 0.$$



Air : -1000 HU.

Lungs : -800 HU.

Fat : -100 HU.

Bone : +1000 HU.

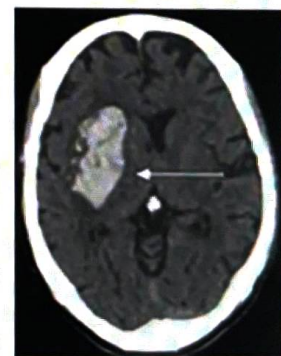
Acute hemorrhage : +45 to +65 HU.

60c6b3eaa8ded0e4e7e5ea7

Q. A 50 year old man was brought unconscious to the casualty. His pulse is 120 bpm, BP is 160 / 140 mm Hg. An emergency CT reveals a hyperdense lesion with CT value +55 HU in the right basal ganglia and centrum semiovale. most likely diagnosis is?

- A. Extradural hematoma.
- B. Multiple sclerosis.
- C. Acute infarct.
- D. Intraparenchymal bleed.

Ans : Intraparenchymal bleed.



Q. The walls of a CT scanner room are lined with?

- A. Glass.
- B. Copper - Faraday's cage.
- C. Lead.
- D. Tungsten.

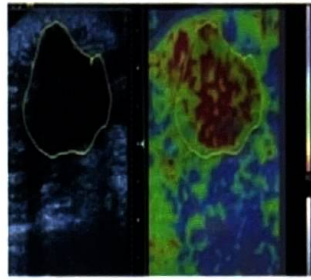
Ans : Lead.



## USG BASICS

Clinical quiz :

Q. In a 45 year old patient of right sided breast mass, USG examination revealed an equivocal appearance that was graded as BIRADS 3 lesion.



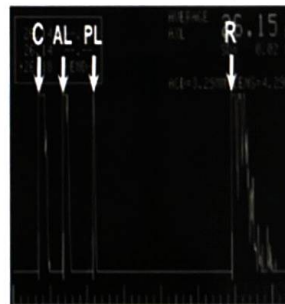
A special application of ultrasound technique was used (shown here) based on estimation of hardness of tissues. Identify the technique :

- A. High intensity focused ultrasound (HIFU).
- B. Contrast enhanced ultrasound.
- C. Elastography.
- D. Spatio temporal image correlation (STIC).

Answer : C. Elastography.

Q. This special method of ultrasound used for the eye is known as ?

- A. A mode.
- B. B mode.
- C. C mode.
- D. M mode.



Answer : A. A mode.

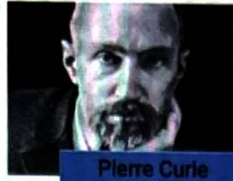
### USG historicals

00:01:36

- Pierre Curie discovered the property of piezoelectricity.
- Karl Dussik attempted head imaging by using USG for ~~the first time~~ [61e6f3e1e8ed0e4e7e5ea7](#)
- Ian Donald used USG for the first time for obstetric imaging. He is called as "father of obstetric imaging".
- John Wild used USG medically for imaging. He is known as "father of medical ultrasound".

Active space





Pierre Curie



John Wild



Karl Dussik



Ian Donald

Ultrasound beam :

mechanical wave consisting of alternate compressions and rarefactions.

60c6b3eeaa8ded0e4e7e5ea7

During the compression, there is an increase in pressure at the tissue.

During rarefaction, there is decrease in pressure.

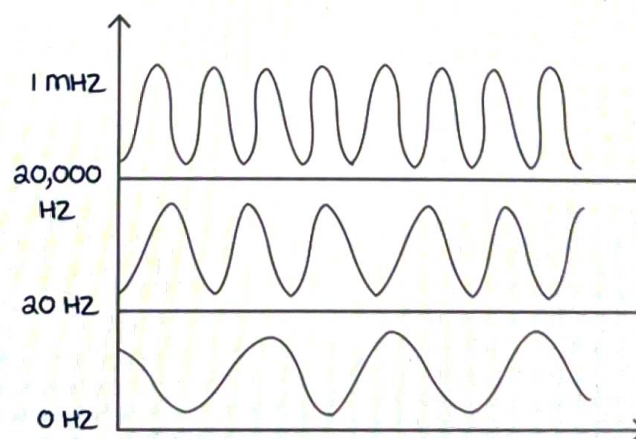
Sound spectrum :

Audible range (sonic range) of sound : 20 Hz to 20000 Hz.

Infrasonic : < 20 Hz.

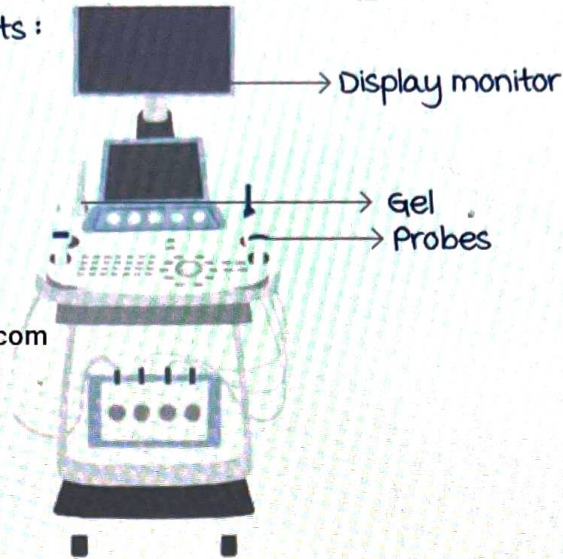
ultrasound : > 20,000 Hz.

For diagnostic imaging, ultrasound spectrum above 1 MHz is used.





USG machine components :



kumarankitindia1@gmail.com

USG probes and their indications :

Pencil probe :

- Least frequency probe.
- Frequency is 1 to 2 MHz.
- It is used for **transcranial doppler/transcranial colour duplex imaging.**

Pencil probe



Frequency : 1 - 2 mhz

Convex/curvilinear probe :

- most commonly used probe overall.
- Frequency is 3.5 to 5 MHz.
- It is used routinely for all **abdomen and pelvis ultrasound/obstetric ultrasound/obstetric doppler.**

Convex / curvilinear Probe



Frequency : 3.5 - 5 mhz

Linear probe :

- Surface of the probe is linear or flat.
- Frequency is 7.5 - 12 MHz.
- It is used for small part imaging such as neck, thyroid, eye, local swellings, joints, breast.
- Also used for **peripheral vascular doppler.**

Linear probe



Frequency : 7.5 - 12 mhz

Endoluminal probe :

- Linear/tubular probe.

Active space



- Frequency is  $>10$  Hz.
- Uses :
  1. Transvaginal ultrasound (TVS).
  2. Transrectal ultrasound (assessment of prostate).
  3. Transesophageal echocardiography (assessment of prosthetic valves).
  4. Endoscopic ultrasound.
  5. Endovascular ultrasound.

Endoluminal probe



Frequency :  $> 10$  MHz

UBM probe



Frequency : 50 MHz

UBM (ultrasound biomicroscopy) probe :

- Highest frequency probe.
- Frequency is 50 MHz.
- It is used for evaluation of eye.

**USG probe – internal structure**

00:11:18

Wire brings in electric current and carries away the signal. At the tip, there are piezoelectric crystals (piezoceramics). most commonly used crystal : **Lead zirconate titanate.**



Production of ultrasound beam :



Reverse piezo electric effect :

Electric current to probe (probe with wire).



Pass through **lead zirconate titanate** crystals.



Re alignment of internal dipole structures within crystals.



Crystals begin to vibrate at a frequency of  $>20,000$  Hz.

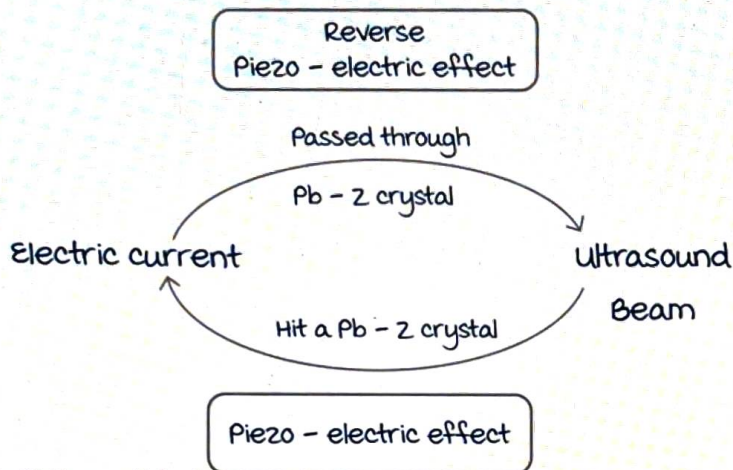
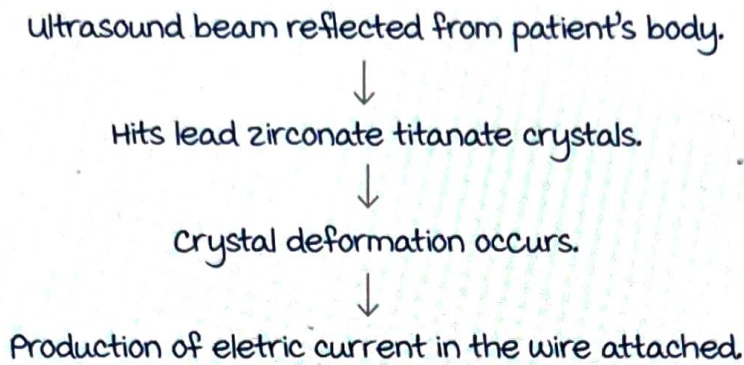


mechanical waves (ultrasound waves) formed around it.

Active space



### Piezo electric effect :



60c6b3eaa8ded0e4e7e5ea7

Both piezo electric effect and reverse piezo electric effect are used in medical diagnostic ultrasound.

### Pulse echo principle :

This technique was used by ships as 'sonar technique'.

Sonar technique : measuring the depth of an ocean →

Emitter at the bottom of the ship emits a 'pulse'. It travels downwards and hits the bottom of the ocean and gets reflected back, 'echo' is formed. It is known as **pulse echo principle**.

The time at which pulse is emitted and the time at which echo is received is measured.

Depth :  $\text{velocity (of sound in water)} \times \text{Time} / 2$ .

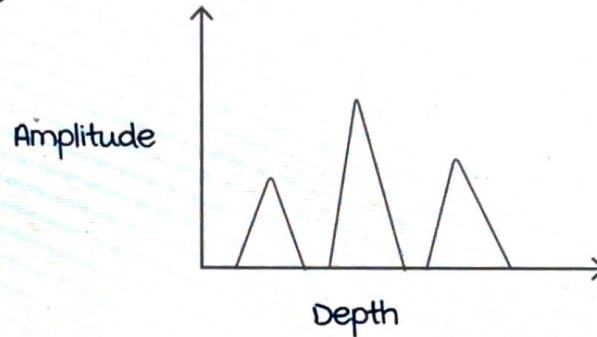
Depth-location of organ is determined using the same principle in human diagnostic ultrasound.



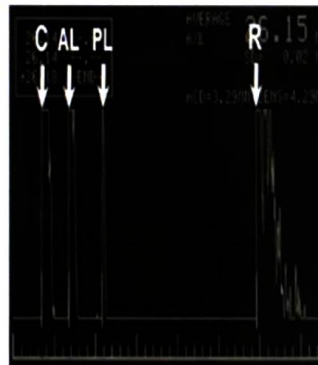
### Ultrasound methods of display :

#### A mode :

- A stands for "amplitude".
- Graph : Y-axis is amplitude. X-axis is depth of origin of signal.



- It is a crude, primitive method. For example : If A mode is used for USG abdomen → multiple peaks are seen from different reflecting surfaces in abdomen.
- A mode ultrasound is not used in routine practice except for ophthalmic ultrasound (only four reflective surfaces in eyes : Cornea, anterior capsule of lens, retina, posterior capsule of lens).



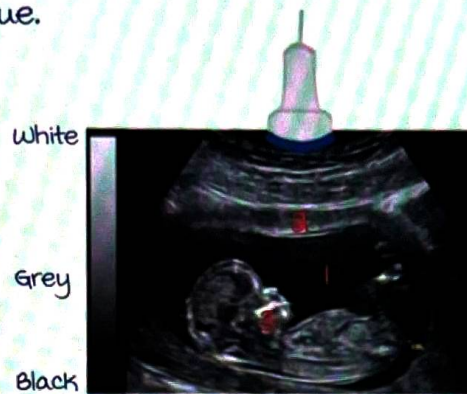
#### B mode :

- most common method of display.
- 'B' stands for brightness.
- Amplitude value measured using A mode is given a brightness value.

An ultrasound probe is kept over the area to be scanned → Pulse is sent, and echo is received. On the left hand side of the image, there is a gray scale which is jet black at the bottom and bright white at the top (increasing shades of brightness from bottom to top). Amplitude of returning



echoes from every point is measured. It determines the brightness value.



Example :

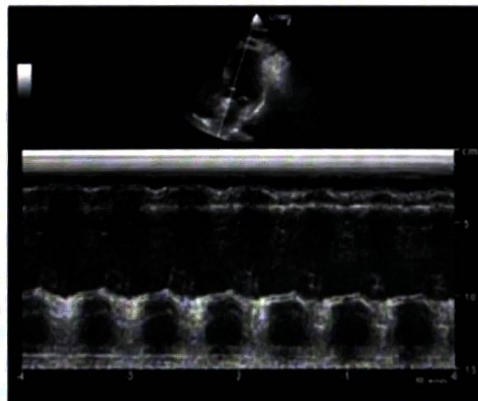
Area 1 : Low amplitude. So, it appears black (hypoechoic).

Area 2 : Intermediate amplitude. So, it appears grey (isoechoic).

Area 3 : High amplitude. So, it appears white (hyperechoic).

M mode :

- M stands for motion.
- Detects any motion that is occurring.
- Motion vs time graph is plotted.
- Used in echocardiography for cardiac evaluation.



## Doppler effect

00:25:08

60c6b3eaa8ded0e4e7e5ea7

The change in frequency of sound that occurs whenever there is relative motion between emitter and receiver of sound.

movement of source of sound towards a person → wavelength decreases and frequency increases.

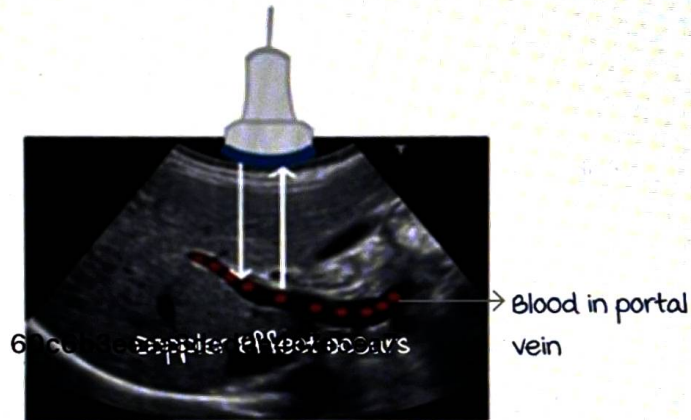
Active space



movement of source of sound away from a person → wavelength increases and frequency decreases.

Clinical application :

- most important application is **vascular imaging** (doppler effect is seen due to relative motion of RBCs and ultrasound probe).
- Helps to detect **direction/velocity of blood flow**. Stenosis, thrombosis, flow alteration pattern, insufficiencies can be diagnosed.



Doppler equation :

$$F_D \text{ (Doppler shift)} = 2 \times F_0 \times v \times \cos\theta / c.$$

$F_0$  = Transmitting frequency of the probe.

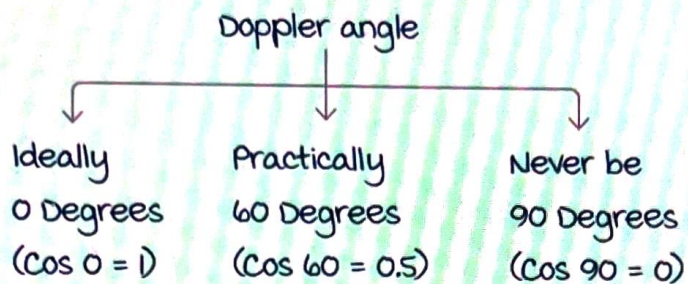
$v$  = velocity of blood flow within the vessel.

$c$  = velocity of sound in human body (constant value - 1540 m/s).

$\theta$  is doppler angle (angle between ultrasound beam and plane of blood flow).

- Ideally, doppler angle should be zero degrees ( $\cos 0 = 1$ ). But this is not practically feasible.
- Practically, doppler angle should be close to 60 degrees ( $\cos 60 = 0.5$ ).
- Doppler angle should never be 90 degrees ( $\cos 90 = 0$ ). Indicates no blood flow falsely.





Colour doppler :



Red = Toward the probe  
Blue = Away from the probe

- Subjective method of doppler interpretation.
- Blood flow can be seen but cannot be measured.
- **Red colour** → Blood flow towards the probe.
- **Blue colour** → Blood flow away from the probe.
- Red/blue colour allotment is subjective/variable.
- Intensity of red/blue colour is determined by velocity of blood flow.
- Disadvantage : Low sensitivity → So can miss low velocity flows.

Power doppler :

kumarankitindia1@gmail.com



Advantage : High sensitivity  
Can detect low velocity flow

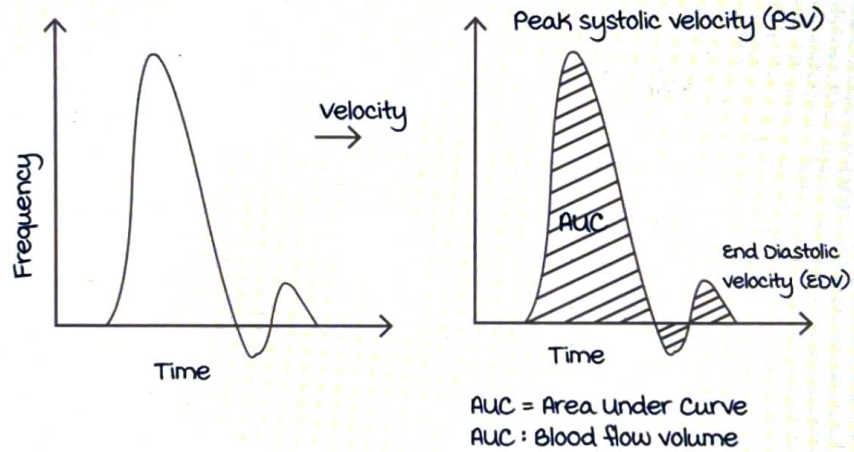
Active space



- Subjective method.
- Blood flow can be seen but cannot be measured.
- Single colour display → Direction of blood flow is not shown.
- Advantage : High sensitivity → Can detect low velocity flow.

#### Spectral doppler :

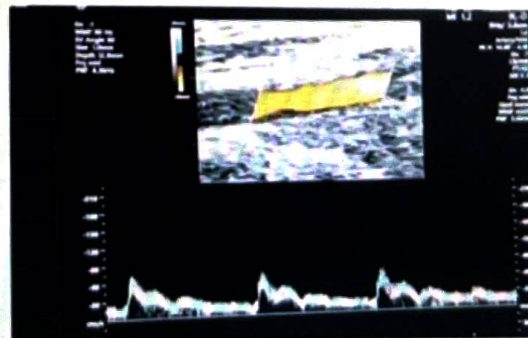
- Objective technique.
- Blood flow can be measured.
- using the various formulae, machine can plot a graph of frequency change against time. Velocity information can be known from frequency.



Highest point : Peak systolic velocity (PSV).

Lowest point : End diastolic velocity (EDV).

Area under curve : Blood flow volume.



Active space

kumarankitindia1@gmail.com



## Biological effects of ultrasound

00:34:58

### Thermal effects :

- Ultrasound beam carries energy that gets deposited into body when the beam is blocked or attenuated. This energy is then converted into heat.
- It is more in doppler.
- **Thermal index (TI) :**  

$$\text{TI} = \frac{\text{Ratio of power produced by the USG probe}}{\text{power required to increase the tissue temperature by 1 degree Celsius.}}$$
 TI for soft tissue (TI<sub>s</sub>) and bone (TI<sub>b</sub>) are different.

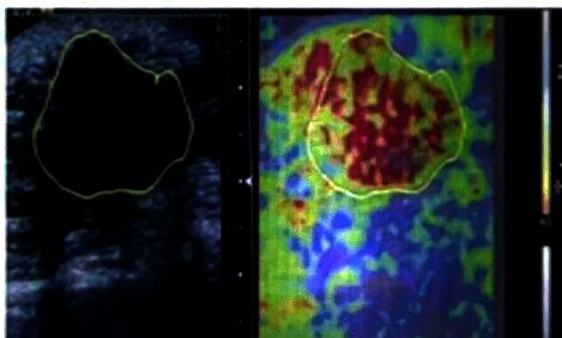
### Mechanical effects :

- Increased pressure in compression and decreased pressure in rarefaction can create mechanical effects.
- more in organs with multiple air-water interfaces such as lungs/bowel.
- Tissue can be damaged because of microcavitation.
- mechanical index : It should be less than 1.9.

## Elastography

00:38:08

- Use of USG to measure hardness of tissue.
- most commonly used in breast and liver imaging.
- Breast cyst is pliable, but breast cancer is known to be **schirrhous/hard**.
- Elasticity information (low/intermediate/high) is given a colour scale and is plotted on a colour map.



Active space



# MRI BASICS

## MRI : History & basic principle

00:02:36

The basic theoretical property of MRI : Nuclear magnetic resonance (NMR) given by Felix Bloch.

NMR states that nucleus behaves like a magnet and has a magnetic field (magnetic moment).

Felix Bloch and Edward Purcell were jointly awarded Nobel prize in 1952 for the discovery.



Raymond Damadian :

First scientist to make a practical attempt to make a machine.

Discovered that malignant tissues had different NMR properties than normal tissues, hence tissue characterization may be possible.

Produced 1<sup>st</sup> ever NMR image of a rat tumor in 1974.

The **indomitable** : 1<sup>st</sup> super conducting NMR scanner developed in 1977.

60c6b3eeaa8ded0e4e7e5ea7

Produced 1<sup>st</sup> human body MRI image that took 5 hours of scanning.





Paul Lauterber :

Developed a 2D tomographic MR image using a magnetic field in 1974.



Peter mansfield :

used field gradient for slice selection : Created 1<sup>st</sup> image of human finger in 1977.

Jointly awarded Nobel prize in 2003.

Basic principle of MRI :

Based on the gyromagnetic property of hydrogen nucleus.

Basic concepts of MRI :

Each atom consists of central nucleus and electrons revolving around it.

Inside every atom, 3 types of movements occur :

- Electron orbiting around nucleus.
- Each electron rotating around its own axis.
- Nucleus rotating around its own axis.

Whenever a charged particle moves in space, it creates a magnetic field around it.

The magnetic field created by rotation of nucleus : magnetic moment.

Gyromagnetic property : The property that arises by spinning of a nucleus, creating a magnetic field around it.

60c6b3eeaa8ded0e4e7e5ea7



mRI active nuclei :

Nucleus	Gyromagnetic ratio (MHz/T)
$^1\text{H}$	42.58
$^3\text{He}$	32.43
$^{13}\text{C}$	10.71
$^{19}\text{F}$	40.0
$^{23}\text{Na}$	11.2
$^{31}\text{P}$	17.2

The ion chosen for basis of mRI was hydrogen because : most abundant nucleus in human body (as 70-80% of body weight is  $\text{H}_2\text{O}$ ).

Abundant hydrogen gives rise to high resolution mRI image. Hydrogen has one of the highest gyromagnetic ratio.

### MRI basic structure

00:09:11

mRI in contrast to CT machine :

- Bigger, broader, and thicker gantry.
- Narrow central bore (24 inches/60 cm wide).

#### 1. mRI magnet :

- Superconducting magnet used.
- Electric current is passed through the wire coils.
- magnetic field is produced.
- Wire coils are placed in liquid helium at temperature of  $-452.4^\circ\text{F}$  or  $-269.1^\circ\text{C}$ .
- At such a low temperature, the wire loses all its resistance.
- Zero resistance coil conduct electric current permanently.
- Thus, the magnetic field is created around the coils permanently.



## 2. Gradient coils :

- They create small gradients (variations) in magnetic field along X-Y-Z axis.
- **vibration** of these coils create loud noise during MRI scanning.

## 3. Radio frequency coils :

- Present inside gradient coil.
- Emit radio frequency excitation pulses (containing energy) towards the patient's body.

## 4. Scanner equipment :

- Helps in slice selection.
- Plane of imaging.
- Slice thickness configuration.

## 5. Computer processor :

- Data processing and image reconstruction.

**Working of MRI**

00:12:23

## Patient in waiting room :

- Patient's body not under the influence of any external magnetic field.
- All hydrogen nuclei are oriented randomly throughout patient body.
- There will be **no Net magnetic vector (NMV)**.

## Patient on MRI machine table :

- Patient body under the influence of strong external magnetic field.
- magnetic field strength : **0.3-3.0 Tesla**.
- majority of nuclei align parallel to  $B_0$  (external field).
- Few align antiparallel, but in same plane (parallel > antiparallel).

60c6b3eeaa8ded0e4e7e5ea7  
• There will be a **net magnetic vector**.

- Nuclei aligned along with  $B_0$  → **wobbles or precession**.



- The machine matches with the frequency of precession resulting in resonance.
- Precessional frequency determined by formula : Larmor equation.

$$\omega = \gamma \times B_0$$

Precessional frequency ( $\omega$ ) = Gyro magnetic constant ( $\gamma$ ) x magnetic field strength ( $B_0$ ).

## MRI image acquisition

00:15:08

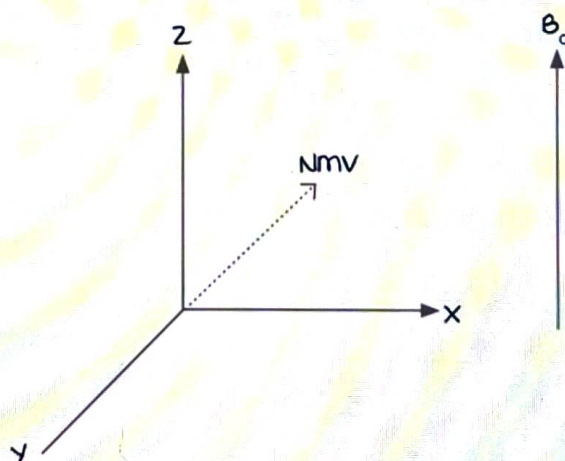
- **Pre-scan :**

In pre-scan, MRI scanner estimates the precessional frequency of hydrogen nuclei in the body.

- **Excitation :**

Radio frequency (RF) pulse applied to the NMV along z axis, results in flipping of NMV in x-y plane.

As long as the RF pulse is applied, the NMV will remain in x-y plane.



- **Relaxation :** Occurs after RF pulse is switched off.

It's of 2 types.

1. T1 relaxation :

- Also known as 'Spin-lattice' relaxation.
- Occurs along z axis.
- Transverse magnetisation is lost.
- T1 relaxation relates to the regaining of longitudinal magnetization.



T1 relaxation time :

- Time required for 63% of longitudinal magnetization to be regained.
- Unique for each tissue : Hence every tissue appears different on a T1W image.
- T1 relaxation is a slower process.

a. T2 relaxation :

- Also called as 'Spin-spin' relaxation.
- Occurs along the X-Y plane.
- RF pulse switched on : All nuclei are in phase.
- RF pulse switched off : Nuclei are out of phase.
- T2 relaxation relates to the dephasing of nuclei along the X-Y axis.

kumarankitindia1@gmail.com :  
T2 relaxation time :

- Time required for 63% of transverse magnetization to be lost.
- Unique for each tissue : Hence every tissue appears different on a T2W image.
- T2 relaxation is a faster process.

During relaxation (T1 & T2), signal is emitted out from patient's body.

- **Acquisition :**  
Signal emitted in form of radio frequency pulses from body is picked up by receiver.
- **Computing and display :**  
Signal is processed and images are formed.



## Contraindications of MRI

00:22:42

Absolute	Relative
<ul style="list-style-type: none"> <li>• Cardiac pacemaker.</li> <li>• metallic foreign body in eye.</li> <li>• Ferro-magnetic haemostatic CNS aneurysm clips (risk for SAH).</li> <li>• Cochlear implants.</li> </ul>	<ul style="list-style-type: none"> <li>• Claustrophobia (sedated first).</li> <li>• Insulin pumps.</li> <li>• Nerve stimulators.</li> <li>• Epidural catheters.</li> <li>• Prosthetic heart valves.</li> <li>• 1<sup>st</sup> trimester of pregnancy (may cause deafness in fetus).</li> </ul>

Internal fixator : MRI compatible (made of stainless steel or Titanium, and they are fixed to bone).

External fixator : MRI contraindicated as they are made of steel or iron wires which has inherent magnetic property. K wires are also loosely fixed to bone and may move.

ACL Reconstruction :

Steel screws deeply bored to bone. Safe for MRI.

Angio plastic stents : Granulation tissue develops after 6-8 weeks. MRI safe after 6-8 weeks.

MRI shielding :

Done by Faraday's cage.

Wood wrapped with copper wires.

Done for magnetic shielding.

magnetic field from outside must not enter the MRI room and

magnetic field of MRI must not

interfere with other equipments outside the room.



60c6b3eeaa8ded0e4795ea7

## Clinical quiz

00:28:37

Q. A patient comes to the casualty with a seizure and was advised an MRI Brain for evaluation. He gives a history of surgery 1 month back and the adjoining radiograph. In view of the internal fixation implant what would be the further management of this patient?



- A. MRI is contraindicated.
- B. MRI may be done with a cast immobilization of the lower limb.
- C. MRI may be done routinely today.
- D. MRI may be done after 6 months.



Q. A labourer was working at his site with a chisel and a hammer. He suddenly felt an impact when he hit his hammer and had an eye injury due to a flying fragment. He was brought to the hospital. Which of the following investigations would be detrimental if done in his case?

- A. B-scan.
- B. CT.
- C. MRI.
- D. X ray orbit.

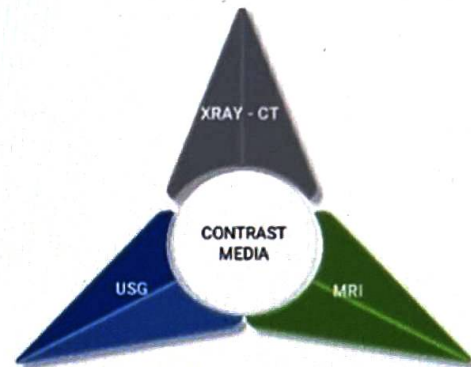
Q. True regarding Faraday's cage is?

- A. used for shielding of MRI rooms.
- B. Present around all MRI machines.
- C. made up of copper wires wrapped around wooden panels.
- D. All the above.



# CONTRAST MEDIA

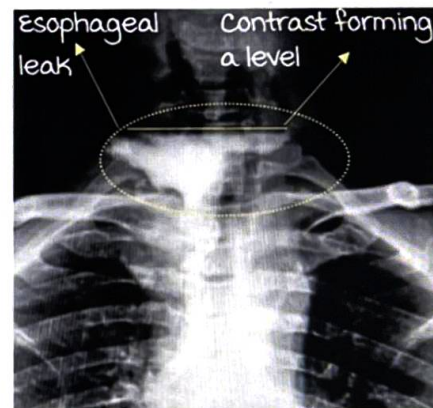
When the image of an X-ray / CT is not properly visible and specific details are not clearly seen, we add the contrast media to improve the visibility. Different contrast media are used for different modalities.



## Clinical scenario

00:01:29

Q. A post hemi thyroidectomy patient complained of difficulty in swallowing, mild swelling and pain in neck of the chest post op day. Suspecting esophageal injury, the surgeon did an oral contrast study which is shown here. Which of the following contrast material is the best one to be used in this clinical situation?



- A. Barium.
- B. Gadolinium.
- C. Gastrograffin.
- D. Iohexol.

Esophageal injury causing an **esophageal leak** is being suspected.

The contrast is being given to check for the leak, hence the contrast must be least toxic to the body (for the cases where it leaks out).

The contrast forms a **level** in the soft tissues of the neck outside the esophagus → Collects in the soft tissues → moves to the mediastinum (esophageal leak).



The **m/c contrast** material used for GI tract evaluations (esophagus, bowels etc.) : **Barium**.

**Absolute contraindication** for the use of barium : **Leak or perforation**.

Explanation :

Barium will cause **chemical mediastinitis** hence can't be used.

Gadolinium is used in MRI, not in CT.

Gastrograffin is high osmolar contrast agent (ionic monomer).

Iohexol is low osmolar contrast agent (non ionic monomer).

Q. Which of the following test should always be done before administering **iodinated contrast** to a patient ?

- A. Liver function tests.
- B. Renal function tests.
- C. Sr. Electrolytes.
- D. C-Reactive protein.

60c6b3eaaa8ded0e4e7e5ea7

Side effect of iodinated contrast : **Contrast induced nephropathy** (renal toxicity).

**Renal function tests** need to be done beforehand to know if nephropathy is already present in the patient (as the iodinated contrast will also induce toxicity).

If renal failure present : Iodinated contrast is not injected.

Q. A patient presented with recurrent abdominal pain. Identify the investigation in this image :

- A. Barium swallow.
- B. Barium meal.
- C. Barium meal Follow Through.
- D. Barium Enema.



Explanation :

**Jejunal loops with feathery appearance** can be seen here.

**Featureless appearance of ileal loops** can be seen.



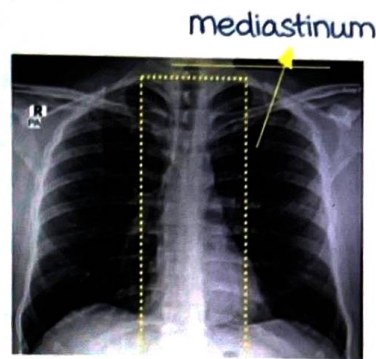
## Contrast medium

00:04:25

Agent used to enhance the appearance of any organ or tissue in the body.

Examples :

mediastinum can be seen in the given X-ray in the marked area.

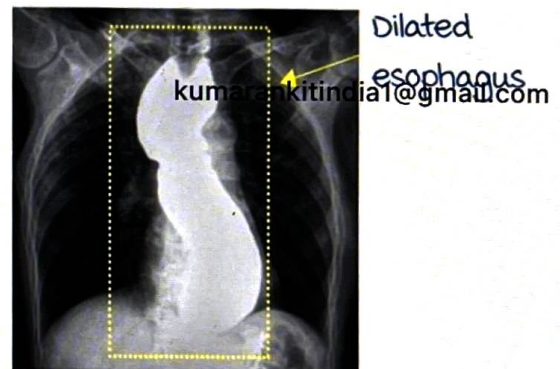


Chest Xray with no contrast

Esophagus cannot be separately seen from the mediastinum. Hence, the patient is given barium to be held in the mouth for better visualisation of the esophagus.

Another X-ray is taken as soon as the patient swallows the barium.

The dilated esophagus can be seen as the Lower Esophageal Sphincter (LES/LOS) is not relaxed. The swallowed barium is accumulated in the esophagus.



After Barium Swallow

Here, Barium is the contrast media used.

Abdominal X-ray showing bones and soft tissues requires a contrast media to help in visualising kidneys, ureters, urinary bladder.

Iodinated material is injected intravenously (IV) which travels to renal arteries gets filtered in the glomerulus → Renal tubules → Renal pelvis → ureters.

Another X-ray taken after 5-10 mins shows left side kidney, calyces, renal pelvis, ureter, urinary bladder.

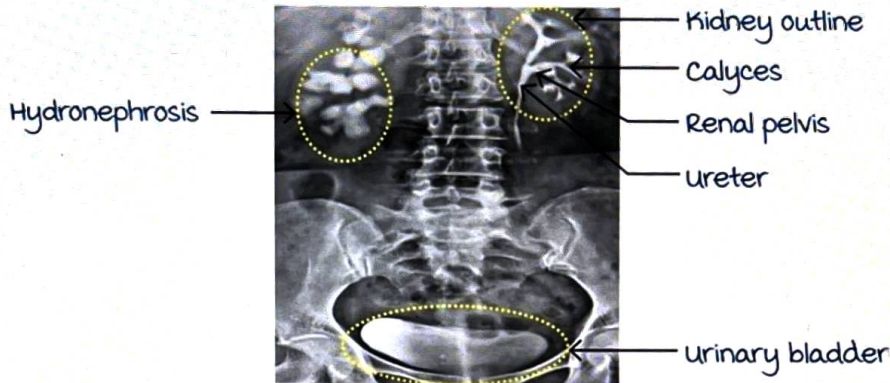
Right side of the image shows calyces that are dilated (kidneys may have been obstructed) called as hydronephrosis.

The iodinated agent is the contrast medium here.





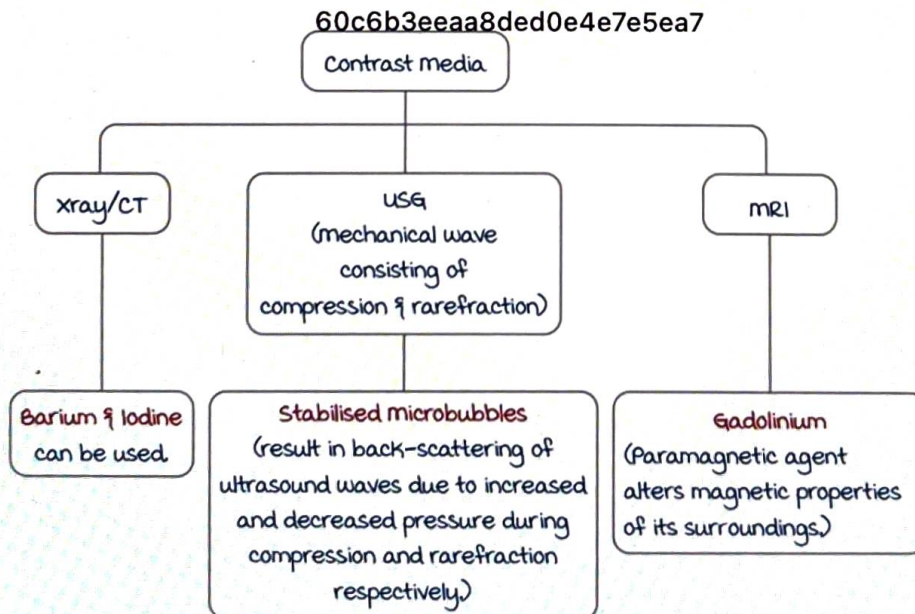
Abdominal xray without contrast



Iodinated agent used as contrast

**X-ray/ CT contrast media**

00:09:49



Positive contrast :

Bones appear white/bright on an x-ray (scapula, humerus, clavicle etc.) because they are dense and block more x-rays. Certain contrast media blocks more xrays than adjacent soft

Active space

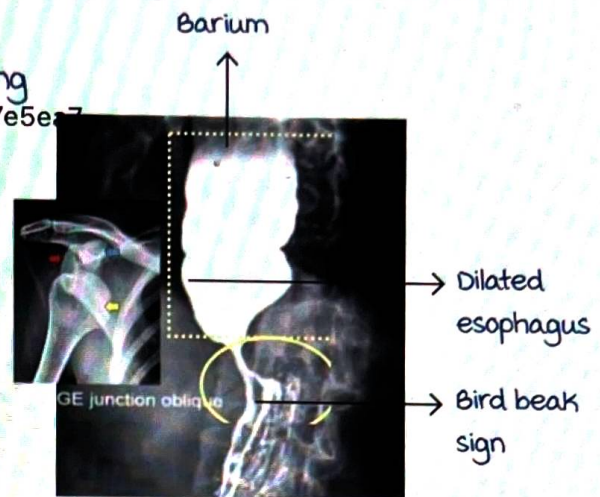


tissues → Appears **white** on X-rays → Positive contrast.  
(eg. Barium & Iodine).

Smooth, elongated tapering  
at the Lower esophageal

sphincter (LES) is called  
as **Bird beak sign**.

Bird beak sign is a  
feature of Achalasia  
cardia due to failure of  
dilation of LES.



Positive contrast : Barium  
swallow

Negative contrast :

Lungs appear **black** as they block less X-rays.

Contrast media blocking less X-rays than surrounding  
tissues → Appear **black/lucent**.

Negative Contrast (e.g. Air, water & mannitol).

A per rectal tube is  
passed into the  
rectum & air (negative  
contrast) is injected  
through the tube to  
distend the colon for  
better visibility of the  
colonic wall on a CT.



Negative Contrast

Water & mannitol are  
given to the patient to  
drink & the bowel loops are distended with fluid content  
making the colonic wall more visible.

## Barium

00:13:54

High atomic Number (56) : Blocks more X-rays, appears  
white.

used in form of  $\text{BaSO}_4$  (barium sulphate), **insoluble** in water.  
Therefore, the patient is given barium sulphate suspension  
(high/low density) to drink.



Barium is preferred in bowel studies because :

- **Inert** → No damage to bowel mucosa.  
→ No interference with digestion/absorption.
- **Not absorbed** from GI tract. Hence, **coats the bowel mucosa**.

used for bowel related studies :

- **Barium swallow** : Evaluation of **hypopharynx** (pyriform sinus, mass lesions etc.) → **Esophagus** → **GE junction**.

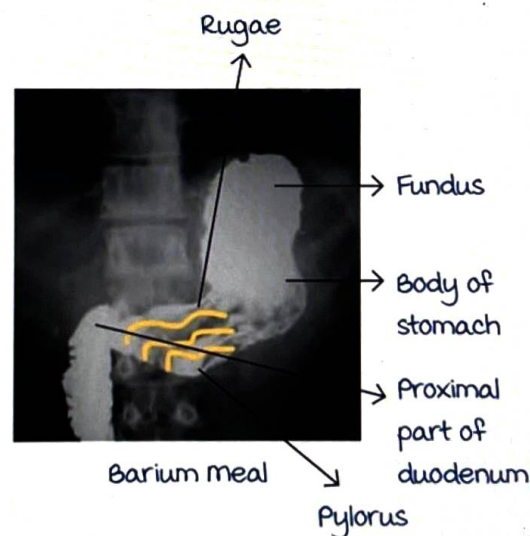
Lesions diagnosed by Barium swallow :

1. Pyriform fossa mass lesions.
2. Achalasia cardia.
3. Carcinoma esophagus.
4. Zenker's diverticulum.
5. Esophageal strictures/webs.
6. Hiatus hernia.

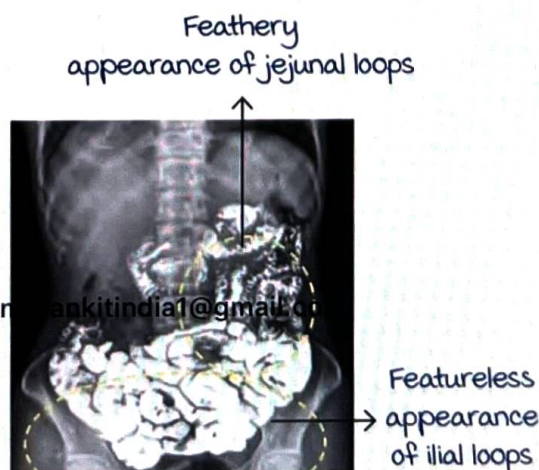
- **Barium meal** : Evaluation of **stomach** & **proximal duodenum**.

Lesions diagnosed by barium meal :

1. Peptic ulcer.
2. Ca stomach.
3. Pyloric stenosis.



- **Barium meal Follow Through (BMFT)** : Evaluation of the **small bowel (jejunum and ileum)** and **ileocecal junction**. Bowel loops appearing in upper left corner give a **feathery appearance** (peculiar of jejunal loops).





Small bowel loops (ileal) located in the central and lower abdomen appear in a **featureless fashion**.

Lesions diagnosed by BMFT :

1. malabsorption Syndromes.
2. Ileocecal TB.

• **Barium enema** is a **subleakage of the large bowel**.

Lesions diagnosed by barium enema :

1. Carcinoma colon.
2. Colonic polyps.
3. Colonic diverticuli.
4. ulcerative colitis.



Barium Enema

Contraindications :

- Absolute : **Bowel perforation/ leak** as barium only remains inert inside the bowel cavity → causes chemical peritonitis/mediastinitis (very severe), if leaked out.
- Relative :
  1. Intestinal Obstruction (risk of perforation).
  2. Tracheo-esophageal fistulas.
  3. Recto-vaginal fistulas.
  4. Recto-vesical fistulas.
  5. Known case of hypersensitivity reaction to Barium.

Q. **Water soluble contrast material** is ?

- A. High density barium.
- B. Iodine.
- C. Low density barium.
- D. Calcium.

Explanation :

Barium is insoluble in water.

Calcium is also insoluble in water.



## Iodinated contrast

00:25:24

High atomic Number (53) : Blocks more X-rays → Appears white.

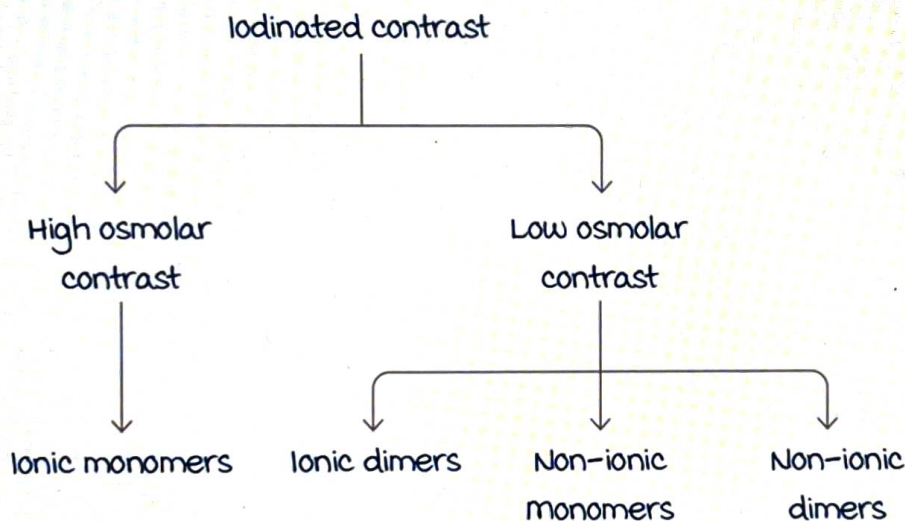
$\frac{\text{Iodine}}{\text{Particle}}$  ratio (I : P) → Higher the ratio, better the contrast.

High Iodine (numerator) means high attenuation of X ray beam → more white appearance.

Particle (denominator) → Osmotically active particle.

Ideal : Low osmolarity / equal to human serum osmolarity (Normal : 290-300 mOsm/kg).

High osmolarity particles cause high toxicity in the body.



High osmolar ionic monomers (1200 mOsmol) :

Examples :

1. Na/meglumine salts of diatrizoic acid.
2. Trazograff/uro-Gastro-Angigraffin.
3. urovision/urovideo.

I : P Ratio : 3 : 2. Not a good ratio.

Peculiarity : Contraindicated for use in myelography.

Low osmolar ionic dimers (600 mOsm) :

Examples :

1. Ioxaglic acid.
2. Iocarmic acid.

I : P Ratio : 6 : 2 (better ratio).

Peculiarity : Safer.

Non ionic monomers (600 mOsm) :



Examples :

1. Amipaque.
2. Iohexol/Omnipaque. (m/c used contrast agent).
3. Iolamidol.
4. Ioversol.
5. Iopromide.

I : P Ratio : 3 : 1 (good ratio).

Peculiarity : m/c used subtype overall.

Non-ionic dimers (300 mOsm) : (AKA Iso-osmolar contrast as similar to human serum osmolarity).

Examples :

1. Iotrol.
2. Iotrolan.
3. Iodixanol.

I : P Ratio : 6 : 1 (highest / best ratio).

Peculiarity : Theoretically safest. High cost.

Clinical insights :

I : P Ratio :

Lowest/worst → Ionic monomers (3 : 2).

Highest/best → Non-Ionic Dimers (6 : 1).

m/c used subtype of Iodinated contrast : Non Ionic monomers.

m/c used individual iodinated contrast medium : Iohexol/Omnipaque.

Iso-osmolar iodinated contrast subtype → Non ionic dimers.

Theoretically safest contrast subtype → Non ionic dimers.

kumaraakitindia1@gmail.com

## Iodinated contrast : Adverse effects

00:39:26

- Hyperosmolarity related : more with high osmolarity agents like ionic monomers, least with iso-osmolar agents like non ionic dimers .
- Chemotoxicity related (related to chemical structure , dose and infusion rate) :
  1. Contrast Induced Nephrotoxicity (CIN).
  2. Hyperthyroidism.
  3. Vasovagal reactions.



CIN → Diagnostic criteria :

Renal function impairment measured by **serum creatinine** (marker for CIN).

1. Increase by **25%**.
2. Absolute increase by **0.5 mg/dL**.
3. Within **48-72 hours** of IV contrast injection.

mechanism of action of chemotoxicity :

1. Direct toxicity of PCT cells.
2. Free radical injury.
3. Vasoconstriction by kidney.

markers of CIN :

1. Serum creatinine.
2. Serum cystatin C.
3. eGFR (estimated Glomerular Filtration Rate) : **<60 mL/min**.
4. **plasma NGAL** ( Neutrophil Gelatinase Associated Lipocalin) → **early predictive biomarker**.

Risk factors :

1. **Deranged Renal Function Tests**.
2. Diabetes mellitus.
3. Elderly age/metabolic syndrome/multiple myeloma.
4. Dehydration.

Single most important patient related risk factor for CIN :

**Pre-existing Chronic kidney disease (CKD)**.

management :

1. Supportive IV fluids & electrolytes.
2. Haemodialysis.

Prevention :

1. Do a pre-contrast RFT.
2. Pre-contrast hydration is required.
3. Low osmolar/iso-osmolar agents can be used.
4. N-Acetyl cysteine (renoprotective) can be used.
5. Bicarbonate therapy.
6. Statins.
7. Vitamin C (free radical scavenger).



Other adverse effects of iodinated agents :

- Anaphylactic & Anaphylactoid reactions.
- Hypersensitivity / Idiosyncratic (independent of dose and infusion rate).

Contraindications :

- Renal impairment.
- Hyperthyroidism.
- Patient on radioactive iodine treatment.
- Patient underwent I-123 based radionuclide scan.

## Ultrasound contrast agents

00:50:22

microscopic gas bubbles :

mechanism : Backscattering of USG beam results in enhancement of various organs.

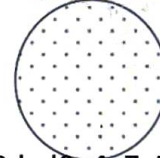
1<sup>st</sup> Generation → Gas : Air.

Shell : None.

Short lived (get disintegrated fast).

Used in large vessels.

1<sup>st</sup> Generation



60c6b3eeaa8ded0e4e7e5ea7

2<sup>nd</sup> Generation



2<sup>nd</sup> generation → Gas : Air.

Shell : Protein.

medium range of durability.

3<sup>rd</sup> generation → Gas : Nitrogen/  
perfluorocarbons/sulphur fluoride.

Shell : Protein/lipid/ polymer.

Stable and long lasting.

3<sup>rd</sup> Generation



Increased stability

excreted through Lungs → Safe in renal failure.

Types :

- Tissue specific : used for lungs , spleen , pancreas.
  1. Levovist.
  2. Sonovist.
  3. SonoZoid.
- vascular (short lived) :
  1. Albunex.
  2. Infosan.



## MRI Contrast agents

00:54:05

	T1 relaxation agents	T2 relaxation agents
Appearance	Bright on T1W	Dark on T2W
Examples	Gadolinium/Gd (m/c contrast used in MRI)	SPIO (Super Para-magnetic Iron Oxide)

SPIO is usually taken by cells of **reticulo endothelial system** (Liver: Kupffer cells) to diagnose **Focal Nodular Hyperplasia (FNH)**.

Hepatocyte specific contrast agents:

- Gd - manganese DPDP.
- mangafodipir trisodium.
- Gd - BOPTA.
- Gd - EOB-DTPA.

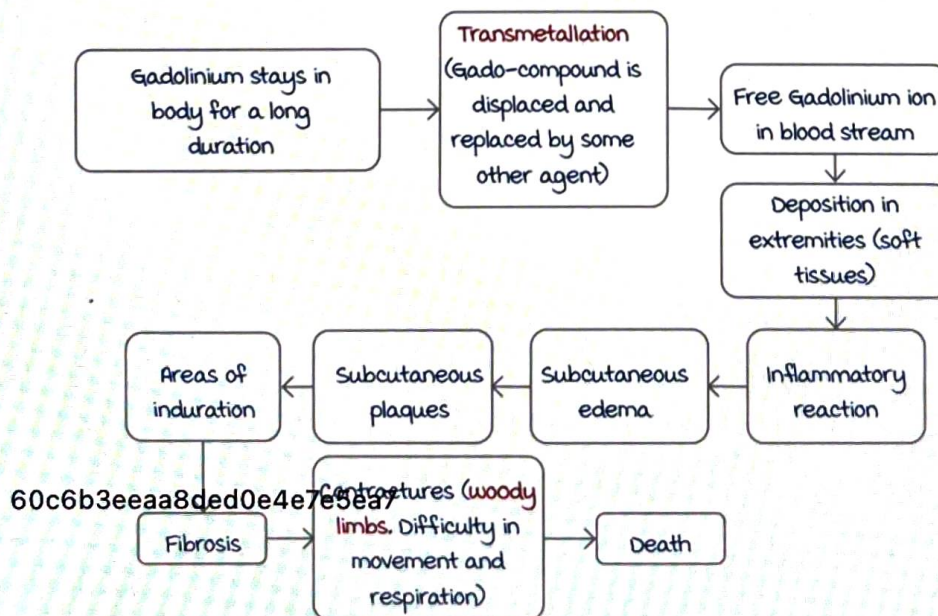
Adverse effects:

**Nephrogenic Systemic Fibrosis (NSF):**

Seen with:

1. Omniscan/Gadodiamide: m/c association with NSF → Banned.
2. magnevist/Gadopentetate dimeglumine: 2<sup>nd</sup> m/c.
3. Optimark/Gadoversetamide.

Risk factors: Renal failure.



Active space



## USG INTERPRETATION MODULE

The reflection of the pulse of the USG beam is what creates the echo. If the amplitude of the echo is low, then **low brightness** is seen on B mode (B : Brightness).

Low amplitude : **Hypoechoic** (low brightness).

Intermediate amplitude : **Isoechoic** (grey).

High amplitude : **Hyperechoic** (high brightness).

Amplitude is determined by the number of reflected waves. This reflection is determined by difference in acoustic impedance of 2 tissues/interfaces. Acoustic impedance is determined by the **difference in densities** between the 2 tissues.

Consider 2 tissues, T1 and T2 with densities D1 and D2 respectively. Waves hitting the interface between the 2 tissues can either transmit ahead or can get reflected back. The higher the difference in densities between the tissues, the **greater the reflection** occurs as echo.

If the reflection is less, then its **hypoechoic**.

If the reflection/amplitude of the returning wave is very high, then the area appears as **hyperechoic**.

Why is USG gel used ?

This is used to eliminate the air gap between the probe and the skin so that the waves do not get reflected at the level of the skin and can easily transmit across the skin.

i.e., to **eliminate the difference in densities** between skin, air and the probe surface, thereby preventing reflection of waves at the level of skin.

Using a gel, the density of the skin surface and the probe remain similar.



Gel consists of :

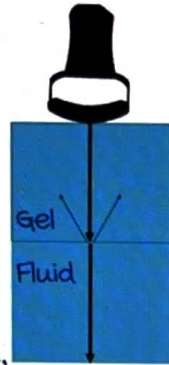
- Polyethylene glycol.
- Glycerin.
- Phenoxyethanol and polyacrylamide gel.

## Various tissues and their appearance on USG

00:10:12

- **Distended urinary bladder :**

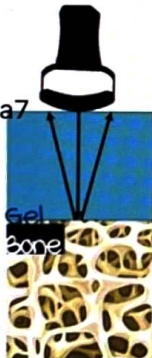
Since the gel and the urine are fluids, they have similar densities. This allows the waves to transmit/pass through the body without much resistance,



therefore less reflected waves are seen (low amplitude).  
i.e., Fluid containing structures appear hypoechoic.

- **Bone/stones :**

Because of a large change in density between the bone and gel applied, there will be maximal (nearly 100%) reflection of waves and hence a



hyperechoic (high amplitude waves) area is seen.

As the waves cannot get transmitted beyond bone/stone, the structures behind it appear black (known as posterior shadow).

Thus, bone appears hyperechoic with posterior shadow.

- **Air :**

There exists a large difference in densities between air and gel, therefore very high reflection of the waves



are seen. The amplitude of the returning echoes will be

Active space



very high, therefore the area would appear as **hyperechoic** (white).

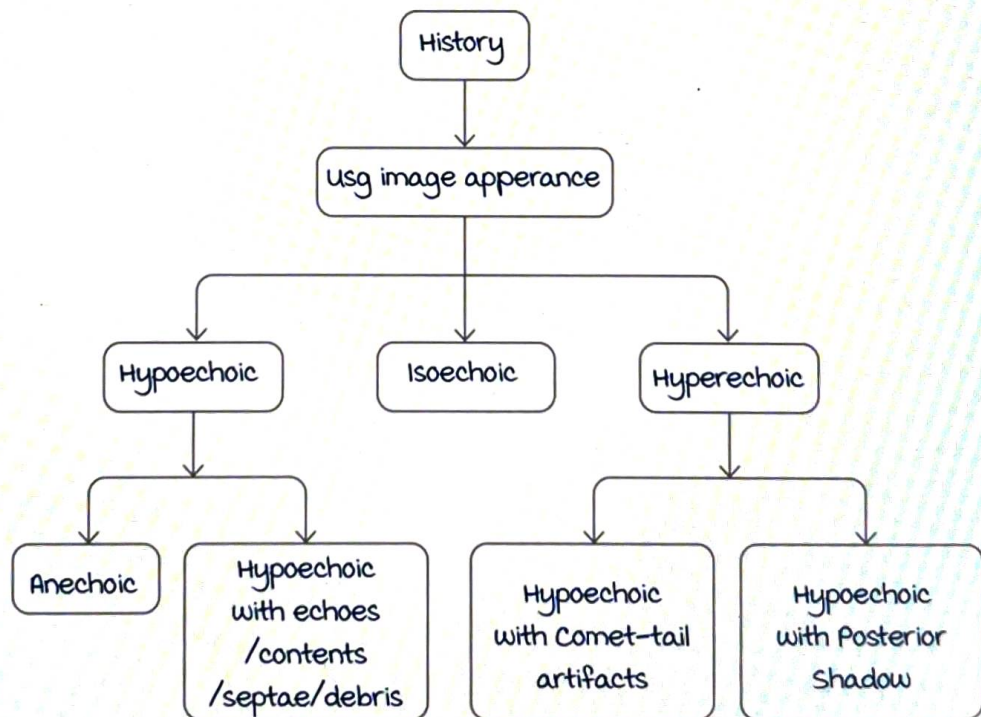
These white areas appear like comet tails/white striped appearance, known as reverberation artifacts.

Fluid	Hypoechoic
Bone/calculus	Hyperechoic with posterior shadow
Air	Hyperechoic with comet tail artifacts

### USG interpretation protocol

00:17:50

- Always understand the history of the patient prior to viewing the USG image.
- Understand which organ is being viewed and identify the hyper or hypoechoic areas.



• **Anechoic**: Appears jet black, seen with clear fluid like urinary bladder (urine appears anechoic), gallbladder, CSF, any simple cyst.

• **Hypoechoic**: Seen in structures having turbid fluid content. Example: Cystitis, cholecystitis, abscess, hemorrhagic/ endometriotic ovarian cyst/hydatid cyst.

• **Isoechoic**: most of the solid organs are isoechoic.



• **Hyperechoic :**

With comet tail : Air/Air filled spaces, like lungs.

With posterior shadow : Bone/stone.

60c6b3eaaa8ded0e4e7e5ea7

Examples of anechoic findings :



Cases :

1. A 35 year old male with incidentally detected clear fluid filled structure in the liver. Asymptomatic.

Ans : Indicative of simple cyst.



2. A 45 year old with incidentally detected clear fluid containing (anechoic) structure in the kidney.

Ans : Suggestive of simple renal cyst.

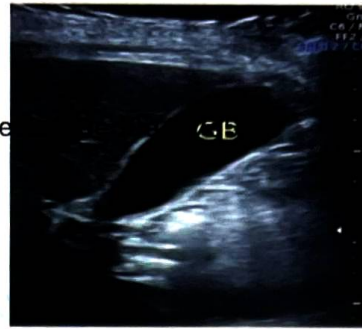


Active space



Normal gall bladder appears anechoic.

60c6b3e



3. A 25 year old female with irregular menses but no pain.

USG : Anechoic jet black structure seen in the right ovary.

Ans :

Suggestive of simple ovarian cyst.

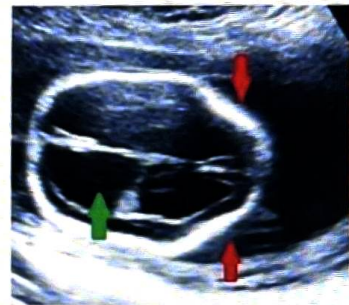


4. Antenatal ultrasound of 24 weeks fetus with lumbar meningocele.

Ans. Lemon shaped fetal skull with dilated ventricles seen.

Suggestive of hydrocephalus.

Typical of Arnold Chiari malformation.

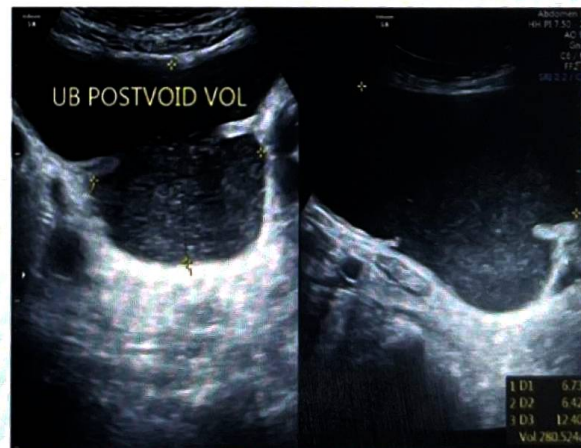


Examples of turbid hypoechoic structures :

5. A 49 year old female with chills, burning & pain during micturition.

Thickened bladder wall with trabeculations along the wall and turbid fluid in it.

Ans : A case of infected urinary bladder or cystitis.





6. A 32 year old man with high grade fever, elevated TLC, pain in RUQ of abdomen. Liver with hypoechoic lesion containing thick internal echoes.



Ans : Indicates infected collection filled with pus. Likely to be a liver abscess.

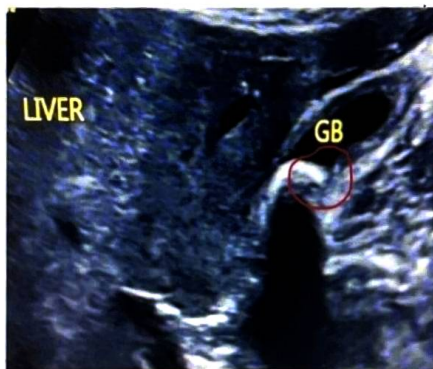
7. A 35 year old female with pain right lower abdomen.



A hypoechoic turbid cyst seen with multiple septae and turbid fluid seen.

Ans : Left ovarian hemorrhagic cyst.

8. A 42 year old obese female with RUQ intermittent mild pain.



USG : Shows a hyperechoic area with posterior shadow.

Ans : Gallbladder calculus.  
 kumarankitindia1@gmail.com

9. A 42 year old obese female with severe acute RUQ pain. Sonographic murphy's sign +



Ans. Acute cholecystitis showing thickened and edematous gallbladder walls with a gall bladder calculus. Turbid bile is seen.

IOC for gall bladder calculi and acute cholecystitis : USG (as biliary calculi have low calcium content).

IOC for renal or ureteric calculi : NC CT.

Active space



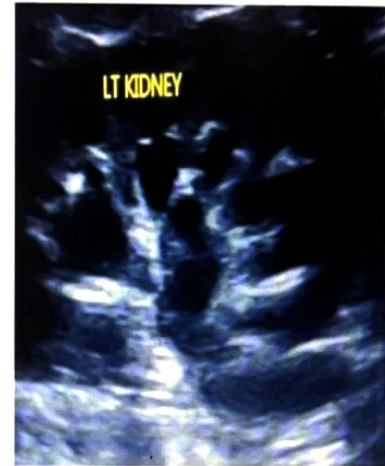
10. A 27 year old male with intermittent severe left lumbar region pain.

Ans. Hyperechoic with posterior shadow seen in left kidney, indicating left renal calculus.



11. A 27 year old male with acute severe left lumbar region pain radiating from loin to groin. Pain/difficulty during micturition.

Ans. Lots of anechoic jet black structures in medulla indicates dilated calyces : Hydronephrosis.



12. A 22 year old male with acute severe RIF pain with tenderness at mc Burney's point.

USG : Blind ended tubular structure.

Ans : Acute appendicitis.



IOC for acute appendicitis in children : USG (CT avoided due to risk of large radiation exposure).

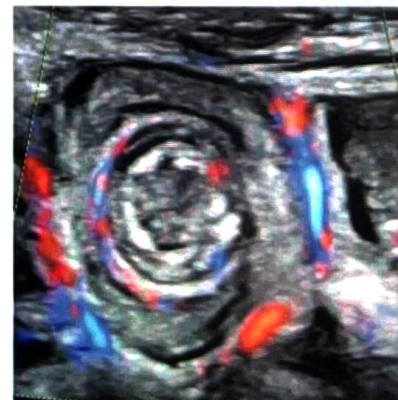
IOC for acute appendicitis in adults : CECT

13. A 4 year old male child with pain in abdomen and red currant jelly stools.

Intussusception : Showing donut sign or target sign or bull's eye appearance.

(bowel within bowel)

IOC for intussusception in children : USG (CT avoided due to radiation exposure).





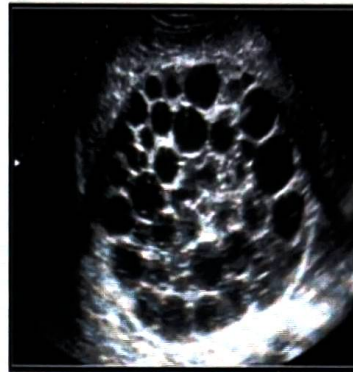
IOC for intussusception in adults : CECT (as intussusception occurs due to tumour/neoplasm for which CT is better).

14. A 25 year old adult with abdominal discomfort and fullness.

O/E : Hepatomegaly.

Ans. No signs of sepsis.

Liver shows big anechoic cyst with multiple daughter cysts. Honey comb appearance of a hydatid cyst in liver.



60c6b3eaa8ded0e4e7e5ea7

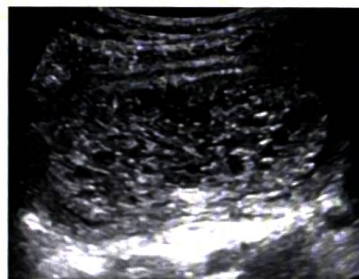
15. A 65 year old adult male who is smoker with complaints of gross painless hematuria.

Ans. Solid isoechoic structure on lateral bladder wall, suggestive of soft tissue mass lesion, likely to be bladder mass (?neoplastic) → Cystoscopy → Biopsy.



16. A 22 year old female with abdominal distension, vomiting urinary pregnancy test positive.

Ans. mixed hyperechoic appearance with multiple cysts, this appearance is known as snowstorm appearance indicating molar pregnancy or hydatidiform tumor.



17. A 2 year old female child with recurrent UTI.

Ans. Anechoic cyst in bladder wall close to where ureter opens into the bladder. suggestive of ureterocele.



Active space

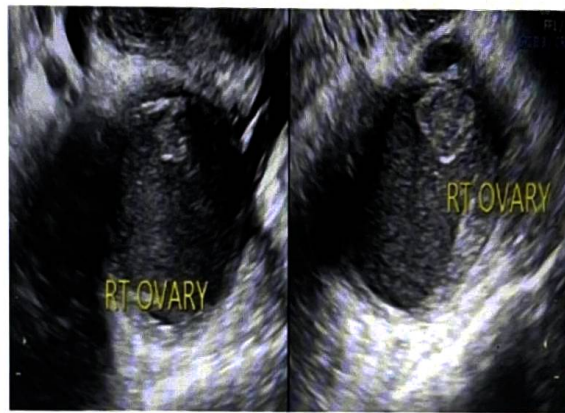


On Intravenous urography (IVU), ureterocolic is seen to have cobrahead appearance or adderhead appearance or spring onion appearance.



18. A 34 year old female, operated case of endometriosis. Not on any treatment with complaints of pain during menses + lower abdomen discomfort.

kumarankitindia1@gmail.com



Ans. Hypoechoic structure in ovary with thick internal echoes. Endometriotic cyst or chocolate cyst within the ovary containing blood



# CT INTERPRETATION MODULE

## CT – basics

00:03:00

Imaging planes :

CT is an **axial** mode of modality.

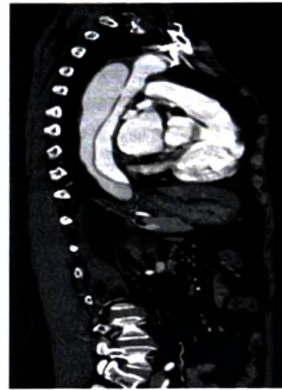
It is **reconstructed** in coronal and sagittal planes.



Axial



Coronal



Sagittal

CT convention for left vs right :



Right

Left



00c67eeaa8ded0e4e7e5ea7

For convention it is assumed that the observer is standing from the **foot end** of the CT machine and seeing from the **inferior aspect**. Side of the CT image is assigned accordingly.

## CT basics : Pre vs post contrast images

00:05:38

Contrast material : Iodinated contrast (MC : Iohexol).

A **positive** contrast, blocks more X-rays hence appears **white**.

Active space



Appearance of the blood vessels :

Look for aorta : Infront of the vertebrae slightly to the left.



Blood vessel is isodense :  
Pre-Contrast



Blood vessel is hyperdense :  
Post-Contrast

### CT : Windowing

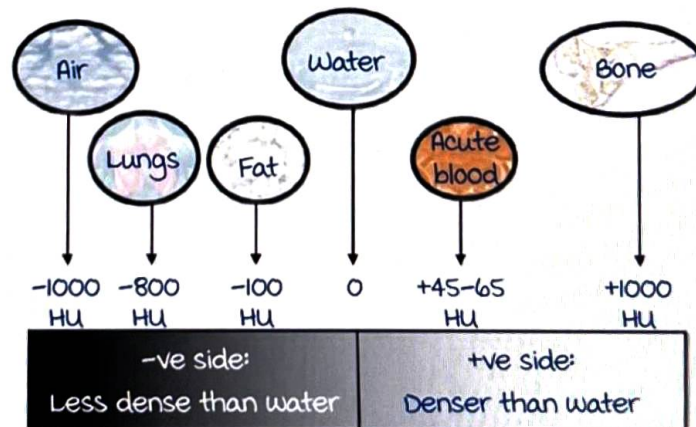
00:08:52

Based on Hounsfield unit scale.

Total Hounsfield values : 2000.

means 2000 shades of grey are present.

Human eye is unable to differentiate 2000 shades of grey. Instead of using the entire 2000 shades it is divided into different windows.



Windowing is post processing image contrast so that we are enabled to overcome the limitations of human visual system.

**Brain window :**

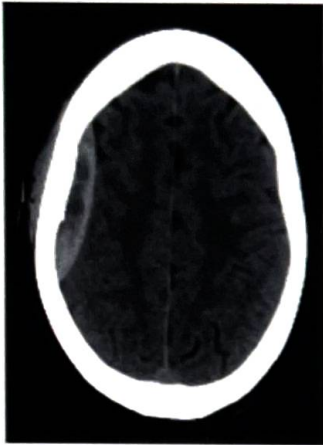
To find out a hemorrhage in brain, we use a window between 0 to 100 (as blood is 45 to 65) where 0 appears jet black. 100 appears bright white.



Here brain tissue and blood are visible.  
Bone is not visible, it is out of window (+1000).

Bone window :

A new window of contrast is selected between 100 to 1000.  
In this image brain is out of window, hence not visible.



Brain window



Bone window

Windowing is also used in thorax

mediastinal structures : 0 to 100.

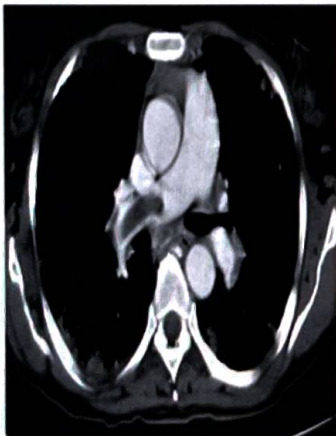
mediastinal and chest wall structures are visible.

Lung parenchyma is not visible.

Lung window : -800 to -700.

Lung parenchyma is visualized.

mediastinum and chest wall structures are not visualized.



mediastinal window



Lung window



## Density

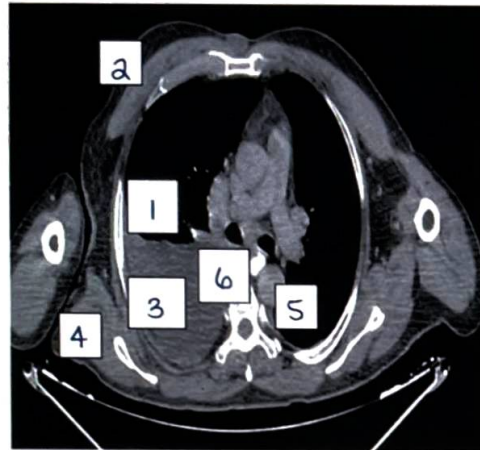
00:15:10

Density is the property of the tissue that determines its appearance on CT scan.

Black : Hypodense.

Grey : Isodense.

White : Hyperdense.



1 = Air

2 = Fat

3 = Water

4 = Soft tissue

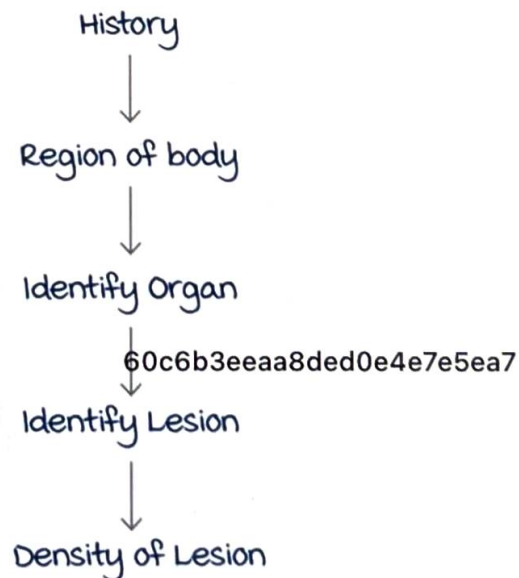
5 = Iodinated contrast

6 = Bone

## Body CT interpretation protocol

00:19:40

History : Gives clue for diagnosis.

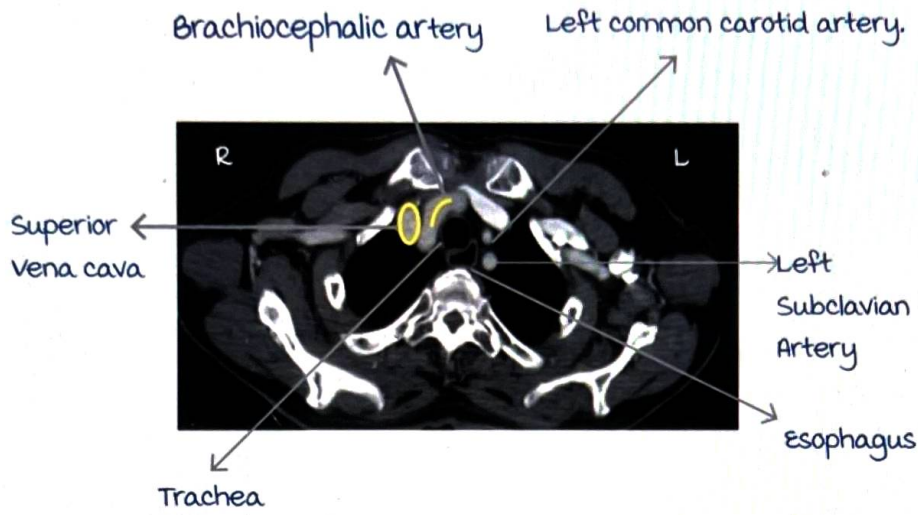


## Normal organ identification

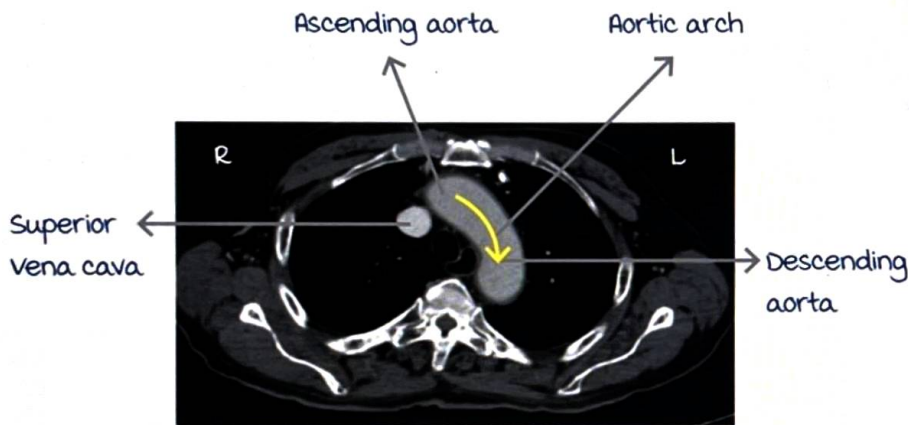
00:22:30

Thorax : mediastinal window.

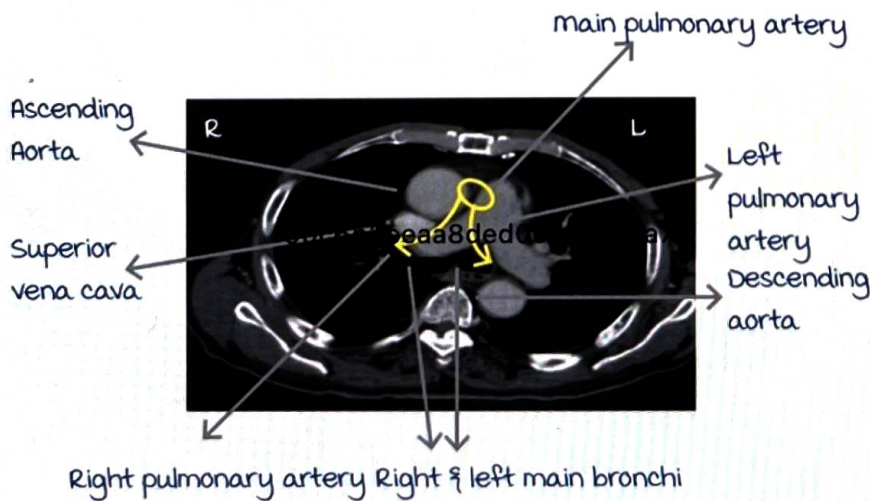




Thorax : At the level of aortic arch.



Thorax : Below level of aortic arch.

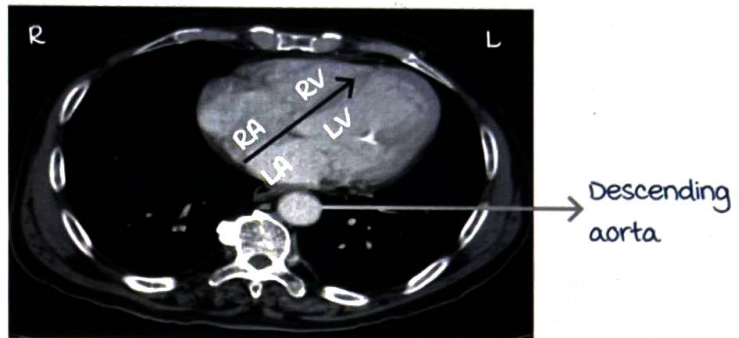


Active space

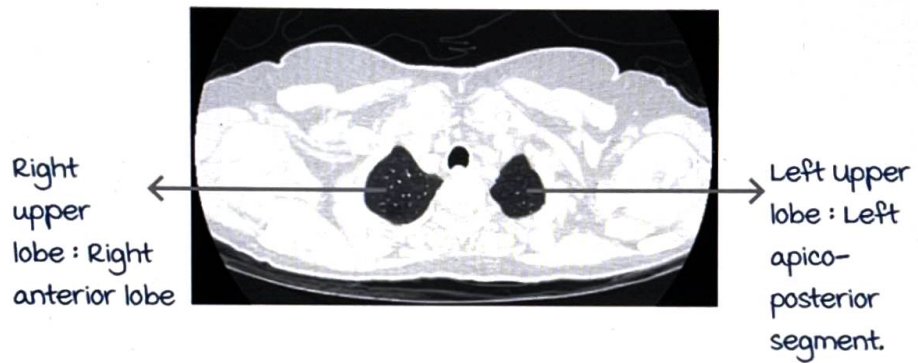


Thorax : At level of heart.

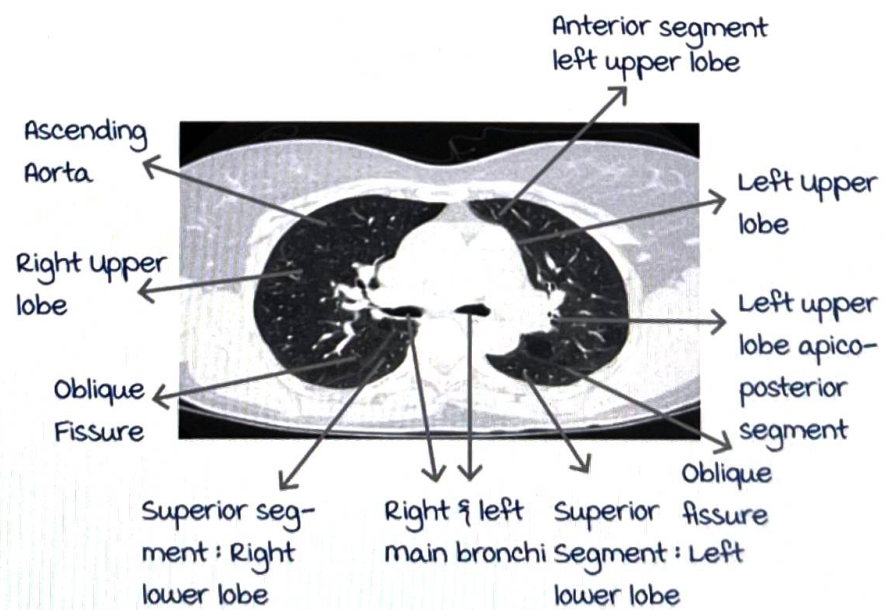
mediastinal window :



Thorax-lung window :



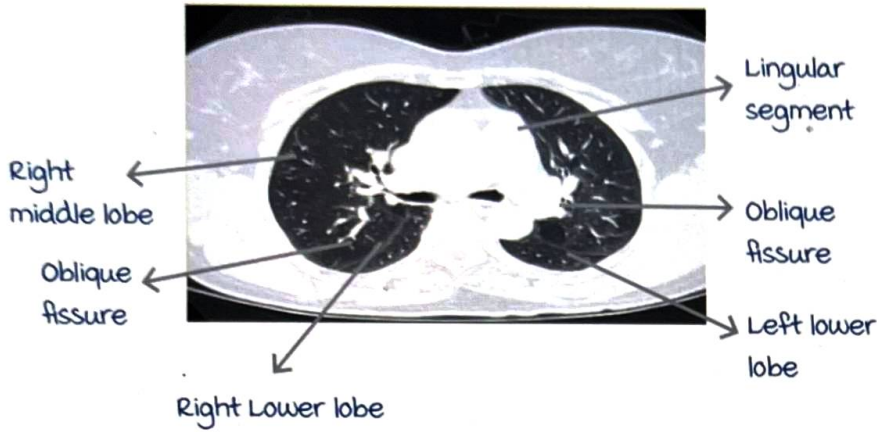
60c6b3eaa8de7047e5ea7



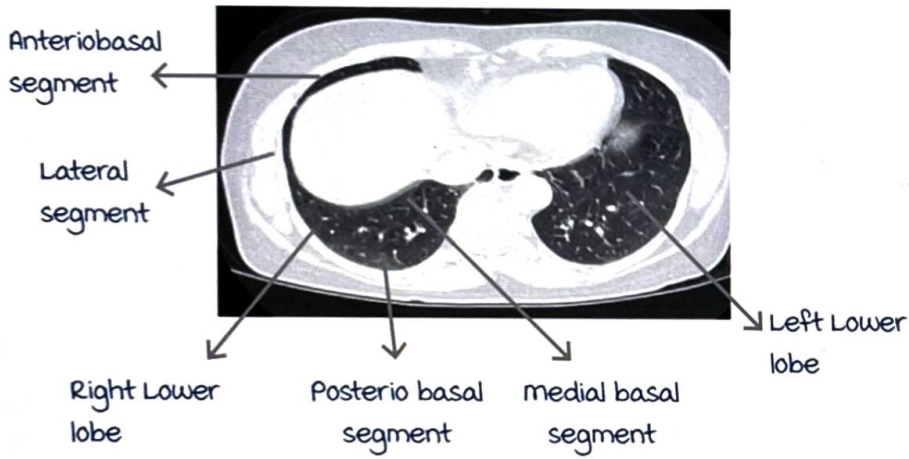
Active space



Thorax : At level of heart.



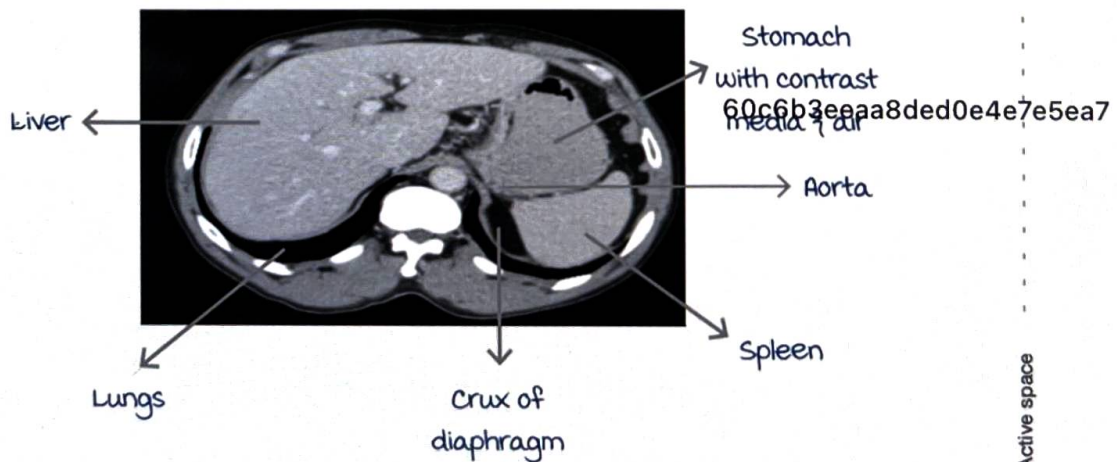
Thorax :



Abdomen

00:29:26

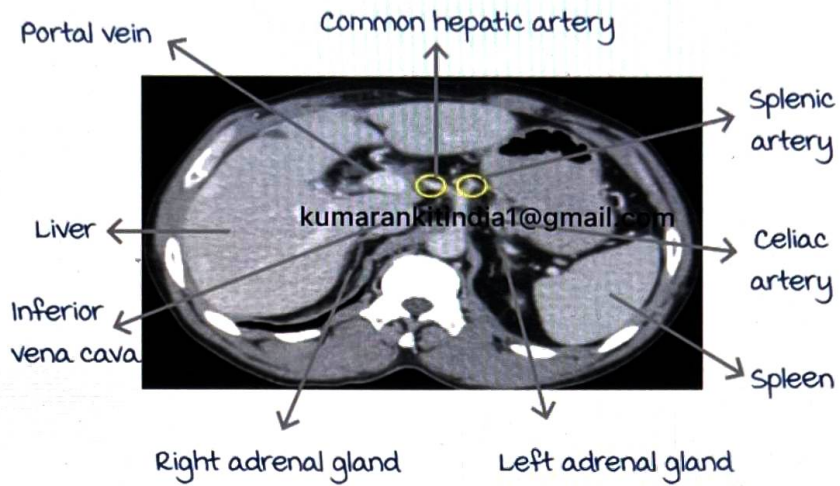
Abdomen :



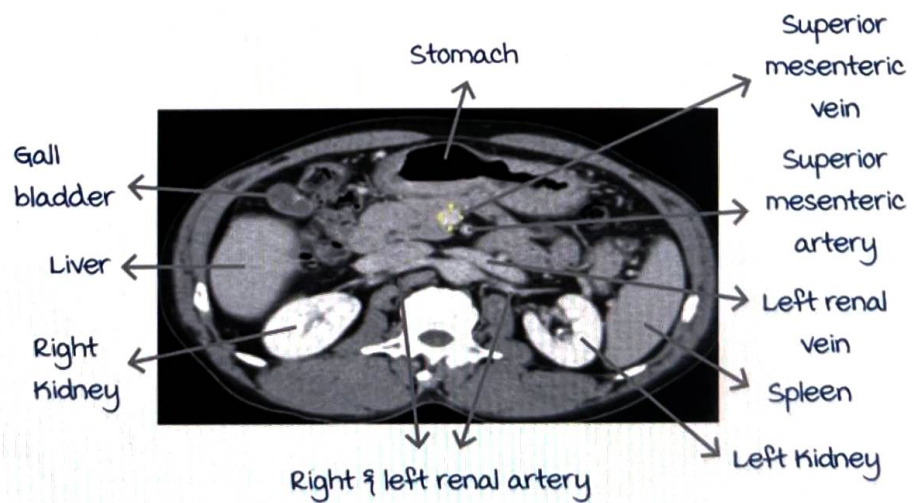
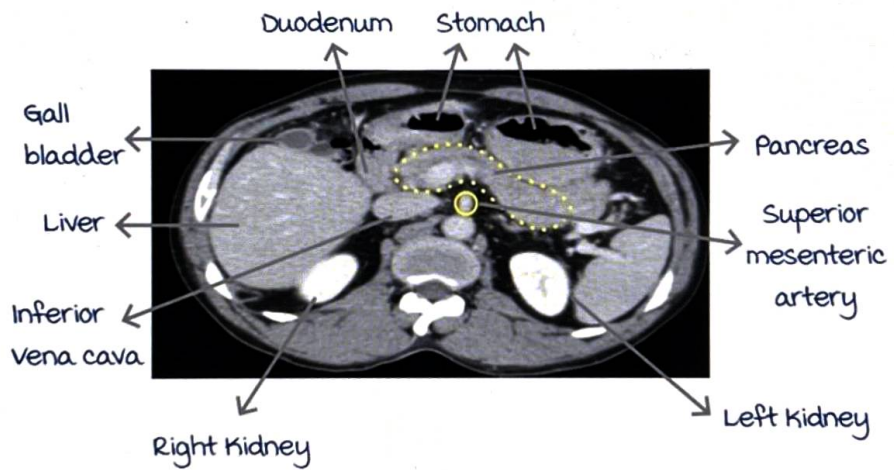
Active space



Abdomen :

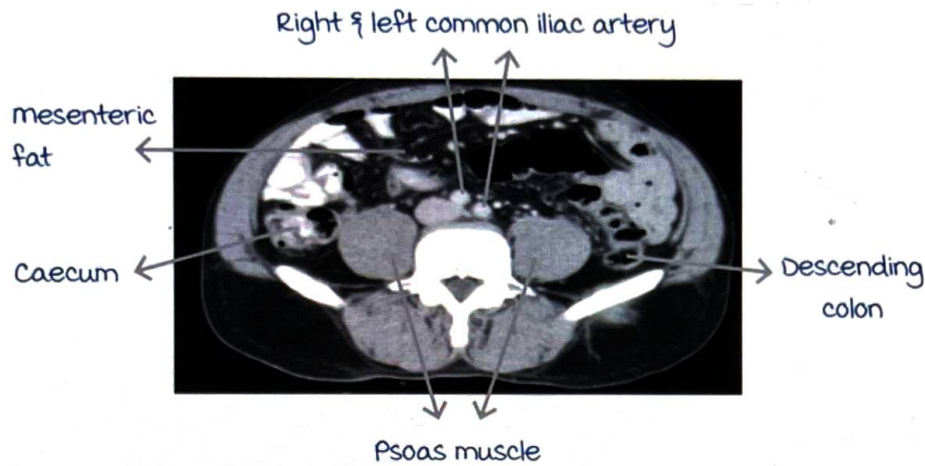


Abdomen :

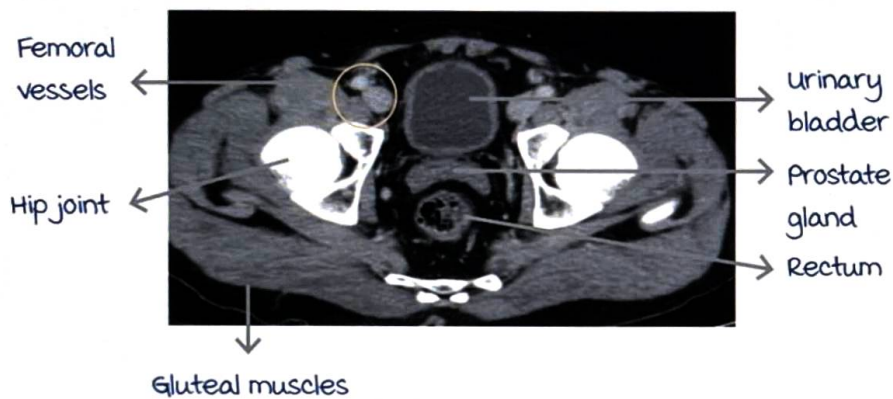


Active space





male :



### Clinical scenarios

00:36:50

History :

middle aged male.

Incidentally detected.

Region : Abdomen.

Organ : Liver, spleen.

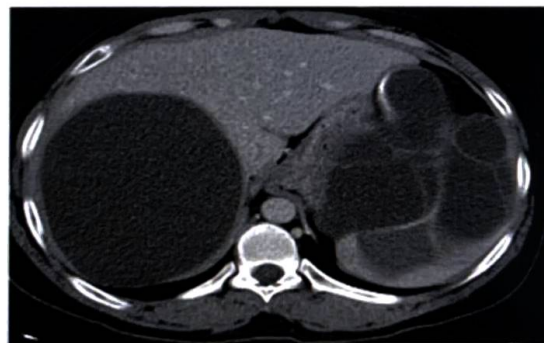
Lesion :

Density : more than

fat, less than air →

water : cyst.

Diagnosis : Simple cyst.



History :

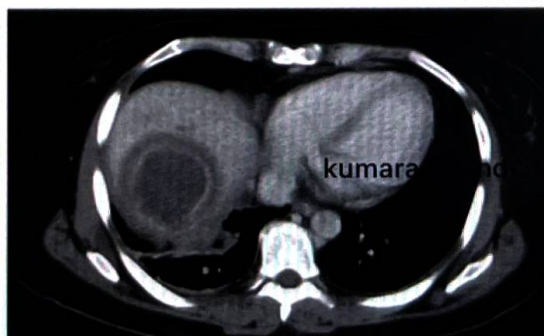
35 Yr old male.

Fever spikes +

elevated counts. Pain in

right hypochondrium

+/- jaundice.



Active space

kumara...@gmail.com



Liver infection.

Region : Upper abdomen.

Organ : Liver.

Density : Water.

Ring enhancement.

Diagnosis : Liver abscess.

History :

32 Year male.

Abdominal discomfort.

mild pain (no sepsis).

Region : Abdomen.

Organ : Liver.

Lesion density : water.

Ring enhancement  
with floating membrane.

Diagnosis : Hydatid cyst.



History :

58 Yr old male.

Chronic alcoholic with  
liver parenchymal  
Disease. (Cirrhosis).

Hep-B positive.

Jaundice.

Elevated alpha-

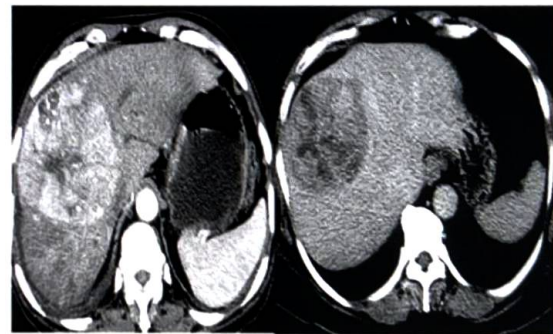
Feto-protein (tumor marker).

Region, organ : Abdomen, liver.

Lesion - density : Diffuse enhancement in arterial phase.

In delayed phase, tumor appears dark : Washout of contrast.

Diagnosis : Hepatocellular carcinoma / Hcc.



### Clinical scenarios

00:45:08

History :

- 25 Yr old male.
- No known illness.
- Large arterially enhancing liver mass lesion with a central calcified stellate scar.



- Normal Alpha-Fetoprotein.
- Elevated Neurotensin-B.

Region : Abdomen.

Organ : Liver.

Diagnosis :

Fibrolamellar Hcc.

History :

- 65 Yr old male.
- O/C/O CA colon On follow-up.
- Anorexia, Generalized Weakness.
- Jaundice.

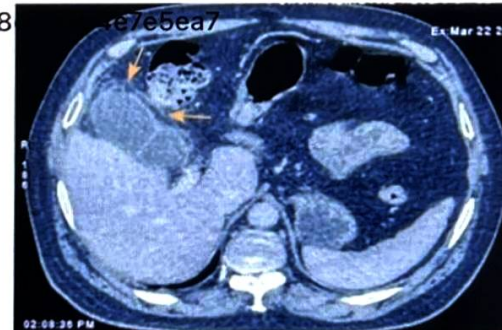
Region : Abdomen.

Organ : Liver.

Diagnosis : Liver metastasis.

History :

- 42 yr old female.
- Severe RHQ pain. (Acute).
- Fever & elevated counts (infection).
- murphy sign Positive.



Region : Abdomen.

Organ : Gall bladder.

Diagnosis : Acute cholecystitis.

History :

- 55 Yr old male.
- Chronic alcoholic.
- Epigastric pain with radiation to back.



- Guarding epigastrium.
- Elevated serum Amylase/Lipase.

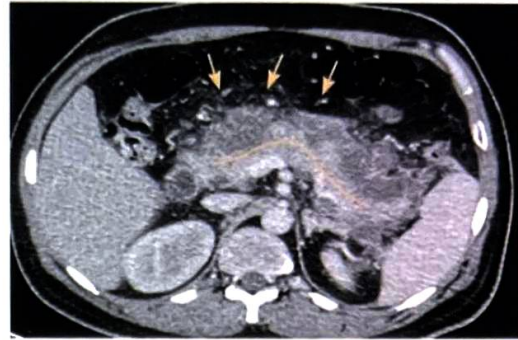
Region : Abdomen.

Organ : Pancreas.

Density : water (fluid).

Hazy mesentery of fat.

Diagnosis : Acute pancreatitis.



History :

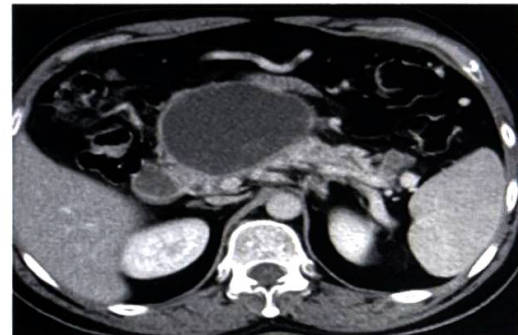
- 55 Yr old male
- K/c/o acute pancreatitis 2 months back.
- Abdominal fullness.
- Vomiting, mild pain in epigastrium.

Region : Abdomen.

Organ : Pancreas.

Density : Water.

Diagnosis : Pancreatic pseudocyst.



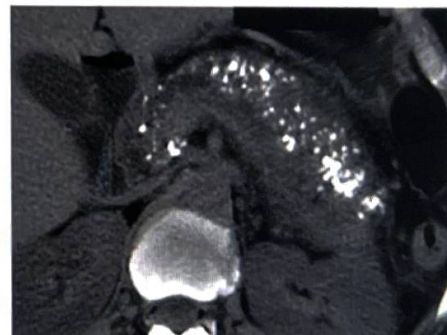
History :

- 65 Yr old male.
- H/o multiple admissions for acute pancreatitis.
- Abdominal discomfort.

Region : Abdomen.  
60c6b3eeaa8ded0e4e7e5ea7  
Organ : Pancreas.

Lesion : Multiple small hyperdense areas.

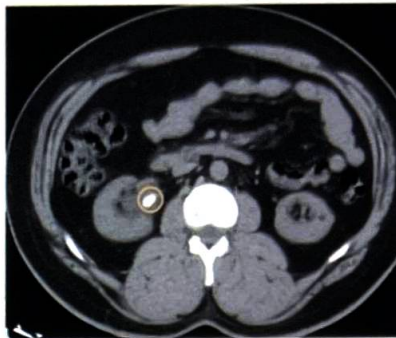
Diagnosis : Chronic calcific pancreatitis.





## History :

- 32 Yr old female.
- Acute right lumbar region pain.
- Burning micturition.



Region : Abdomen.

Organ : Kidney.

Lesion : Hyperdense.

Diagnosis : Right renal calculus.

## History :

- 32 Yr old female.
- Acute right lumbar region pain.
- Burning micturition.
- Fever and elevated counts.



Renal calculi + infection.

Region : Abdomen.

Organ : Kidney.

Lesion : Hyperdense.

Diagnosis : Right renal calculus + hydronephrosis +  
Pyelonephrosis.

## History :

- 65 Yr old male.
- Painless hematuria.

? urinary tract tumor.



Region : Abdomen.

Organ : Kidney.

Lesion : Heterogeneously  
enhanced right kidney. (Post  
contrast).

Invaded to inferior venacava.

Diagnosis : Renal cell cancer.



## Clinical scenarios

00:55:25

History :

- 45 Yr old male.
- Bosniak type 3 cyst.
- Otherwise asymptomatic.

? Renal mass

Region : Abdomen.

Organ : Kidney.

Density : Fat.

Diagnosis : Renal angiomyolipoma.

History :

- 65 Yr male.
- Chronic smoker.
- Painless hematuria.

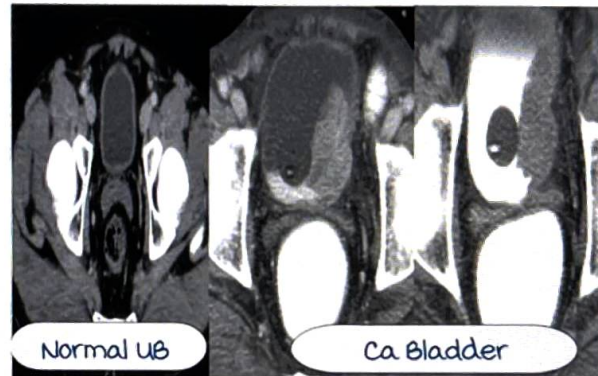
? Tumor

Region : Pelvis.

Organ : Urinary bladder.

Lesion : Soft tissue density (growth).

Diagnosis : Carcinoma bladder.



History :

- 55 Yr old male.
- Known alcoholic.
- Abdominal distension.

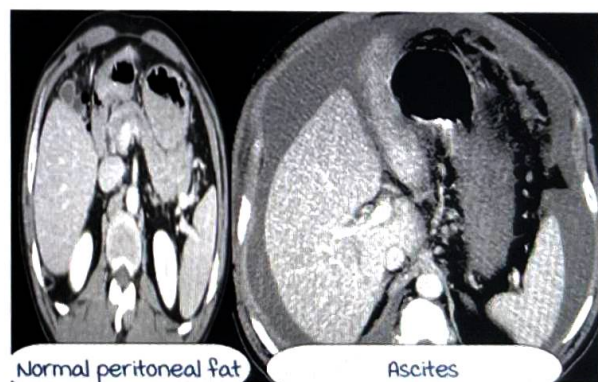
? Ascites.

Region : Abdomen.

Organ : Peritoneum.

Lesion : Fluid in peritoneal cavity.

Diagnosis : Ascites.



History :

- 15 Yr old male.





- H/o spinal TB.
- Low grade fever, dull backache & persistent Flexion of the left hip joint.
- Hip joint motion was limited & painful.

Region : Abdomen.

Organ : Left psoas muscle.

Density : Water.

Diagnosis : Psoas abscess.

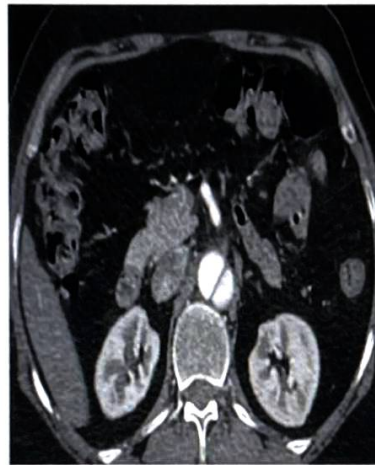
History :

- 65 Yr old male.
- K/c/o uncontrolled Hypertension.
- Acute tearing pain in Posterior chest/back.

Region : Abdomen.

Organ : Aorta.

Diagnosis : Aortic dissection.



History :

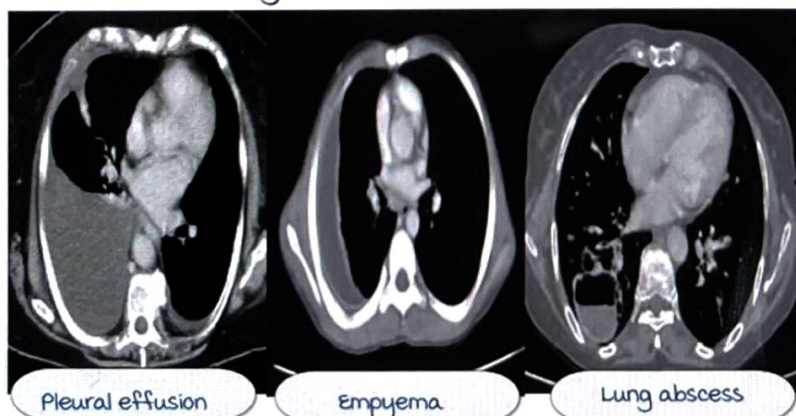
Cough, breathlessness & fever.

Region : Thorax.

60c6b3eaa8ded0e4e7e5ea7

Organ : Pleural cavity.

Lesion : Water density.



History :

35 Yr old male with multiple recurrent LRTIs.

Chronic cough with expectoration.



Region : Thorax

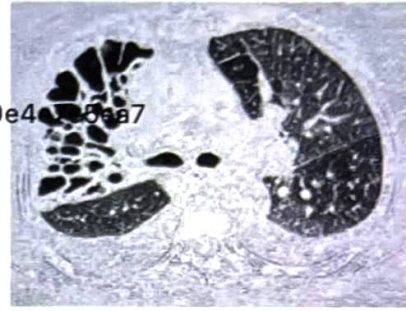
Organ : Lungs.

Lesion : Air density

Thick walled air filled lesions :

Dilated bronchi.

Diagnosis : Bronchiectasis.



History :

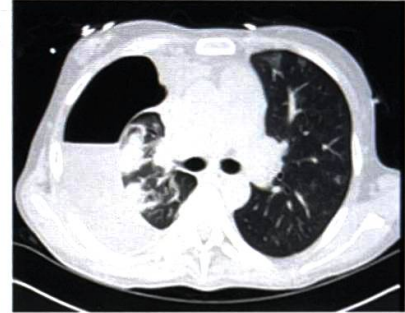
- 36 Yr old male.
- Breathlessness.
- Cough.

Region : Thorax

Organ : Lungs/pleura.

Lesion : water and air density in right lungs.

Diagnosis : Hydro pneumothorax.



History :

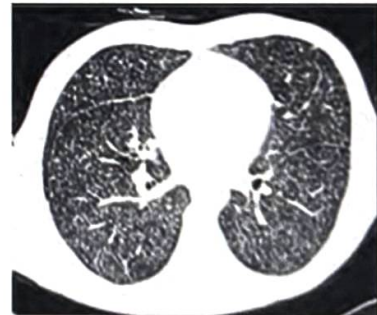
45 Yr old male with breathlessness & cough.

Region : Thorax.

Organ : Lungs.

Lesion : Multiple tiny nodules  
Scattered throughout the lungs.

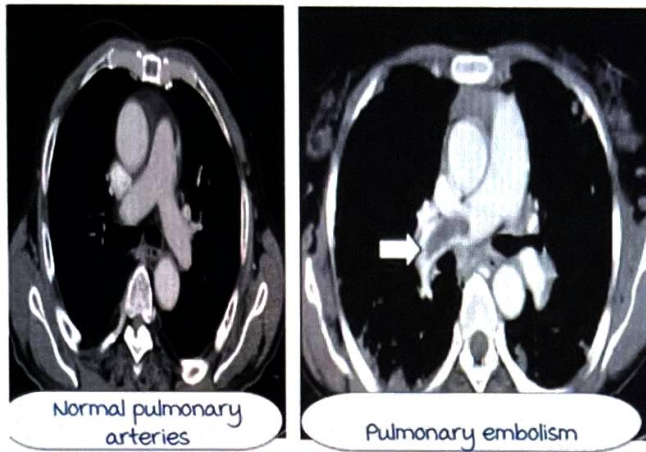
Diagnosis : miliary TB.



History :

- 25 Yr old male, o/c/o fracture femur.
- Left lower limb swelling.
- C/o cough with hemoptysis + breath lessness.
- SIQ3t3 on ECG. & D-dimer positive.





Region : Thorax

Organ : Lungs/Pulmonary artery.

Lesion : Filling defect in the pulmonary artery.

Diagnosis : Right Pulmonary artery embolism.

60c6b3eaa8ded0e4e7e5ea7

Active space

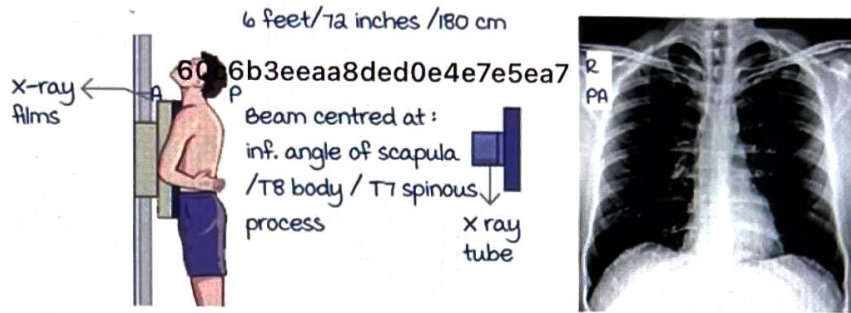


# CXR BASICS : PART - 1

## Basic projections

00:06:16

PA view :



- Postero anterior view (PA view) is the **most common** projection.
- Direction of X ray beam is posterior to anterior.
- Distance between X ray tube and patient is **6 feet/ 72 inches/ 180 cms.**
- Patient faces X ray film → Hands are at the back and shoulders are turned forwards to draw the scapulae laterally. Patient can also embrace the X ray film to draw the scapulae laterally.
- X ray beam is directed at **inferior angle of scapula/ T8 body/ T7 spinous process.**
- X ray beam is more or less **parallel** by the time the it enters the patient's body.

Types of PA view :

Low Kvp (Kilo volt peak) technique :

- **60 - 80 KV** is used.
- **High contrast** image.
- **miliary nodules, lung calcifications** are seen better.

High Kvp technique :

- **120 - 160 KV** is used.
- **High penetration.**
- **Hidden areas** are seen well.

Increased Kvp = Increased penetration.



kvp affects the contrast inversely (low kvp  $\rightarrow$  high contrast and high kvp  $\rightarrow$  low contrast).

## Standard technique of chest X ray

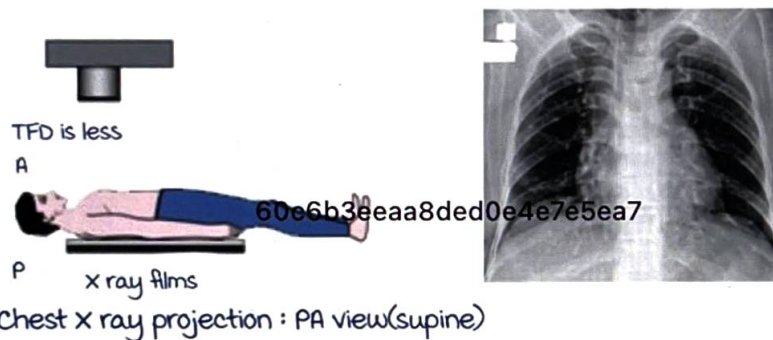
00:11:03

- Chest x ray should always be done in **PA view**.
- Should be done in an **erect position**.
- Should be done in state of **suspended end-inspiration**.

In neonates, unconscious/polytrauma/intubated patients, PA view cannot be done.

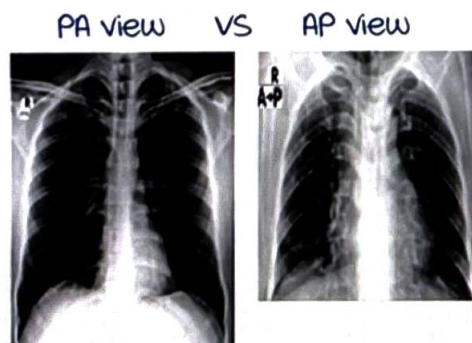
In such patients, **AP view** is used.

AP view :



- Antero posterior view : Direction of X ray beam is anterior to posterior.
- Patient lies supine. X ray film is kept below the patient.
- Distance between X ray tube and film is significantly less.
- X ray beam is divergent.

PA view vs AP view :

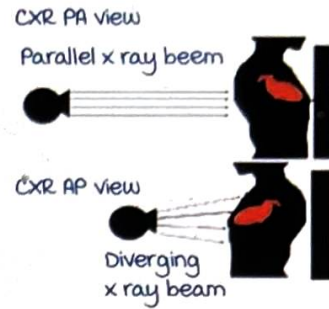


**False cardiomegaly** is seen on AP view.  
In PA view, heart is close to the film.



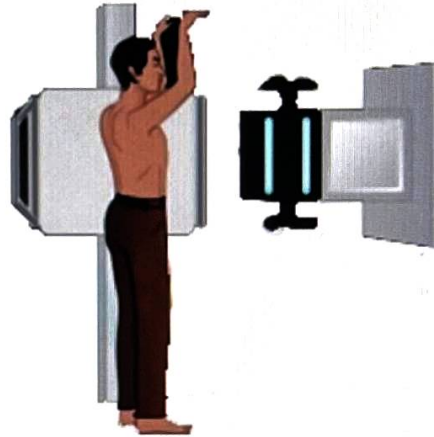
Tube to film distance (TFD) is almost 6 ft and beam is parallel. Heart is depicted in **original size**.

In AP view, heart is far from the film. Tube to film distance is significantly less and beam is divergent.



Heart appears enlarged on film : **False cardiomegaly**.

Lateral chest x ray :



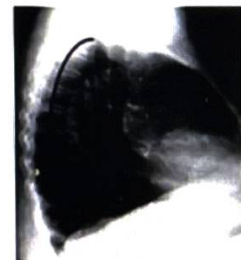
Previously, lateral chest x ray was done if any abnormality noted on AP/PA view.

It is not done nowadays, since CT is available.

Patient's hands are up, shoulders are elevated (minimal overlap over lung apices). Left side of the patient is in contact with the film. Beam is passed from lateral side.

Findings :

- **Retrosternal lucency.**
- **Retrocardiac lucency.**
- **Lucency along vertebral column** increases from top to bottom.
- **Shape of the diaphragm** : Dips down from anterior to posterior giving rise to **Posterior costophrenic recess** (deepest and most dependant part of pleural cavity. Pleural fluid accumulates first in this recess.



kumarankitindia1@gmail.com



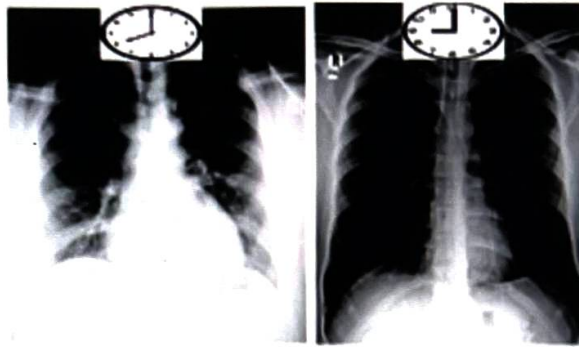
Descriptive terms :

Black area on X ray : **Lucency.**

White area on X ray : **Opacity.**

## Expiratory chest X ray

00:23:44



Expiration

End inspiration

In expiration :

Diaphragm raises upwards and heart appears **broader.**

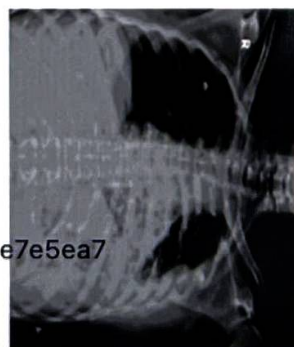
The blood vessels in lungs (especially in lower lobes) are not well filled with air and appear crowded giving rise to **bilateral basal opacities.**

Indications for expiratory chest X ray :

- **Pneumothorax**
- Foreign body aspiration (air trapping within the lung field is seen). MC foreign body to be aspirated is peanut. It is radioluscent. Hence only air trapping can be seen.
- Obstructive airway disorders.  
Example : Chronic bronchitis, emphysema, asthma.
- Diaphragmatic palsy/paralysis.

## Lateral decubitus view

00:30:40



Active space



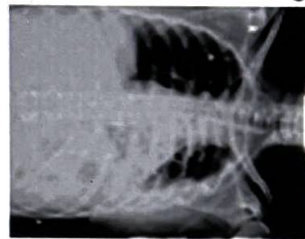
- Patient lies on left lateral aspect.
- X ray film is behind the patient.
- X ray beam is horizontal.
- Left lateral thoracic wall is the most dependent part → Fluid in left pleural cavity settles down.
- Used for detection of minimal pleural effusion.

Best radiograph for pleural effusion : Lateral decubitus X-ray.

Best investigation for pleural effusion : USG.

Best radiography  
for pleural effusion

Lateral decubitus X ray



Best investigation  
for pleural effusion

USG



Fluid is friend of USG → To detect fluid.  
Pleural effusion.

Pericardial effusion (Echocardiography).

Ascites/ fluid in peritoneal cavity (FAST : Focussed  
Assessment with Sonography for Trauma).

Hydrocephalus in infant.

Hydronephrosis.

For all these conditions, investigation of choice is ultrasound.

Air is enemy of USG.

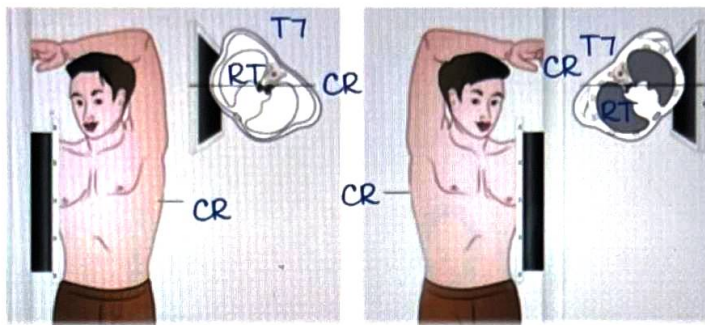
Investigation of choice to detect air in body : CT.

Lung abnormalities (HRCT), bowel abnormalities,  
retroperitoneal organ abnormalities such as pancreatic  
abnormalities, renal or ureteric calculi (NC-CT).

For all these conditions, IOC is CT.



Anterior oblique views :

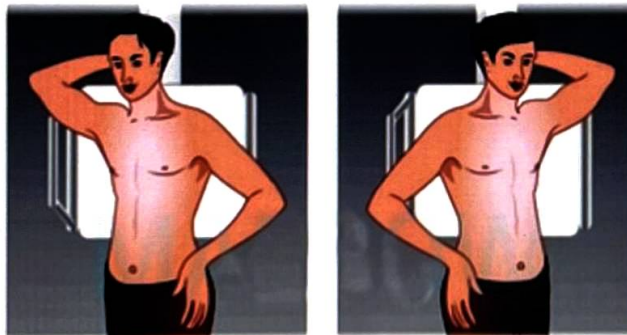


Right anterior oblique view      Left anterior oblique view

Right anterior oblique view : Right side of the patient faces the X ray film. Better for visualization of **left lung**. useful for visualization of **sternum, esophagus in a barium swallow**.

Left anterior oblique view : Left side of the patient faces the X ray film. Better for visualization of **right lung**. used for assessment of **aorta/aortic window**.

Posterior oblique views :



Right posterior oblique view      Left posterior oblique view

Right posterior oblique view : Patient stands obliquely and right posterior aspect of the thorax touches the X ray film.

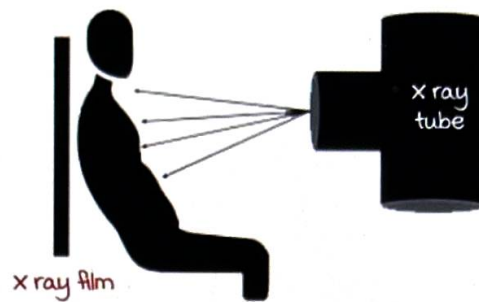
Left posterior oblique view : Patient stands obliquely and left posterior aspect of the thorax touches the X ray film.

Indications :

used for **ipsilateral rib fracture evaluation**.



Lordotic view/Apicogram :



Lordotic view :

Spine is bent convex anteriorly (lordosis).  
used for detection of **middle lobe diseases**.

Apicogram :

Clavicles are projected above the apices so that there is no **overlap**.

used for **evaluation of lung apices**.

60c6b3eaa8ded0e4e7e5ea7

MCQ :

Which of the following projections best demonstrates the aortic window?

- A. PA.
- B. Left anterior oblique.
- C. Right anterior oblique.
- D. Right posterior oblique.



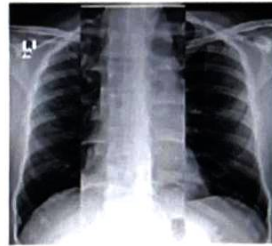
## CXR BASICS : PART - 2

### Normal chest x-ray interpretation

00:00:29

- Exposure is related to exposure factors **KVp** (kilovoltage peak) and **mAs** (milliampere second).

Adequate exposure :  
margins/end plates of lower thoracic vertebral bodies are barely visible.

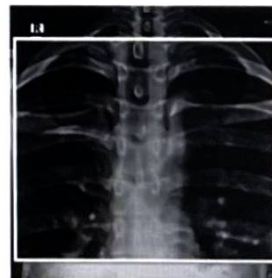


Underexposed film :  
margins/end plates of lower thoracic vertebral bodies are not visible (overall white appearance).

Overexposed film : 60c6b3eeaa8ded0e4e7e5ea7  
margins of lower thoracic vertebral bodies are visible in great detail (overall black appearance).

- Centering/rotation :

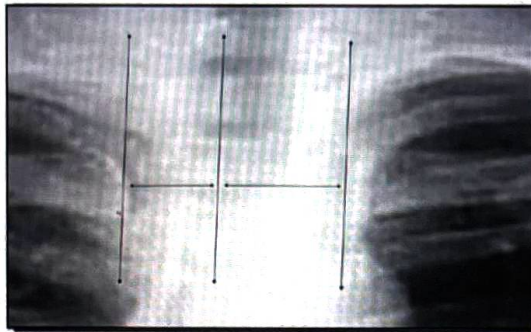
**midline anatomical landmark :**  
Spinous process of upper thoracic vertebra (slit like opacity).  
**a Lateral anatomical landmarks :**  
medial ends of clavicles on either sides.



Distance between midline and lateral anatomical landmarks are equal on both sides → Well centered radiograph.  
Distance between midline and lateral anatomical landmarks are unequal on either side → Patient is in rotation.  
If distance is more on one side → Patient is rotated towards that side.



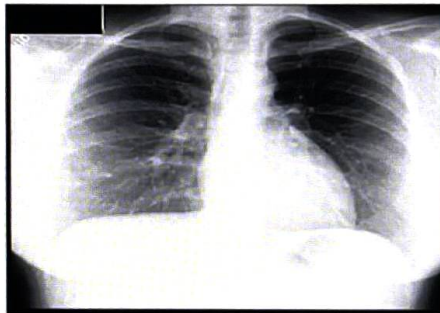
Image shows distance between midline and lateral anatomic landmarks is more on left side : Indicates patient is rotated towards left side.



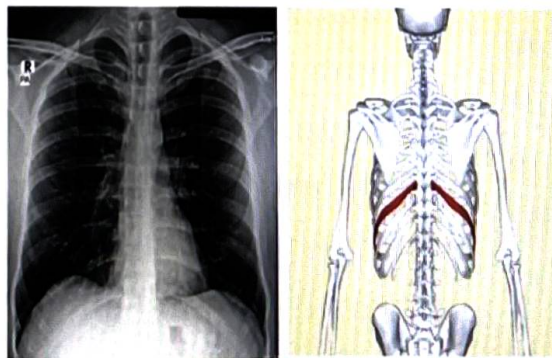
Patient rotated towards left side.

Effect of rotation :

Unilateral radiolucency : Left lung field appears slightly lucent on the side of rotation (one lung appears black & another white).



3. Identifying ribs (has medico legal importance) :



60c6b3eeaa8ded0e4e7e5ea7  
Posteriorly, head of rib articulates with 2 hemi facets on lateral adjacent thoracic vertebral bodies. Rib also articulates with transverse process of thoracic vertebra.

It goes round the chest & ends away from the sternum (midline) anteriorly.

Gap between sternum and the anterior end of rib is breached by costal cartilage.



Anterior end of rib :

- Away from the midline.
- Oblique in orientation/direction.

Posterior end of rib :

- Closer to the midline.
- Horizontal in orientation/direction.



Standard technique of CXR :

Always PA view in erect position with suspended end inspiration.

Criteria for adequate inspiration :

Count the number of ribs above the dome of diaphragm. At least 6 anterior ends of ribs & 10 posterior ends of ribs above the dome of diaphragm indicates good inspiratory radiograph (diaphragm is pushed down with inspiration).

kumarankitindia1@gmail.com

## Assessing heart size

00:16:21

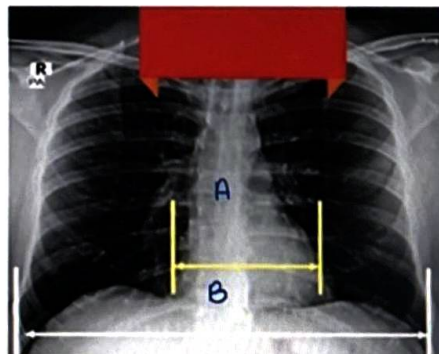
Cardio thoracic ratio :

Ratio of maximum transverse diameter of heart (A) to maximum transverse diameter of inner thorax (B).

Objective measurement.

more accurate method :

$$\frac{a_1 + a_2}{B}$$



PA view :

Cardiothoracic ratio < 0.50 is normal.

Ratio 0.50 to 0.55 indicates borderline (indeterminate).

Ratio > 0.55 indicates cardiomegaly.

AP view :

Normally, AP view shows false cardiomegaly.

CT ratio > 0.60 indicates pathological cardiomegaly.

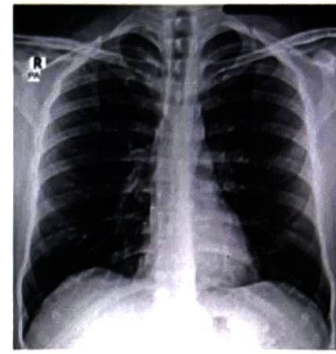


mediastinal margins :

Two types of structures :

1. Blood vessels :

- Right side : Veins.
- Left side : Arteries.

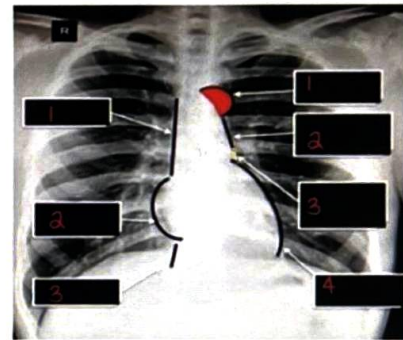


2. Cardiac chambers :

- Right heart border : Right atrium.
- Left heart border : Left ventricle and left atrial appendage (Since right ventricle projects anteriorly & left atrium projects posteriorly, they do not contribute to heart borders).

Right mediastinal border :

1. Superior vena cava.
2. Right atrium.
3. Inferior vena cava.



Left mediastinal border :

1. Aortic knuckle.
2. Main pulmonary artery.
3. Left atrial appendage.
4. Left ventricle (major contributor of left heart border).

MCQ :

A patient has a stab injury at the mid sternum at the level of 4th intercostal space. Which heart chamber would be involved in this injury?

- A. Left atrium.
- B. Left ventricle.
- C. Right atrium.
- D. Right ventricle (Anterior most chamber of heart).



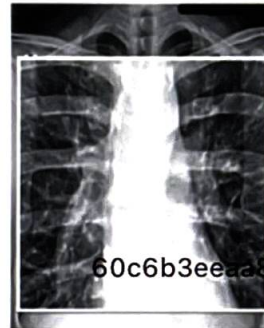
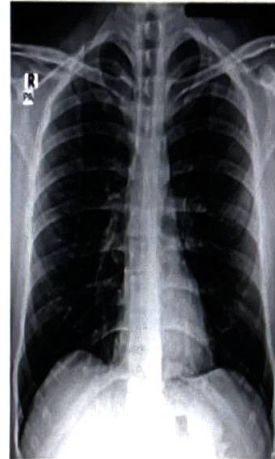
## Hilum

00:26:45

Site where blood vessels and trachea enter into lungs.

Hilar shadows :

- Appear **white**.
- Formed mainly by **blood vessels**.
- Has small indistinct upper limb (formed by **superior pulmonary veins**) and long prominent lower limb (formed by **lower lobe pulmonary arteries**).
- minor contribution : Left and right main bronchi.



**Lower lobe pulmonary veins** never contribute to hilar shadows (do not run along hilum).

Hilar point :

Point at which upper and lower limb of hilum meet each other.

Hilar level (imaginary line joining both hila) :

Normal : **Left** hilum is **slightly higher** compared to right hilum/  
**both** right and left hilum **at same level**.

Hilar shape :

Hilum is normally **concave**, facing laterally.

If it becomes **convex** and lobulated laterally → Indicates **lymphadenopathy** (tuberculosis).

MCQ :

Hilar shadows are formed by all except ?

- Lower lobe arteries.
- Upper lobe veins.
- Bronchi.
- Lower lobe veins.

Active space



## Lobar anatomy

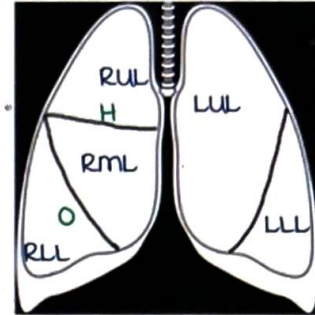
00:33:15

Right and left lungs are divided by fissures.

There are two fissures on the right side → Oblique (O) and horizontal (H).

They divide right lung into right upper, middle and lower lobes.

Right para cardiac area : Right middle lobe.



There is only one fissure on the left side → Oblique fissure.

It divides the left lung into left upper and lower lobes.

Left para cardiac area : Lingular segment - tongue like (part of left upper lobe - above and anterior to oblique fissure).

(Para cardiac area : Area adjacent to heart)

Right lung :

Oblique fissure runs obliquely from posterosuperior to anteroinferior.

Horizontal fissure runs horizontally forwards.

Above horizontal fissure : Right upper lobe.

Between horizontal fissure and lower part of oblique fissure : Right middle lobe.

Below and behind oblique fissure : Right lower lobe.

Left lung :

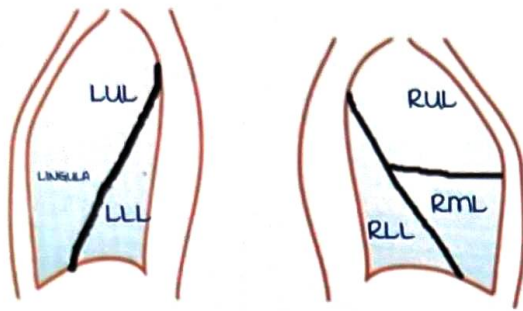
Oblique fissure runs obliquely from posterosuperior to anteroinferior.

Above and anterior to oblique fissure : Left upper lobe (includes lingular segment).

Below and behind oblique fissure : Left lower lobe.

kumarankitindia1@gmail.com





Diaphragm :

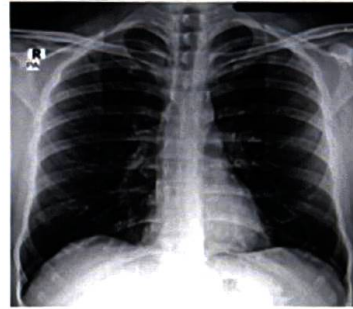
Right and left hemidiaphragms :

Sharp margins.

Central tendon of diaphragm :

Heart lies directly above it.

So, no sharp margin.



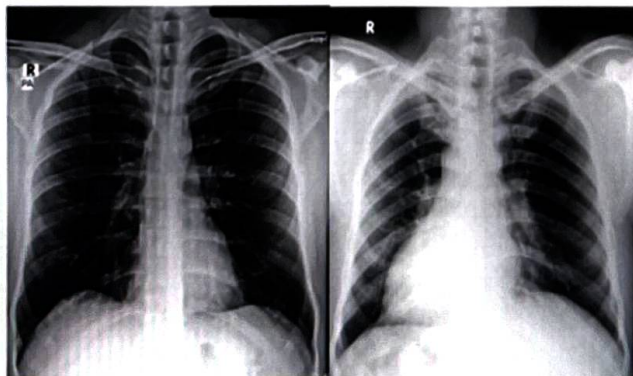
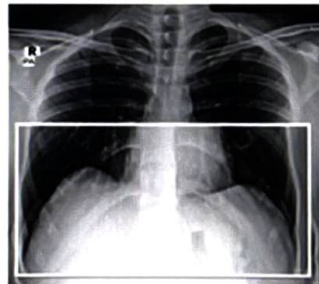
Two angles :

- Costophrenic angles : Acute and sharp. They are blunted in **pleural effusion**.
- Cardio phrenic angles. Both are seen on Rt & Lt sides.

Diaphragmatic levels :

**Left dome** of diaphragm is **lower** compared to right as **weight of heart** is transmitted onto left dome of diaphragm.

In **Dextrocardia**, right dome of diaphragm is lower compared to left.



Normal

Dextrocardia



Diaphragmatic asymmetry :

> 3cm level difference between the two domes of diaphragm.  
Seen in **diaphragmatic palsy** (best diagnosed using USG : shows up & down movement of diaphragm).

Diaphragmatic flattening :

Imaginary line from base of diaphragm to peak height of one of the domes.

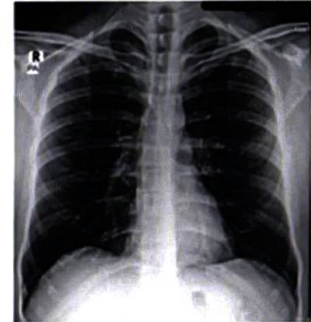
Height of diaphragmatic peak < 1.5 cm. Seen in **hyperinflation**.

### Hidden areas

00:43:27

High kVp technique which results in high penetration is used to visualize hidden areas (sometimes CT scan may be needed to visualize them).

1. Lung apices (overlapping of transverse process, clavicle, ribs).
2. mediastinum + Hila (esophagus/small hilar nodes).
3. Retrocardiac lung.
4. Lung in posterior costophrenic angle recess (deepest and most dependent part of pleura). Overlapped by liver and spleen anteriorly.
5. Lung overlapped by bones.

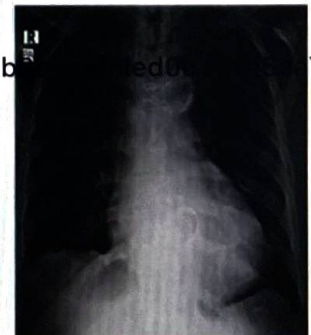


### Clinical scenarios

00:51:27

A 45 year old male has a history of cardiac surgery. CXR is done, what is the diagnosis ?

- A. Prosthetic mitral valve.
- B. Prosthetic aortic valve.
- C. Implantable pacemaker.
- D. Constrictive pericarditis.



Sternotomy sutures, calcification of aortic knuckle are also seen in this chest X ray.



IOC for assessing prosthetic valve : **2D Echo.**

Identifying prosthetic cardiac valves on CXR :

On PA view, identify 2 landmarks :

- **Left atrial appendage.**
- **Right cardiophrenic angle.**

Draw a line between them.

2 valves are located above this line :

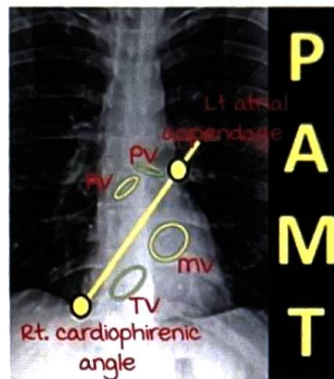
based on their origins :

**Pulmonary valve (left side),**

**Aortic valve (right side)**

2 valves are located below this line :

**mitral valve (left side), Tricuspid valve (right side).**



Sequence from top to bottom :

**PAMT (Pulmonary, Aortic, Mitral and Tricuspid).**

On lateral radiograph :

Identify 2 landmarks :

- **Carina.**
- **Cardiac apex.**

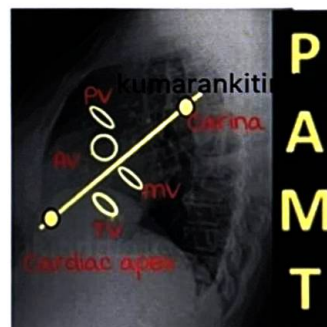
Draw a line between them.

2 valves are located above this line :

**Pulmonary valve, Aortic valve.**

2 valves are located below this line :

**mitral valve, Tricuspid valve.**



Sequence from top to bottom :

**PAMT (Pulmonary, Aortic, Mitral and Tricuspid).**

Q. A 22 year old male undergoes a chest X ray PA view for pre-employment check up. Based on this finding, this patient may have a propensity to develop which of the following ?

- Bronchiectasis.
- Chronic sinusitis.
- Infertility.
- All of the above.

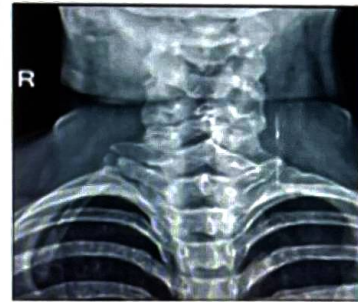


Chest X ray shows **situs inversus totalis** (apex of heart and gastric bubble are seen on right side). It is seen in **Kartagener syndrome** associated with primary ciliary dyskinesia.



Q. This incidentally detected finding is associated with ?

- A. Lung cancer.
- B. Thoracic outlet syndrome.
- C. Hyperthyroidism.
- D. Cervical lymphadenopathy.



Chest X ray shows **cervical rib** (mostly asymptomatic). Can cause compression of subclavian vessels : Ischemia of upper limb.

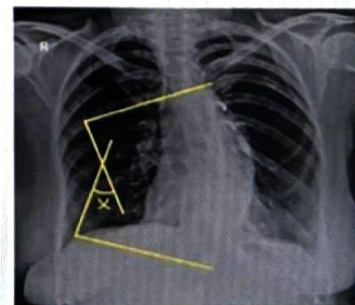
Explanation :

Transverse process of C7 is almost horizontal & that of T1 is directed upwards.

Lateral to C7 transverse process, an elongated bony structure (**cervical rib**) is seen articulating with both vertebrae

Q. A child with a known skeletal deformity is being assessed and an angle is measured. Can you name the measurement being made here ?

- A. Cobb's angle.
- B. Bohler's angle.
- C. Pauwel's angle.
- D. Pott's angle.



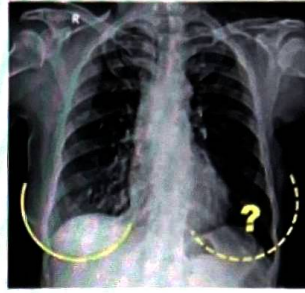
X ray shows **scoliosis**.

Imaginary lines parallel to upper border of uppermost vertebral body & lower border of lowest vertebra of the scoliotic curve. Draw perpendiculars from both & measure the angle formed at the meeting point of both perpendiculars.



Q. Looking at this radiograph you may conclude that this patient has been operated for ?

- A. Clavicular fracture.
- B. CABG.
- C. Ca Breast.
- D. Mitral valve replacement.



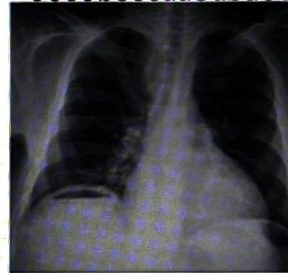
Right breast shadow is seen.

Left breast shadow is not visible (post mastectomy status).

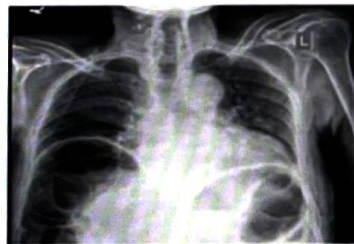
Q. 25 year old male presents with severe abdominal discomfort, tachycardia. A chest X ray PA view is done in an erect position. most likely diagnosis is ?

- A. Pneumothorax
- B. Pleural effusion.
- C. Pneumomediastinum.
- D. Pneumoperitoneum.

60c6b3eeaa8ded0e4e7e5ea7



X ray shows free air below the dome of right diaphragm indicating bowel perforation (surgical emergency). Free air appears jet black.



X ray has similar appearance to pneumoperitoneum, but bowel wall markings are also seen.

It is pseudo pneumoperitoneum showing Chilaiditi sign.

Colonic loop between diaphragm above and liver below.

Along with radiographic appearance, if the patient has pain, it is known as Chilaiditi syndrome.

Active space



# PLEURAL ABNORMALITIES AND LOBAR COLLAPSE

60c6b3eaa8ded0e4e7e5ea7

## Pleural effusion

00:03:30

Pleural effusion :

Accumulation of abnormal amount of fluid within a pleural cavity.

Best radiograph for detection of pleural effusion : **Lateral decubitus chest X-ray.**

Best investigation for Pleural effusion : **Ultrasonography (USG).**

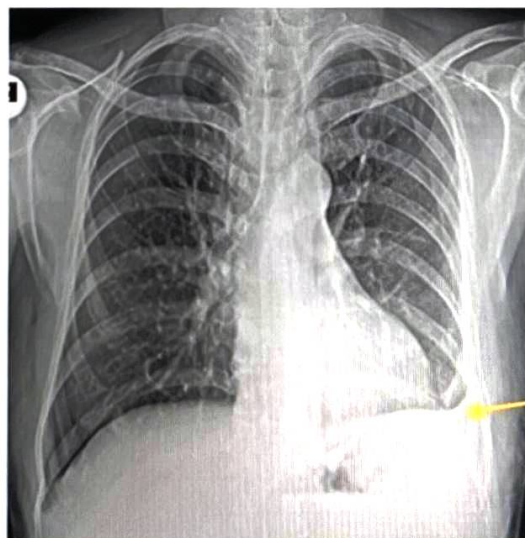
Fluid is a **friend** of USG; Air is an **enemy** of USG.

**Typical imaging findings of pleural effusion on chest X-ray :**  
Blunting of Costophrenic / CP angle.

**Earliest** finding on Chest X-ray.

Amount of fluid required : **200 to 300 cc.**

The most dependent part of the pleural cavity is the **posterior costophrenic recess.**



**Pleural meniscus sign :**

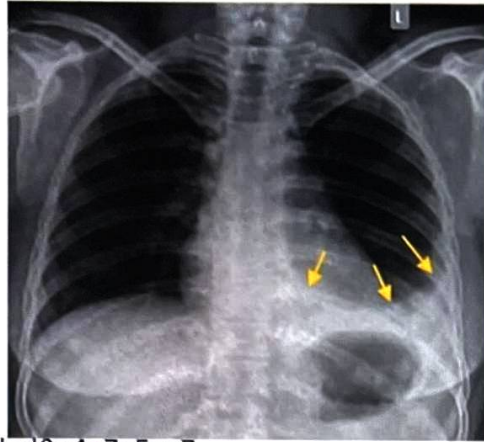
As fluid accumulates, it rises.

It creates dense opacity with an **ill defined** upper margin.



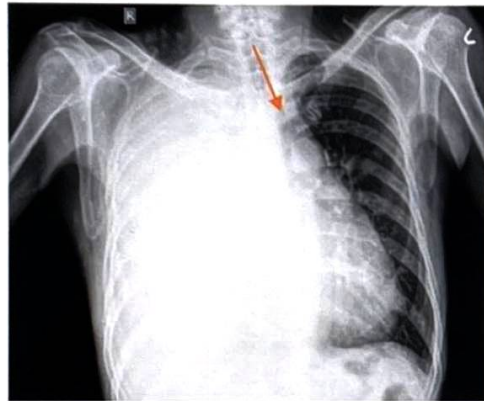
It takes a meniscus like appearance.

Amount of fluid : 500ml to 1 litre.



60c6b3eaa8ded0e4e7e5ea7  
Pleural meniscal sign

Opaque hemithorax :



Whiteout lung.

Amount of fluid : 3 to 5 litre.

1<sup>st</sup> Investigation : Chest X-ray.

Investigation of Choice : **CE-CT**.

mediastinal shift : To the opposite side.

Clinical Insights :

Differential diagnosis of Opaque Hemithorax :

Diagnosis	mediastinal shift
Pleural effusion.	Opposite side
Total lung collapse.	Same side
massive consolidation.	midline : No shift.



Q. A 45-year-old patient presents with breathlessness and cough. A CXR is done. most likely diagnosis is?

- A. Pleural effusion
- B. Consolidation
- C. Lung collapse
- D. Pneumothorax
- E. Pneumonectomy



Whiteout lung.

Tracheal deviation : Same side.

Volume loss.

### Atypical imaging findings of pleural effusion

00:17:00

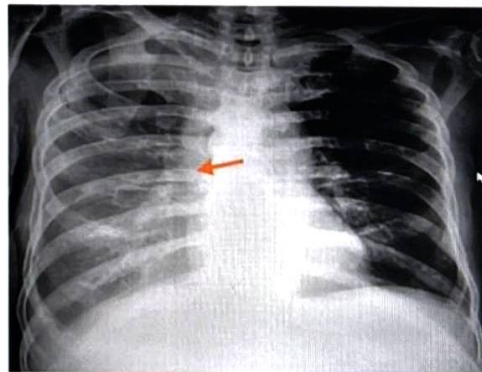
Effusion on supine film (AP view) :

Dependent part : Posterior thoracic wall.

Density of the entire right hemithorax is increased.

Vascular markings are visible, as lungs are normal.

Pleural effusion  
on supine xray.  
(vascular  
markings visible)



Effusion on Lateral decubitus film :

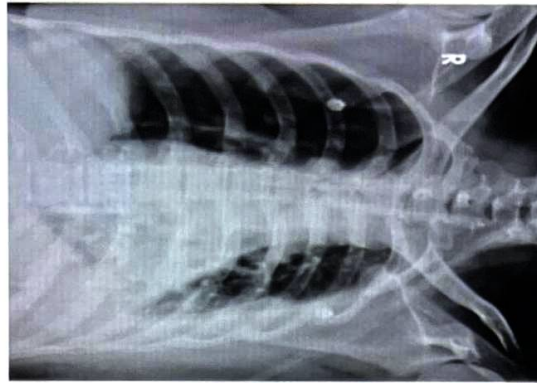
Lying down on one side.

Here left lateral decubitus film.

Best x-ray for pleural effusion.



Pleural effusion on left lateral decubitus xray view.



Lamellar pleural effusion :  
Lamellar means thick band/ layer like appearance.  
Fluid rises vertically parallel to the lateral thoracic wall.



Lamellar pleural effusion

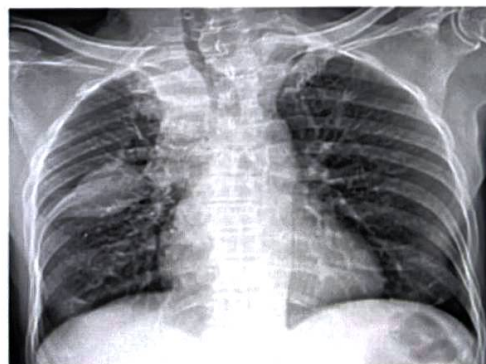
Clinical Scenario : History clinchers :

Elderly male with dyspnea on exertion.

O/E : Basal crepts, Bipedal edema.

CXR : mass like opacity in RMZ.

CXR : mass like opacity disappears in 72 hours.



Diagnosis : **Loculated** Pleural effusion.

Loculated : when fluid gets trapped.



most common site : **Fissures.**

This results in oval **well-defined** opacity which looks like a tumour/ mass.

Typically seen in **congestive heart failure** as there is back pressure in the pulmonary vasculature.

On treatment, pleural effusion disappears.

Hence known as **Phantom lung tumour/** vanishing lung tumour.

Pleural effusion **USG** findings :

IOC : **USG**. Fluid appears **hypoechoic/black**.

Detects **5 to 10ml** of abnormal fluid accumulation.

**USG** guided thoracentesis : Fluid aspirated for diagnostic & therapeutic purposes.



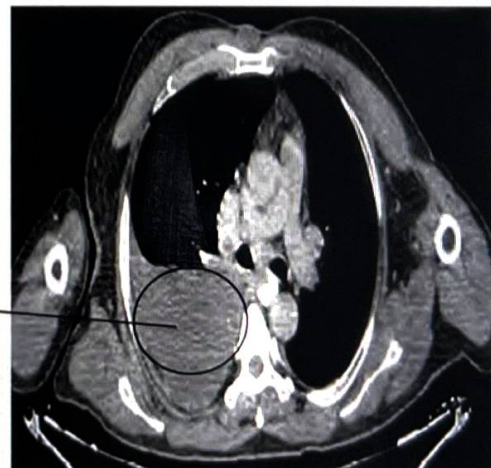
Pleural effusion : CT not usually done for diagnosis.

used only when malignancy, pleural nodules, deposits causing pleural effusion are suspected.

**No enhancement** is seen.

Free fluid collection in the dependent part.

Free fluid collection  
: Pleural effusion ←





## Empyema :

Loculated fluid collection.

Can be seen even in **non-dependent** areas.

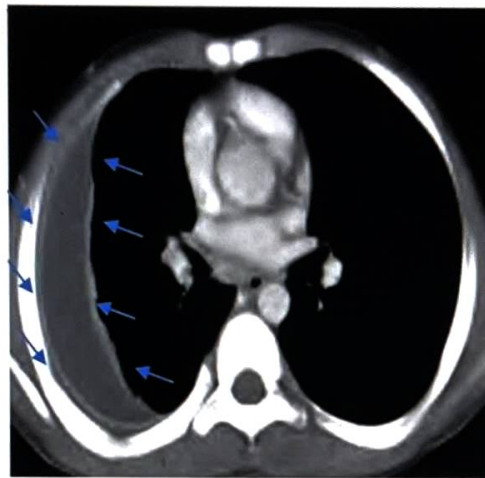
**Enhancement** around the fluid is always seen.

Due to infection / inflammation along margins of pleural layers.  
kumarankitindia1@gmail.com

## Split pleura sign :

Due to **pus** collection between the inflamed layers of parietal and visceral pleura.

Loculated fluid  
collection : Empyema



Split pleura sign.

## Pneumothorax

00:32:30

Best investigation for pneumothorax : **CT**.

Best radiograph for pneumothorax : **CXR PA view in expiration.**

**"Bread Butter Brunch."**

On applying the same amount of butter on a large and a small size bread slice.

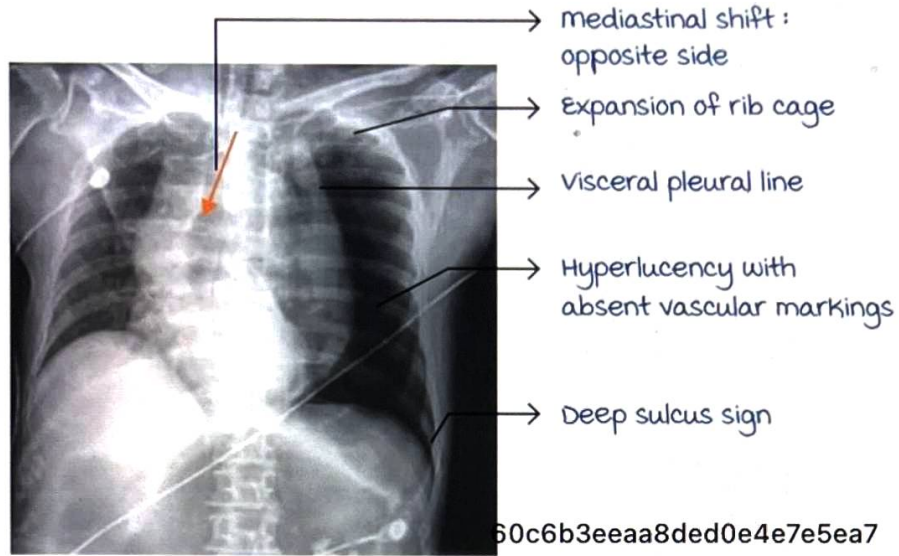
A thicker layer of butter is applied to the smaller bread slice.

Similarly,

On expiration, air in the pleural cavity (butter) appears thicker on the smaller surface area of the inner thoracic wall in the expiratory phase (Smaller bread slice).



Imaging in pneumothorax : CXR findings.



**Tension pneumothorax**

00:42:22

One way valve from lungs into the pleura.

As air enters, negative pleural pressure → Becomes zero → Positive.

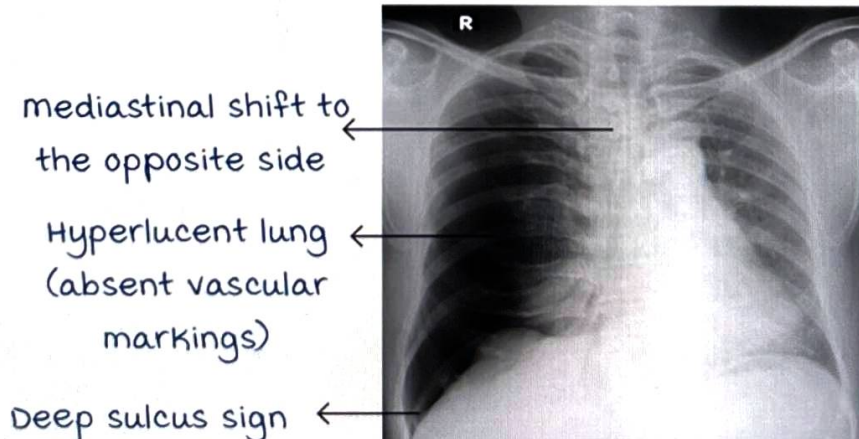
The excess air in the thoracic cavity compresses the lungs, Superior vena cava, inferior vena cava. Venous return is blocked and cardiac output is blocked, resulting in collapse and death.

Imaging :

Hyperlucent (jet black) with absent vascular markings.  
mediastinal shift to the opposite side.

Deep sulcus sign.

Active space





Treatment :

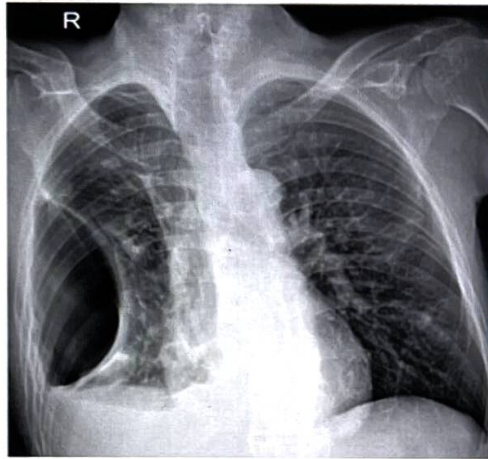
1<sup>st</sup> step : Needle thoracotomy.

Adults : 5<sup>th</sup> intercostal space in mid axillary line, or anterior to the midaxillary line.

Children : 2<sup>nd</sup> intercostal space in the midclavicular line.

2<sup>nd</sup> step : intercostal drain insertion with the underwater seal at the outer end.

Loculated pneumothorax.



Investigation of choice : CT

In Lung window, Jet black area is pneumothorax.



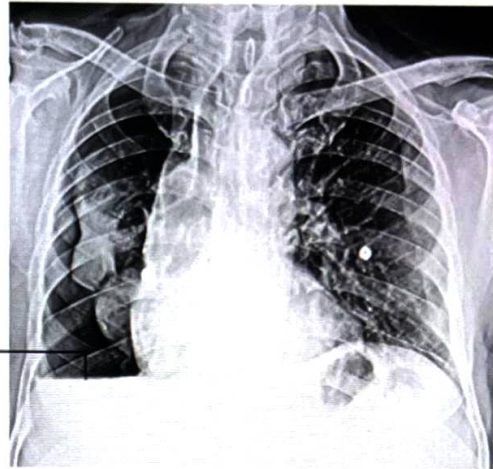
60c6b3eaa8ded0e4e7e5ea7

Active space



Hydropneumothorax :

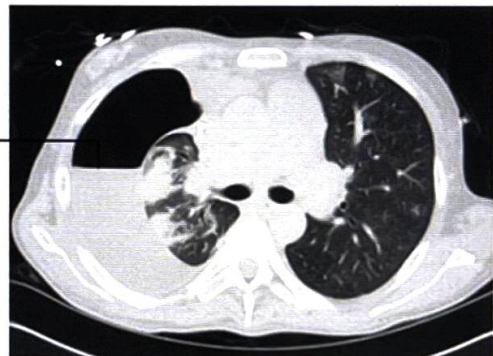
Horizontal air-fluid level.



Air-fluid level ←

On CT scan :

Horizontal air-fluid level in the pleural cavity.

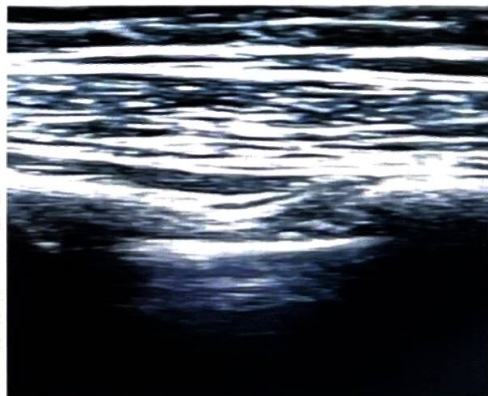


Air-fluid level ←  
kumarankitindia1@gmail.com

**USG Findings in pneumothorax**

00:50:15

Normal USG thorax : B mode



Chest wall layers

Pleural layers

Lungs

Active space

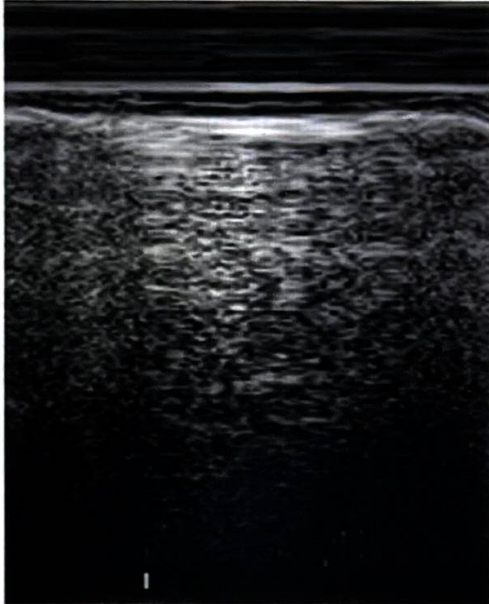


Normal USG thorax shows **pleural sliding** with inspiration and expiration.

Pleural sliding is **absent** in Pneumothorax.

**Seashore sign** :

Normal USG Thorax : motion (m) mode.



Waves : movement of the chest wall.

Sand : Uniform and granular : Lungs.

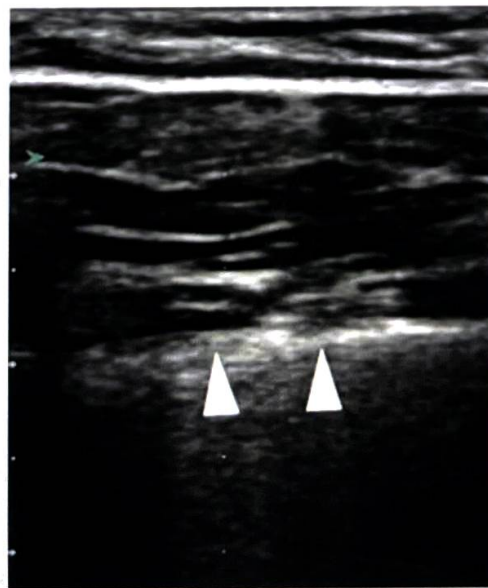
Seashore sign : Normal thorax

Pneumothorax :

**Pleural sliding is absent.**

kumarankitindia1@gmail.com

**Comet tail appearance** of normal lungs, is absent.



Active space

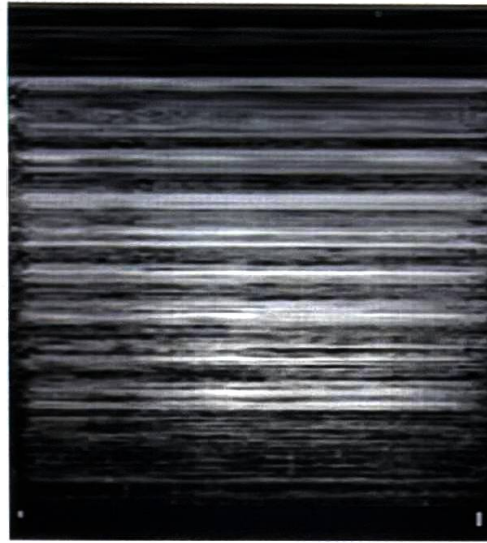


Pneumothorax USG findings : m mode.

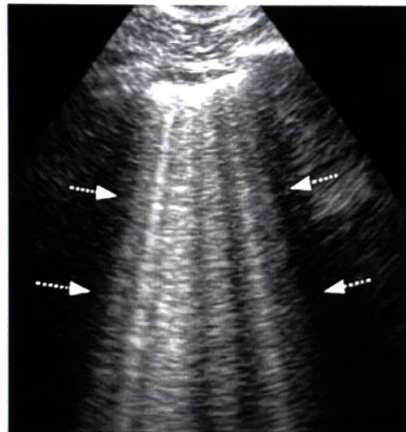
Stratosphere / barcode sign.

Striped lines appearance.

60c6b3eaaa8ded0e4e7e5ea7



Normal : B lines : Vertical.



Comet tail

Pneumothorax :

A lines : Horizontal.



Q. A patient with RTA came with tachypnoea and tachycardia. m-mode USG revealed barcode sign. What is the diagnosis ?

- A. Pleural effusion
- B. Hemothorax
- C. Pneumothorax
- D. Pericardial tamponade

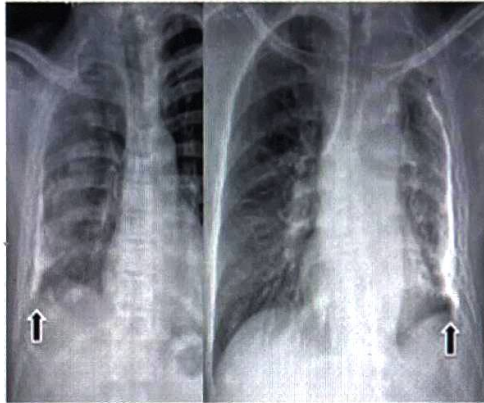


Calcified pleural plaques :

Holy leaf sign.

Asbestosis.

IOC : CT.



## Lobar collapse

00:59:26

Right lung has 2 fissures horizontal fissure and oblique fissure, and divides lung into 3 lobes :

Right upper lobe / RUL.

Right middle lobe / RML.

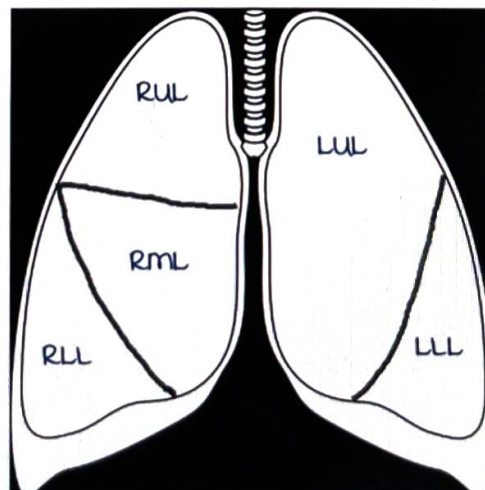
Right lower lobe / RLL.

The left lung is divided by an oblique fissure into :

Left upper lobe / LUL.

Left lower lobe / LLL.

60c6b3eaa8ded0e4e7e5ea7



Active space



Lobar collapse :

1. Volume loss.
2. Density change.

Initial investigation : Chest x-ray

kumarajkitindia1@gmail.com

Investigation of choice : **CECT** : It also helps in identifying the cause.

Direct signs :

(What happens in the affected lung)

- Loss of aeration : Change in density.
- Displacement of adjacent lung fissures : **most reliable sign.**
- Crowding of blood vessels.

Indirect signs :

(What happens around the affected lung)

- mediastinum shift.
- Elevation of diaphragm.
- Hilar displacement.
- Rib crowding.
- Compensatory hyperinflation.

RUL collapse :

RUL collapses upwards.

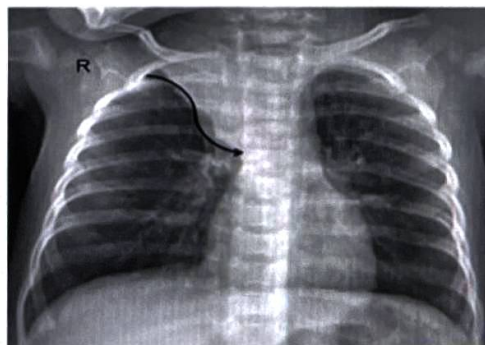
**Pulls horizontal fissure upwards.**

RUL collapse due to central mass lesion :

**Golden S sign.**

Convex : medial part : RUL collapse.

Concave : Lateral part : Central mass.



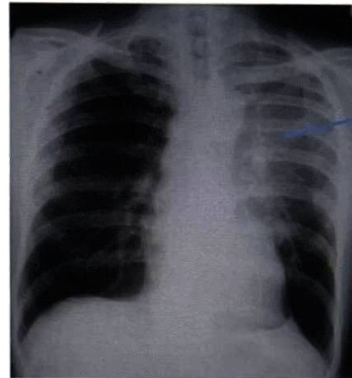
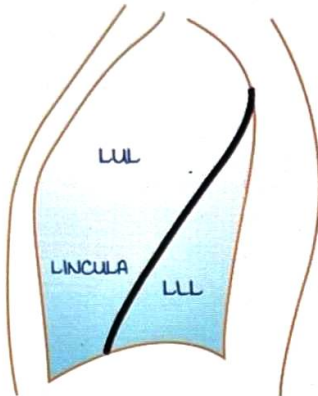
LUL collapse :

LUL collapses forwards.

Pulls oblique fissure forwards.

kumarankitindia1@gmail.com

veil / curtain like opacity.

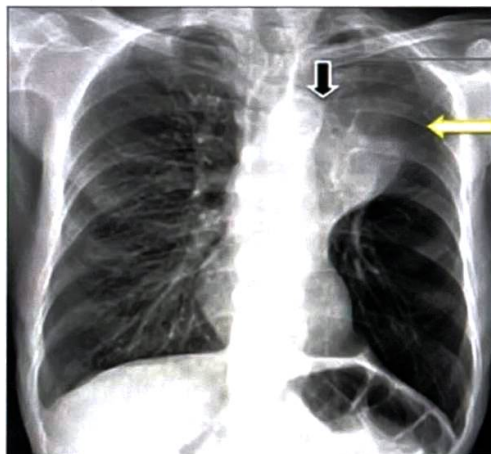


Veil / Curtain like opacity

Luftschichel sign : Air crescent is visible.

Seen in LUL collapse due to compensatory overinflation of LLL.

Superior segment of LLL lines the aortic knuckle.



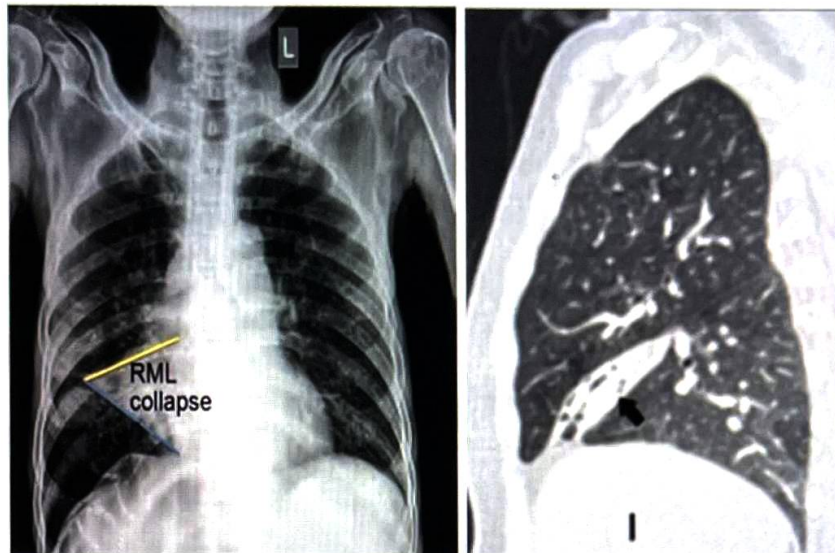
Air crescent

RML collapse :

The upper and Lower lobes move close to each other.

Triangular abnormality with 2 fissures close to each other.





Associations :

RML syndrome :

Chronic RML collapse + Bronchiectasis.

Lady Windermere Syndrome :

Rare condition.

Pulmonary mycobacterium Avium Complex (MAC) infection.

Elderly females.

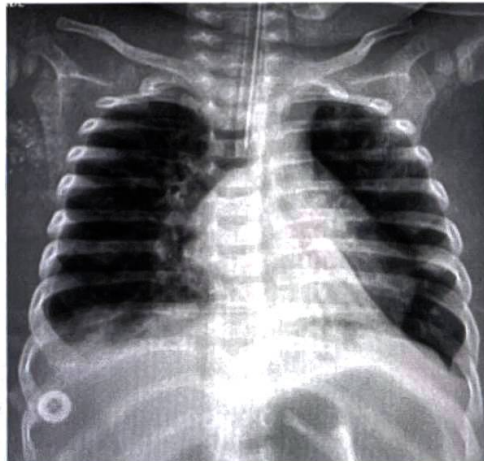
RML + Lingular segments.

RLL / LLL Collapse :

Triangular wedge-shaped density.

Superior triangular sign.

Flat waist sign : Flattening of aortic knuckle in extensive LL collapse.

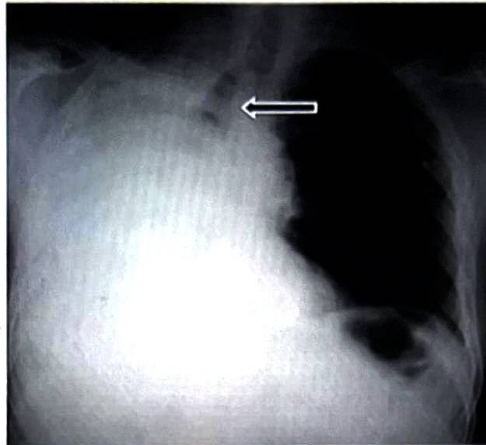


Active space

60c6b3eaa8ded0e4e7e5ea7

Complete Lung Collapse :  
Whiteout lungs.

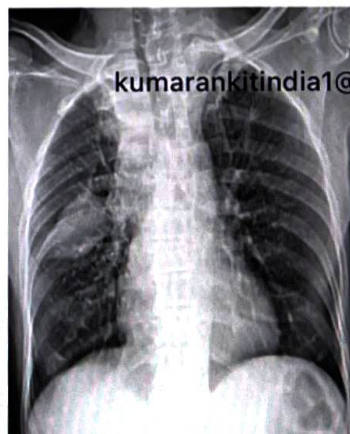
mediastinal shift to same  
side.



Lobar Collapse patterns	Signs
Golden S sign :	RUL collapse
Juxtaphrenic peak sign :	Any upper lobe collapse
Luftsichel sign :	LUL collapse
Superior triangle sign :	LLL collapse
Lady Windermere syndrome :	RML collapse

Q. A patient presents with breathlessness, pedal oedema and basal crepitations on auscultation. CXR PA view finding is shown here. He is admitted to the ICU and the 3<sup>rd</sup> day CXR showed complete disappearance of the opacity shown here. The most likely diagnosis is?

- A. Pneumococcal pneumonia
- B. Lung tumour.
- C. Pleural mesothelioma
- D. Loculated pleural effusion.



Active space



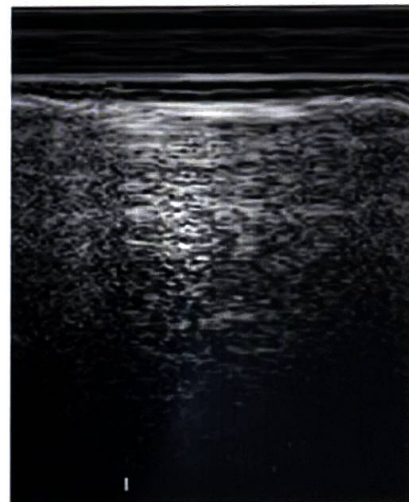
Q. Patient presented with sudden onset difficulty in breathing, with RR 28 /min, normal blood pressure. Xray is suggestive of unilateral hyperlucency with absent vascular markings and mediastinal shift to opposite side. The 1st step in the treatment of this patient would be ?



- A. IV fluids
- B. ICD insertion
- C. Needle thoracotomy
- D. Endotracheal intubation

Q. [kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)  
 This appearance seen on a normal patient on m-mode ultrasound is known as ?  
 (INI-CET 2022 Pattern).

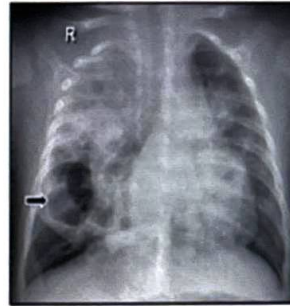
- A. Stratosphere sign.
- B. Seashore sign.
- C. Barcode sign.
- D. Whiteout sign.



## SILHOUETTE SIGN AND LUNG INFECTIONS : PART - 1

Q. A child presents with high grade fever, cough and elevated TLC. He is put on IV antibiotics. On the 5<sup>th</sup> day of illness, a CXR is done and is shown here. This child is most likely suffering from ?

- A. Klebsiella pneumonia .
- B. Pneumocystis pneumonia.
- C. Staphylococcal pneumonia.
- D. TB.



Q. Based on this radiographic image findings, this patient may be suffering from all the following except ?

- A. TB.
- B. Varicella pneumonia.
- C. Lymphangitis carcinomatosa.
- D. Klebsiella pneumonia.



Q. True regarding CORADS is ?

- A. CORADS 0 is a normal lung.
- B. CORADS 5 is typical of COVID.
- C. Pleural thickening is typical of COVID.
- D. COVID can present with large consolidation.

### Silhouette sign

00:03:50

Is a shadow or an image with a very sharp margin.  
It is based on the concept of differential radiographic density theory.

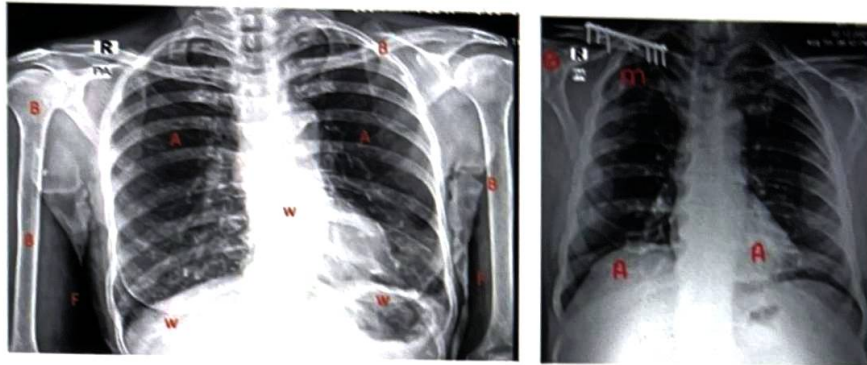


Active space



It states that in any x ray image of any part of body, there are only 5 different densities which can be identified separately from one another. They are :

- Increasing density ↓
1. Air density (A) (lungs).
  2. Fat density (F).
  3. Water density (W) : All soft tissues except fat (heart, diaphragm, abdominal soft tissues, muscles).
  4. Bone density (B).
  5. metal density (m) (implants).



Sharp margins :

Sharp borders are seen between 2 tissues, when tissues of different radiographic densities are adjacent to each other.

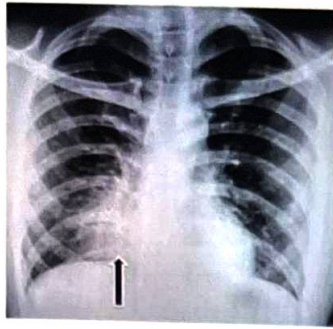
- Sharp borders of the clavicle : 2 tissue densities of bone density & muscle (water density).
- Sharp borders of heart : water density & air density.
- Sharp borders of right & left dome of diaphragm : water density & air density.



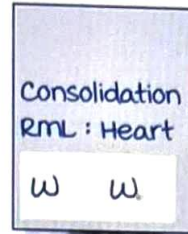
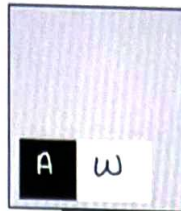
aa8ded0e4e7e5ea7

Consolidation : Air within the alveoli is replaced by fluids.

In case of right middle lobe consolidation, where air density is changed to water density due to consolidation, and the adjacent structure heart is also of water density, there is obscurity of the sharp border called **positive silhouette sign**.

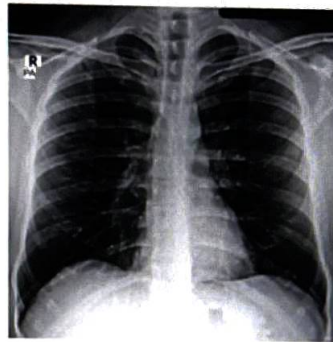
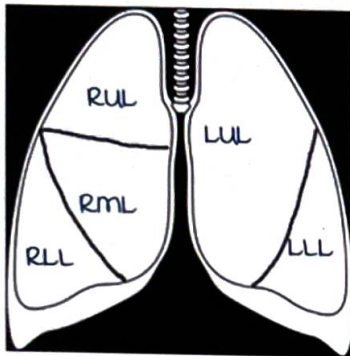


Right heart border obscured : Positive silhouette sign



### Silhouette sign based on lobar anatomy

00:19:51



kumarankitindia1@gmail.com

Right lung has two fissures, horizontal and oblique fissures, they divide the right lobe into :

- Right upper lobe (RUL) along the right upper mediastinal border.
- Right middle lobe (RML) along the right paracardiac area.
- Right lower lobe (RLL) lines the right dome of diaphragm.

Left lung has one fissure (oblique) which divides it into,

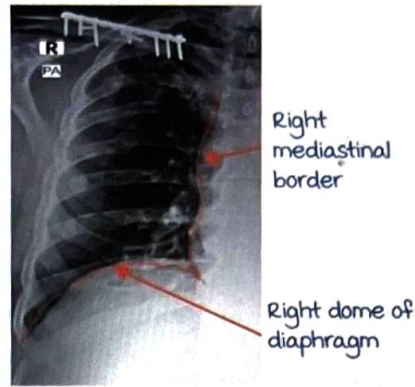
- Left upper lobe (LUL) (lingular segment along the left heart border).
- Left lower lobe (LLL).

Right sided silhouettes :

- If right upper mediastinal border is obscured then disease lies in anterior segment of RUL.
- If right heart border is obscured then disease lies in medial segment (>>lateral) of RML.
- If right dome of diaphragm is obscured then disease mostly lies in the RLL >> RML.

Active space





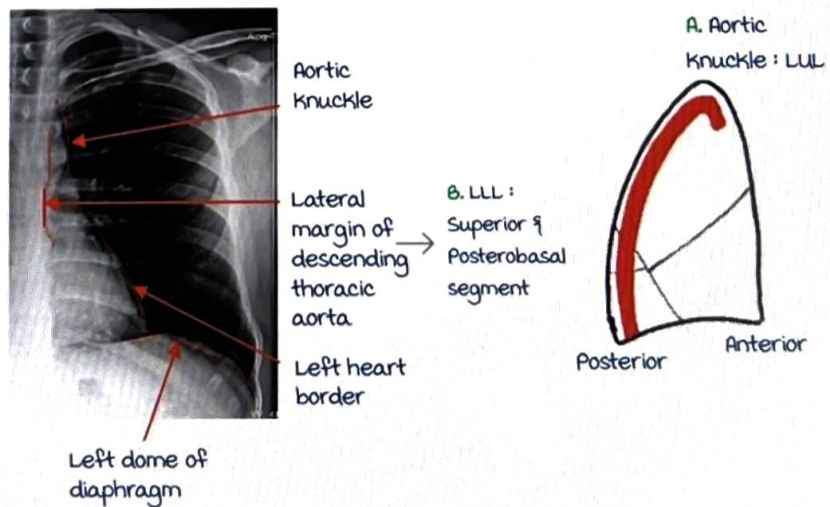
**Left sided silhouettes**

00:23:11

Left upper lobe has apico posterior segment and anterior segment.

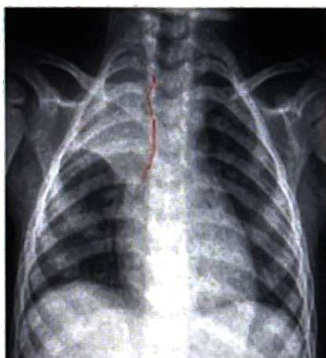
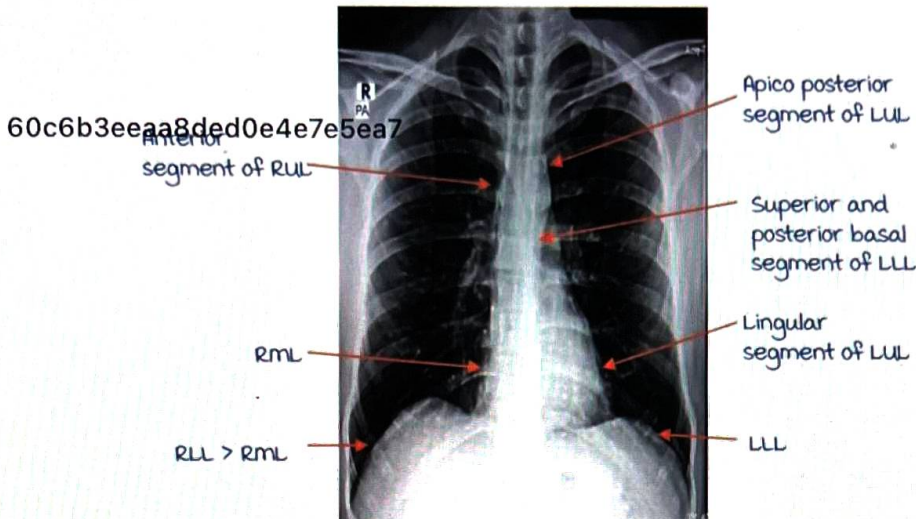
Left lower lobe has superior segment, antero & postero basal segment, medial and lateral basal segments.

- A. If aortic knuckle is obscured : Disease in apico posterior segment of LUL.
- B. If lateral margin of descending thoracic aorta is obscured : Disease lies in LLL (superior segment & postero basal segment).
- C. If left heart border is obscured : Disease in lingular segment of LUL.
- D. If left dome of diaphragm is obscured : Disease in LLL.

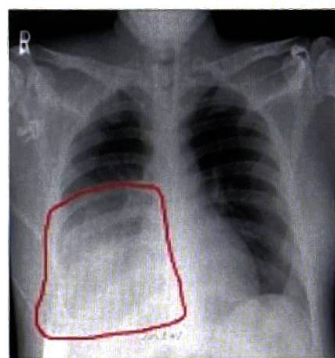


Active space

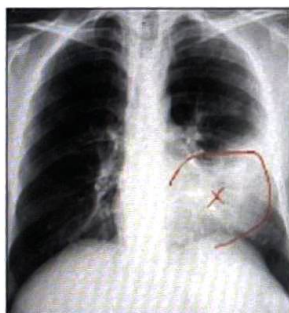
Areas of lung involved in various silhouette signs :



Opacity in right upper zone, right mediastinal border is obscured : Consolidation of anterior segment of RUL



Sharp margin of right dome of diaphragm is obscured : Consolidation of RLL.



Haziness in the left paracardiac area and left heart border is obscured : Consolidation of lingular segment of LUL.



Sharp margin of left dome of diaphragm is obscured : Consolidation of LLL.

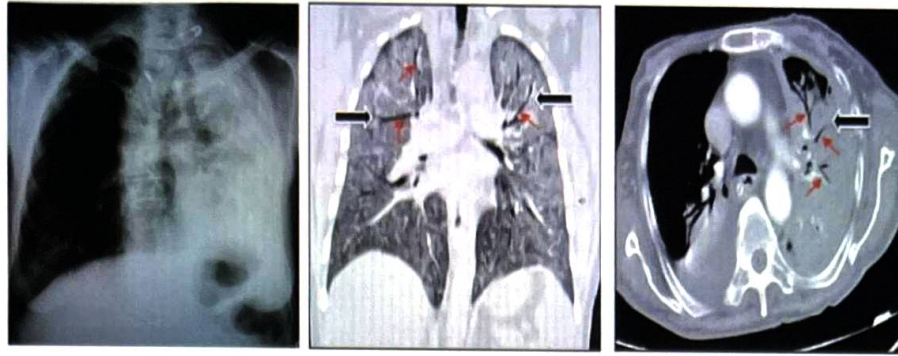
**Air bronchogram sign**

00:34:31

Visualization of **black lines** within a consolidated lung/ linear branching pattern, can be seen in pulmonary edema, pulmonary hemorrhage, tumors.  
 m/c condition : **infective consolidation**. (Lung density is water, bronchiole density air).

Active space





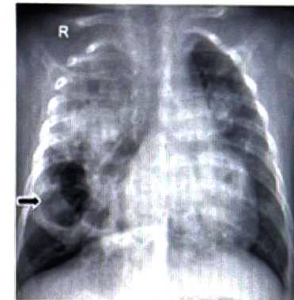
## Lung infections with clinical scenarios

00:38:02

Clinical scenario 1 :

H/o : Fever, cough with expectoration, breathlessness.

On Rx with antibiotics.



Findings :

Single/multiple air filled cysts : Pneumatocele.

Pneumatocele is an etiological pointer to **Staphylococcal pneumonia**.

In community acquired pneumonia (mainly Streptococcal/ Pneumococcal) : No pneumatocele.

Clinical scenario 2 :

H/o : Chronic alcoholic/ debilitated patient. Fever, cough with expectoration, breathlessness.



Findings : Cavity (50%), consolidation with bulging of fissure (bulging fissure sign) seen in **Klebsiella pneumonia**.

Clinical scenario 3 :

H/o : Less prominent signs of LRTI, more prominent constitutional symptoms headache & myalgia.



Findings : Atypical findings, reticulonodular pattern of consolidation. Infection : **Atypical/mycoplasma pneumonia**.

60c0b3eaa8ded0e4e7e7ea7

## Clinical scenario 4 :

- Acute outbreak within 2 to 8 days of an indoor gathering.
- Signs of LRTI.
- GIT involvement : Nausea, vomiting & diarrhoea.
- CNS involvement : Headache, confusion, lethargy.
- Water borne. Source : Infected water in ACs/coolers.
- Blood investigations : Hyponatremia.



## Findings :

Delayed imaging findings that also clear late.

Bilateral multifocal consolidations seen.

Infection : *Legionella pneumoniae*.



## Clinical scenario 5 :

- K/c/o HIV,  
CD4 <200 cells/mm<sup>3</sup>.
- Insidious onset dyspnea, non productive cough.

## Findings :

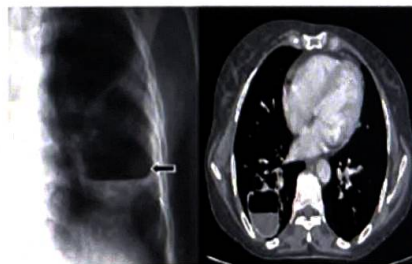
- Reticular interstitial opacities : Central perihilar regions.
- Subpleural blebs/pneumatoceles.
- HRCT : Central perihilar ground glass opacities.

In case of HIV, consider Pneumocystis pneumonia & TB.

Infection : *Pneumocystis pneumoniae*.

## Clinical scenario 6 :

- Chronic alcoholic, found unconscious.
- Later develops cough with expectoration, high grade fever.



## Findings :

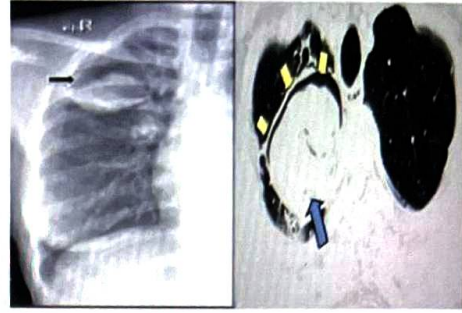
60c6b3eaa8ded0e4e7e5ea7  
Cavitary lesion in the lung with an air fluid level.

+/- surrounding consolidation.

Infection : *Lung abscess*.

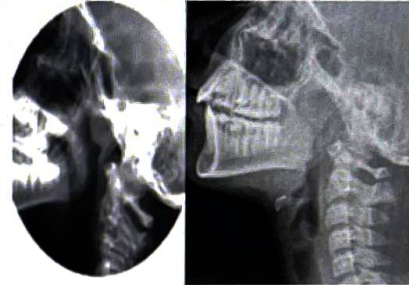


Clinical scenario 7 :  
 Old k/c/o TB with pre existing  
 cavity.  
 Asymptomatic/occasional  
 cough with hemoptysis.



Findings :  
 Lung cavity with mobile dependent contents : **monod sign** in  
 aspergilloma.  
 Infection : **Aspergilloma**.  
 Also called air crescent sign (misnomer), descriptive of  
 invasive aspergillosis.

Clinical scenario 8 :  
 8 year old child with persistent  
 rhinorrhoea, nasal congestion.  
 Also has 2 episodes of otitis  
 media.



Normal

Adenoid  
enlargement

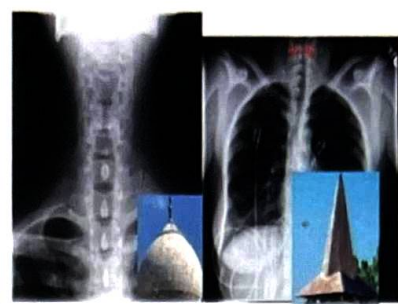
Findings :  
 Nasopharyngeal lateral radiograph : **Bulged soft tissue** with  
 compromise of airway.  
 Infection : **Adenoid enlargement**.

Clinical scenario 9 :  
 4 year old child : H. influenza B  
 infection.  
 C/o fever, change in voice with  
 difficulty speaking, inspiratory  
 stridor.



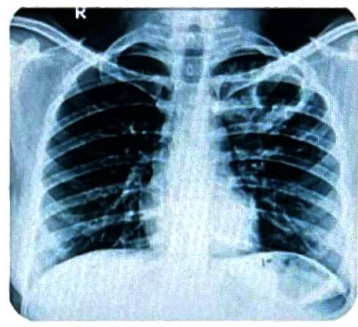
Findings :  
 Nasopharyngeal lateral radiograph showing epiglottitis is **thickened**  
 called **thumb sign**.  
 Infection : **Acute epiglottitis**.

Clinical scenario 10 :  
3 years old child with protracted barking cough, inspiratory stridor.



Findings :  
Neck AP radiograph shows tapering and elongated subglottic airway called **steeple sign**.  
Infection : **Croup/acute laryngotracheobronchitis**.

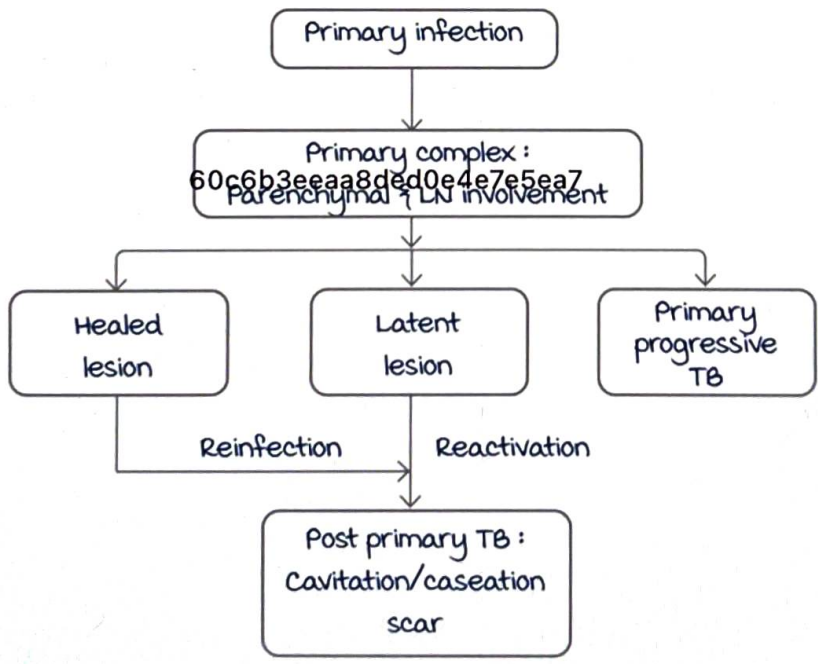
Clinical scenario II :  
22 year female, cough with expectoration since last 1 month, low grade fever.



Findings :  
CXR PA view : **multifocal patchy consolidation, round cavity**.  
Infection : **Tubercular consolidation with cavitation**.

**Tuberculosis**

00:58:53



Primary infection is 1<sup>st</sup> exposure of the tuberculous bacillus to the body, **no hypersensitivity** (cavitation is never seen in primary TB).  
Primary complex also called **Ghon's focus**.

Active space



Primary TB usually occurs in childhood.

If immune status is reduced, reactivation of latent infection can occur (post primary TB) and is the most common form of TB in adults in India.

It is the 2<sup>nd</sup> exposure to the body.

There is hypersensitivity reaction.

Cavitation is the hall mark of post primary TB.

Post primary TB :

Image 1 : An adult in India with persistent cough, consolidation in upper lobe of lung with lung cavity → Apical fibrosis → Shift of trachea and mediastinum.

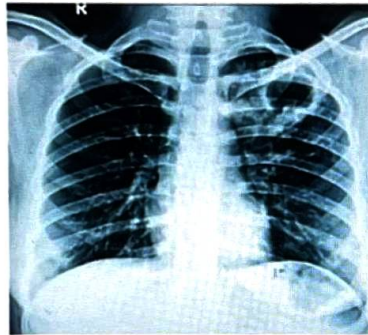


Image 1

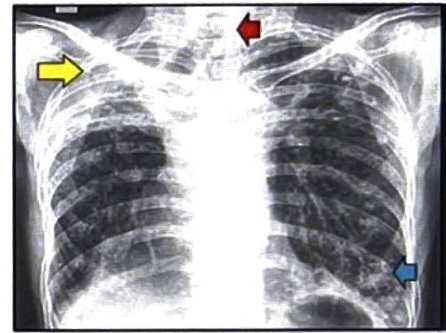


Image 2

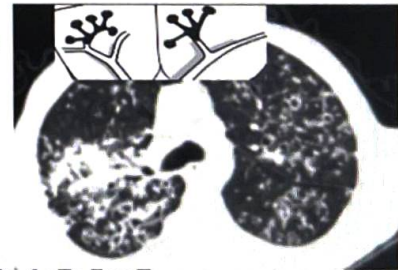
Image 2 : K/C/O post primary TB with RUL fibrosis, volume loss. Trachea is pulled to right side.

Tree in bud opacities is not specific for TB, but is mostly seen in TB.

Bronchogenic spread of infection : multiple budding appearance.

Seen in any form of bronchiolitis.

60c6b3eaa8ded0e4e7e5ea7



## Miliary tuberculosis

01:04:38

multiple tiny discrete nodules : 1 - 3 mm of size.

Created from hematogenous spread of disease.

Scattered in both lung fields, LL > mid/upper lobes + mild interstitial thickening.



Types of nodule distribution :

Centrilobular.

Perilymphatic.

Randomly distributed nodules - miliary TB.

Investigation of choice : HRCT.

60c6b3eaa8ded0e4e7e5ea7

miliary nodules (millet seed like) can be seen in :

Infections :

TB, Healed varicella infection, Histoplasmosis,  
Brucellosis, Blastomycosis, Coccidioidomycosis,  
Cryptococcosis.

Cardiac :

Prolonged mitral stenosis (causing backload over  
pulmonary vasculature), Prolonged pulmonary  
edema.

Neoplastic :

Lymphangitis carcinomatosa, metastasis,  
Lymphomas, Leukemia.

Pneumoconiosis :

Coal worker's pneumoconiosis, Silicosis.

Allergic : Loeffler's syndrome.

Others : Sarcoidosis, alveolar microlithiasis.



## Eponyms in TB

01:09:17

**Ghon's focus/lesion** : Lung parenchymal involvement in primary TB (area of consolidation/scar/calcification but never a cavity).

**Ghon's complex** : Ghon's focus + involvement of lymphatics + involvement of hilar lymph nodes.

kumarankitindia1@gmail.com

**Ranke's complex** : Calcified Ghon's complex.

**Simon's focus** : Apical lung nodule originating from extra pulmonary primary TB.

**Assman's focus** : Reactivation of Simon's focus.

**Puhl's lesion/Aschoff Puhl reinfection** : Isolated lesion of chronic pulmonary TB in apex.

**Weigert focus** : Sub intimal caseating focus in the pulmonary vein.

**Rasmussen's aneurysm** : Aneurysm involving pulmonary artery and can give rise to torrential hemoptysis.

# SILHOUETTE SIGNS AND LUNG INFECTIONS : PART - 2

60c6b3eaaa8ded0e4e7e5ea7

## COVID 19

00:00:33

Overall investigation of choice (IOC) : RT-PCR test.

Imaging :

- 1<sup>st</sup> choice : Chest X ray.
- Overall IOC (imaging) : HRCT chest.

Chest x ray :

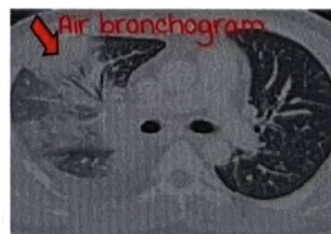
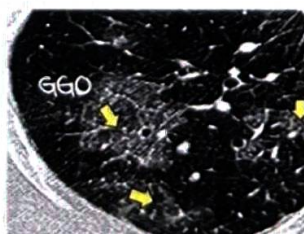
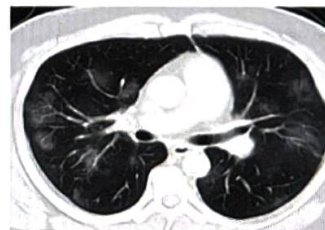
- Normal in most early cases.
- Airspace opacities (consolidation/GGO) : B/L peripheral & lower zone are predominantly affected in COVID.
- mainly used for follow up of cases.
- Daily X rays can be done to see the progress of infection.
- IOC (Imaging) : HRCT Chest
- MC imaging finding in COVID 19 (in HRCT) : Peripheral, multifocal, ground glass opacities (GGO).
- In HRCT, normal lung lucency, consolidation, GGO, crazy pavement appearance, Atoll/reverse halo sign : All these are seen in COVID19.



Normal lung on HRCT : Deep grey with white dots/lines which suggest blood vessel and central black area which are bronchi containing air.



Normal



Active space

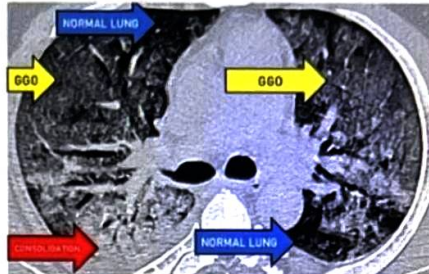


**GGO** : Hazy increase in lung density without obscuration of underlying blood vessels.

60c6b3eaaa8ded0e4e7e5ea7

**Consolidation** : marked increase in lung density with obscuration of underlying blood vessels.

Air bronchogram may be seen.



Stages of COVID 19 based on imaging

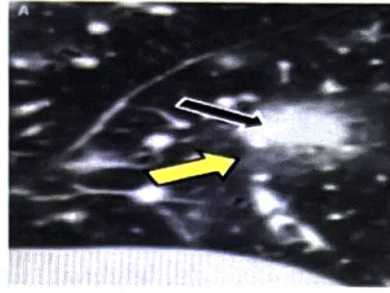
00:09:24

Stages	Imaging	Image
Group 1 : Pre clinical stage.	Uni/bi lateral, few multifocal Ground Glass Opacifications (GGO).	
Group 2 : 1 <sup>st</sup> week after onset. Patient presents with fever & respiratory symptoms.	Bilateral, Diffuse Subpleural GGO ± septal thickening. Thickened inter & intralobular lines : Crazy paving pattern.	
Group 3 : 2 <sup>nd</sup> week after onset.	Diffuse GGO is still the main finding, but consolidation may also be seen.	
Group 4 : 3 <sup>rd</sup> week after onset.	GGO + consolidation + reticular pattern, s/o Interstitial changes/fibrosis.	

Active space

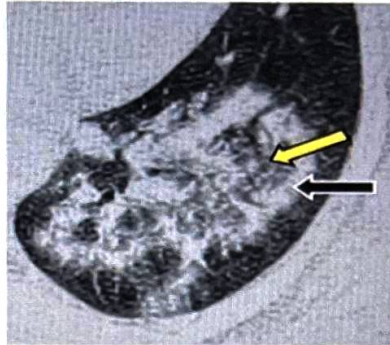
**Halo sign :**

Seen in invasive aspergillosis (central consolidation + peripheral halo of GGO).



**Reverse halo sign/Atoll sign :**

Central GGO + peripheral halo of consolidation, seen in COVID 19, Cryptogenic Organizing Pneumonia (COP).



**CT involvement score :** Objective assessment about how much lung is involved.

Scoring scale : Each lobe (3 right lobes & 2 left lobes).

- No involvement : 0 (minimum).
- < 5 % : 1.
- 5 - 25 % : 2.
- 25 - 50 % : 3.
- 50 - 75 % : 4.
- > 75 % : 5.

kumarankitindia1@gmail.com

Assess the % of each lung lobe involved :

Lung lobe	Score
RUL	0 - 5
RML	0 - 5
RLL	0 - 5
LUL	0 - 5
LLL	0 - 5

Total score : 0 - 25.

Active space



**CORADS : COVID 19 Reporting and Data System**

00:15:00

Probability/likelihood of an infection due to COVID.

Corads 1	Highly unlikely	Normal.
Corads 2	Unlikely	Abnormality : Pleural effusion/lymphadenopathy (not seen in COVID).
Corads 3	Equivocal	Single GGO (peripheral).
Corads 4	Probable	3 peripheral GGO.
Corads 5	Highly likely	multifocal, peripheral GGO + consolidation + Atoll sign/ reverse halo sign or crazy pavement sign.
Corads 6	RT-PCR proven	Image findings are not considered if RT-PCR positive.

**Siemens**

Based on differential radiographic density theory.

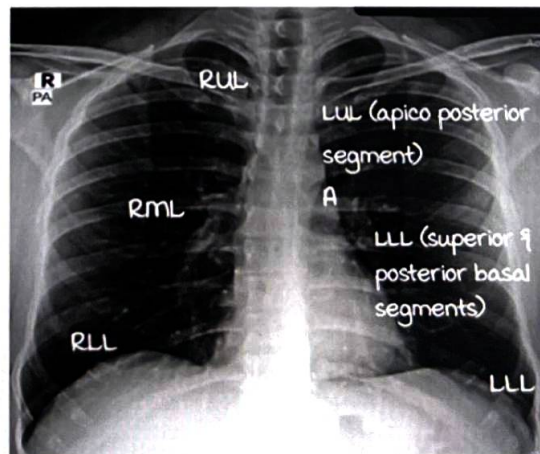
Theory states that :

Only 5 densities can be seen separately.

A sharp margin can be seen when 2 different densities are located adjacent to each other.

Through margins, we can see which lobe exactly is diseased/ abnormal.

Lobar/segmental localization of disease possible.



Active space

margins of	Adjacent diseased lobe
Right upper mediastinum	RUL
Right heart	RML
Dome of right diaphragm	RLL
Aortic knuckle	LUL (apico posterior segment)
Lateral margin of descending thoracic aorta	LLL (superior & postero basal segments)
Left heart	Lingula
Dome of left diaphragm	LLL

### Etiological diagnosis of pneumonitis

possible in some cases

00:19:03

Pneumatocele	Staphylococcal pneumonia. Rarely, Pneumocystis pneumonia.
Central GGO	Pneumocystis pneumonia.
monod sign	Aspergilloma.
Bulging fissure sign	Klebsiella pneumonia.
Interstitial opacities	Atypical/mycoplasma pneumonia.

### Tuberculosis (TB) :

- Cavitation never seen in primary TB.
- Cavitation always seen in post primary TB.
- Tree-in-bud opacities (named specific entities of TB).
- miliary shadows (named specific entities of TB).
- Apical involvement + cavity : Post primary TB.

### Covid imaging :

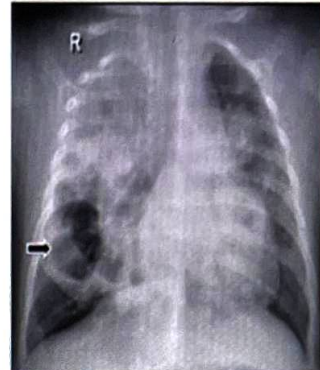
- 1st Investigation : CXR.
- IOC : HRCT Chest.
- mc Imaging finding on HRCT : Peripheral multifocal GGO.
- most specific test : RT-PCR for COVID 19.
- CT severity score : 0 to 25.
- CORADS : Probability of a particular infection being COVID.

60c6b3eeaa8ded0e4e7e5ea7



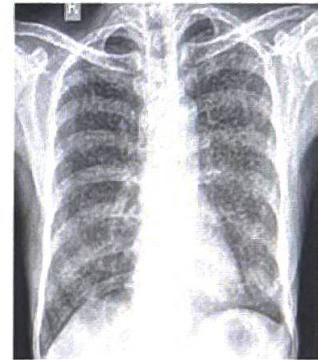
Q. A child is presents with high grade fever, cough and elevated TLC. He is put on IV antibiotics. On the 5th day of illness a CXR is done and is shown here. This child is most likely suffering from ? (AIIMS Nov 2017 pattern)

- A. Klebsiella pneumonia.
- B. Pneumocystis pneumonia.
- C. Staphylococcal pneumonia.
- D. TB.



Q. Based on this image findings, patient may be suffering from all of the following except? (NEET 2019 pattern / FMGE Aug 2020 pattern)

- A. TB.
  - B. Varicella pneumonia.
  - C. Lymphangitis carcinomatosa.
  - D. Klebsiella pneumonia.
- (never gives rise to miliary nodules).



miliary nodules

Q. True regarding CORADS is ? (INICET Nov 2021 pattern)

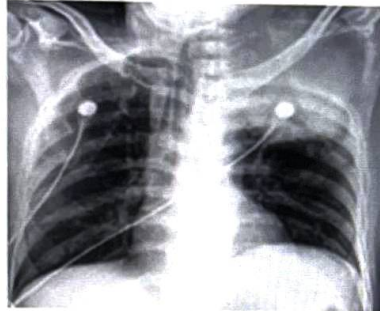
- A. CORADS 0 is normal lung.
- B. CORADS 5 is typical COVID.
- C. Pleural thickening is typical of COVID.
- D. COVID can present with lobar consolidation.

## MEDIASTINUM : LUNG TUMOURS AND MISCELLANEOUS

### Clinical scenarios

00:00:09

Q. A 65 year old smoker presents with cough and hemoptysis. His CXR is shown here. He has also developed left sided Horner's syndrome and left upper limb pain and paraesthesia. most likely diagnosis is?



- A. Hydatid cyst.
- B. Pulmonary metastasis.
- C. Pancoast tumor.
- D. Loculated effusion.

**Explanation :** Elderly smoker with cough & hemoptysis : Clue towards neoplasm.

60c6b3eaaa8ded0e4e7e5ea7

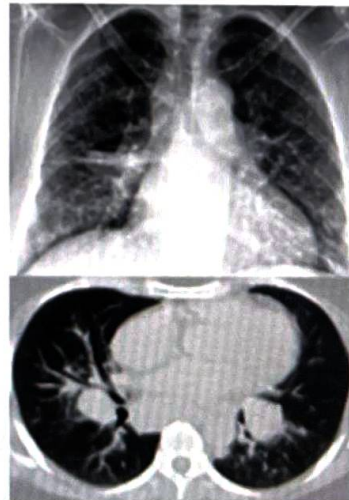
CXR shows loculated left apical effusion.

Horner's syndrome : Involvement of cervical sympathetic ganglia.

Upper limb pain and paraesthesia : Nerve root involvement (probably of brachial plexus).

Q. All lung carcinomas for diagnosis requires CECT thorax but MRI is useful in which of the following?

- A. Small cell lung carcinoma.
- B. Adenocarcinoma.
- C. Carcinoid.
- D. Pancoast tumor.



Q. A 35 year old female patient presented with fever, weight loss and elevated ACE levels. A CXR reveals bilateral convex hilar shadows as shown here. most likely diagnosis is?



- A. TB.
- B. Silicosis.
- C. Sarcoidosis.
- D. Lung cancer.

Convexity is due Hilar lymphadenopathy.

60c6b3eaa8ded0e4e7e5ea7

### Mediastinum : classification

00:02:51

Anatomical : Heart with pericardium, trachea in middle mediastinum.

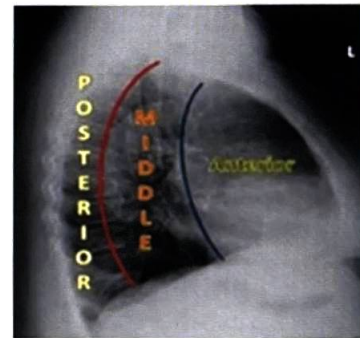
Structures in front & behind them are in anterior & posterior mediastinum respectively.

Less accurate as structures pass across compartments.

more accurate is Radiological/**Felson classification** :

**Line 1** is drawn along the backside of the heart and along the anterior margin of trachea.

**Line 2** connects the dots placed 1 cm posterior to the anterior margin of the thoracic vertebral end plates.



Area between 2 lines is middle mediastinum.

Area in front of line 1 is anterior mediastinum.

Area behind line 2 is posterior mediastinum.

Anterior mediastinum contains heart, thymus gland, retrosternal extension of thyroid gland.

middle mediastinum contains trachea, esophagus, lymph nodes.

Posterior mediastinum contains **neural elements** from spinal canal.

mediastinal imaging :

- 1<sup>st</sup> investigation : Chest X ray.
- Investigation of choice : CT scan.

mediastinal tumors : Contrast enhanced CT.

Investigation of choice for posterior mediastinal lesions :

**Contrast enhanced MRI** to look for spinal involvement as they are neurogenic lesions.

most common lesions of mediastinum :

kumarankitindia1@gmail.com

- Overall, m/c mediastinal mass lesion : **Thymoma**
- m/c anterior mediastinal mass lesion : **Thymoma**
- m/c middle mediastinal mass lesion : **Lymph nodal mass.**
- m/c middle mediastinal mass lesion in children :  
**Foregut duplication cyst (Bronchogenic cyst).**
- m/c posterior mediastinal mass lesion : **Neurogenic tumors**  
(like Neurofibromas, Schwannomas).

Anterior mediastinal lesions : 4T's

- **Thymoma.**
- **Teratoma.**
- **Thyroid lesion with retrosternal extension.**
- **Terrible lymphoma.**

## Thymoma

00:08:54

- m/c mediastinal tumor overall.
- m/c anterior mediastinal tumor.
- m/c tumor of the thymus gland in adults.
- Thymoma is associated with **myasthenia gravis.**
- Shows **uniform homogenous enhancement** on CECT.
- Central area of necrosis, large cystic areas, invasion into adjacent structures suggest **thymic carcinoma.**

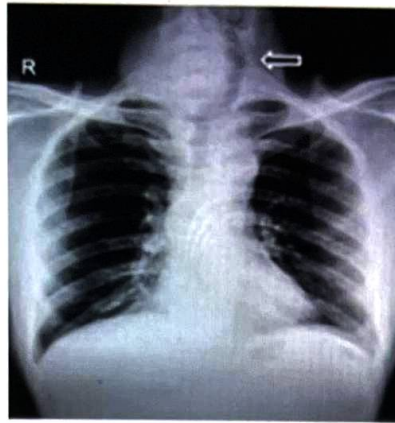


Anterior mediastinal lesions :

Thyroid lesion with retrosternal extension pushing trachea towards left side.

Active space

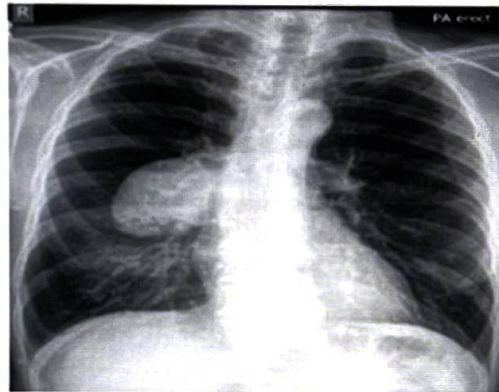




Thyroid mass with retrosternal extension

#### Hilum overlay sign :

Overlay of a lesion on the hilum suggests that the lesion is **not in middle mediastinum**. Hilar blood vessels are seen. It is most commonly associated with **anterior** mediastinal mass. Lesion can be in the posterior mediastinum as well.



#### middle mediastinal lesions :

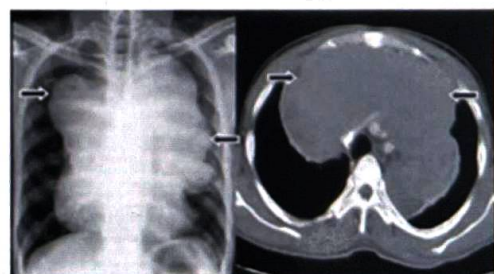
- m/c middle mediastinal lesion in children :  
Foregut duplication cysts (bronchogenic cysts/esophageal duplication cysts).
- m/c middle mediastinal lesion in adults :  
Lymph nodal masses (lymphoma/tubercular lymph nodes).

60c6b3eaa8ded0e4e7e5ea7

**Cervico thoracic sign** : If a lesion extends above the clavicle, it indicates lesion extension into **posterior mediastinum**. Because anterior mediastinum ends at the level of clavicle.

#### Lymphoma :

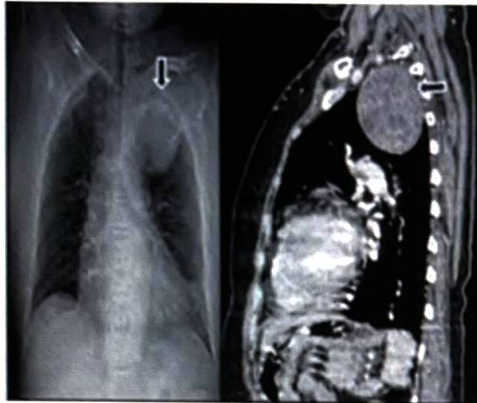
- Lobulated contour, hilum overlay.
- Diffuse low level uniform enhancement.
- No heterogeneity.



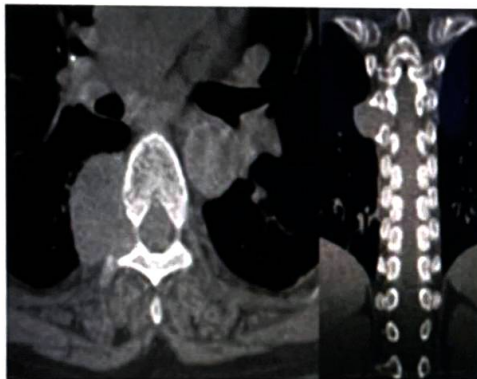
- Lesion extends across anterior, posterior and middle mediastinum.
- Encasement of mediastinal great vessels.

Posterior mediastinal lesions :

- Posterior mediastinum contents : Nerve roots, sympathetic ganglia, thoracic duct, aorta.
- m/c posterior mediastinal mass : **Neurogenic tumors.**
- Investigation of choice : **Contrast enhanced MRI.**

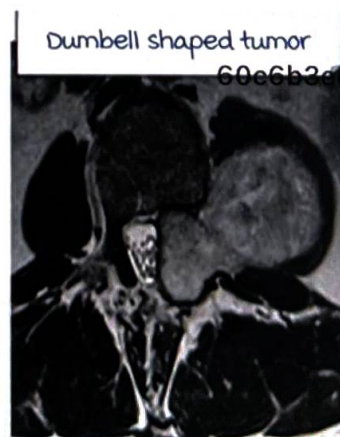


posterior  
 mediastinal  
 lesion extending  
 above clavicle



Neurogenic tumor extending into neural foramen of spinal canal causing widening of foramen.

**Dumb bell shaped tumor** : Arises from spinal cord, extends into and causes **widening of neural foramen** of the spinal canal. Characteristic of **neurogenic tumor**.



Dumbbell shaped tumor

60e6b2c0aa8ded0e4e7e5ea7

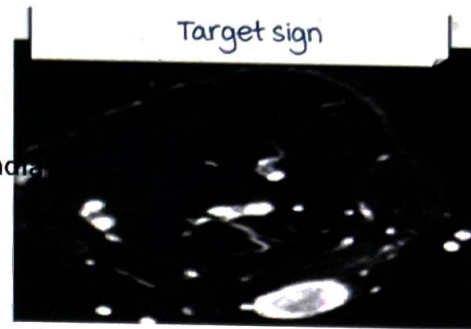
Active space



Target sign :

Seen in **peripheral neurogenic tumors**.

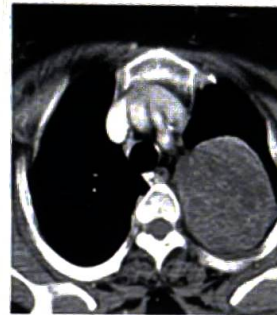
Periphery of the lesion appears bright, and center of the lesion appears dark, giving rise to target shaped appearance on T2 weighted MRI.



Clinical scenario :



Butterfly vertebra



Post mediastinal cystic lesion

vertebral segmentation defect : **Butterfly vertebra/** hemivertebra.

If it is associated with posterior mediastinal cystic lesion, diagnostic of **neurenteric cyst**.

## Pneumo mediastinum

00:20:21

Air in the mediastinum.

1<sup>st</sup> investigation : Chest X ray (ineffective because of air in lung fields).

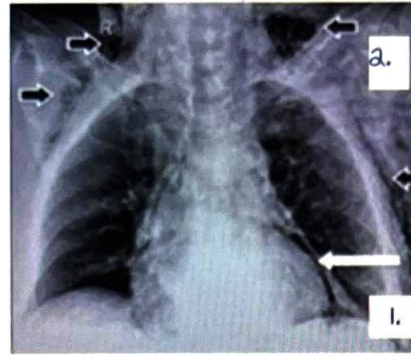
Best/investigation of choice : CT.

IOC to detect minimal fluid anywhere : ultrasound

IOC to detect minimal air anywhere : CT).

Features on chest X ray :

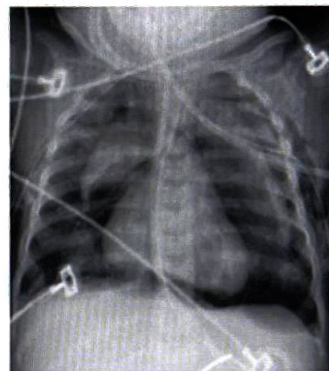
1. **Streaky lucencies** alongside the heart.
2. Air in the base of soft tissue of **neck** (mediastinum & neck are in continuity).



**Spinnaker sign/Angel wing sign :**

Normal : Shadow of thymus gland is prominent in children which is seen as widening of superior mediastinum on X ray. Sharp margins of the thymic lobes are not seen as it merges with mediastinal soft tissue.

In pneumomediastinum, very sharp margin of thymic lobes are seen & they look like wings : Angel wing sign/spinnaker sign.



**Continuous diaphragm sign :**

Central tendon of diaphragm is not seen as a sharp margin normally (as heart & central dome are of same density).

In pneumomediastinum, sharp margin of central tendon of diaphragm is seen (trapping of free air between heart & central tendon).

Continuous tracing of the diaphragm is possible due to lucent band below the base of the heart & above central tendon.

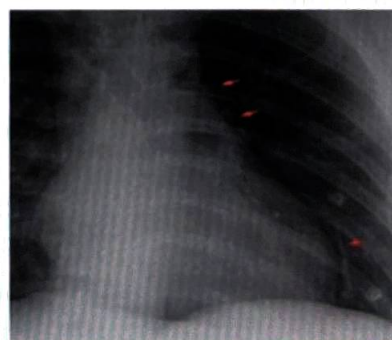
**Naclerio's V sign :**

V shaped lucency is seen as the air lines the lateral margin of descending thoracic aorta & the medial margin of left hemidiaphragm.

It has been described in pneumomediastinum due to esophageal rupture though not specific.

**Other signs :**

- Tubular artery sign
- Ring around the artery sign
- Double walled bronchial signs.



Active space



## Solid lung lesion

00:26:28

< 3cm : **Nodule**.

> 3 cm : **mass** (always be evaluated further by biopsy/PET scan to rule out malignancy).

Solitary pulmonary nodule (SPN) :

- Definition : Single nodule < 3 cm (solid lesion) within the lung.

60c6b3eeaa8ded0e4e7e5ea7

- 1<sup>st</sup> investigation : **Chest X ray**.
- Investigation of choice : **CECT > PET-CT**.
- malignancy should be ruled out by **CECT**.



CECT uses multiple parameters to

asses the nodule and classifies as low/intermediate/high risk for malignancy.

Low risk : Follow up.

High risk : Biopsy the lesion.

Question :

25 year old male presents with solitary pulmonary nodule on chest X-ray. CT shows lung nodule with coarse calcification. What is the diagnosis?

Answer : **Pulmonary hamartoma**.

**Popcorn calcification** is a feature of pulmonary hamartoma (multilobulated with coarse calcification).



Pulmonary hamartoma is

associated with **Carney's triad** :

- multiple lung hamartomas.
- Gastrointestinal stromal tumors (GIST).
- Functioning paragangliomas/pheochromocytomas.

Lung tumors (mass >3cm) :

1<sup>st</sup> investigation : Chest X ray.

Best/investigation of choice : CECT.

(Exception is Pancoast tumor : CE-MRI).

PET-CT is used for distant metastasis & tumor staging.

Specific lung tumors (based on HPE) :

Adenocarcinoma : (mnemonic : Adeno = Away)

- Peripheral location.
- m/c type overall.
- m/c type in women.

Squamous cell carcinoma :

- Central location.
- m/c type to show cavitation.
- m/c type associated with pancoast tumor.
- m/c cancer in smokers.

Bronchiolo alveolar carcinoma (Adenocarcinoma in situ) :

- Origin : Type 2 pneumocytes.
- usually presents as consolidation/air bronchograms (non resolving infection).
- Endobronchial spread : Lepidic pattern of spread.

kumarankitindia1@gmail.com

Small cell carcinoma :

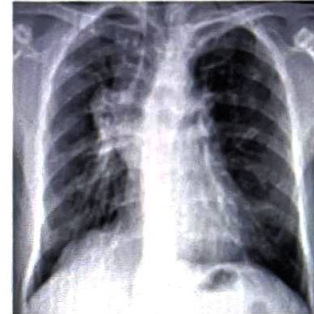
- most aggressive subtype.
- Fastest growth : Worst prognosis.
- Central/peri hilar in location.
- Presents with paraneoplastic syndromes, necrosis, SVC obstruction.
- Prophylactic craniospinal irradiation is given (propensity for neural spread).

Usually presents with metastasis.

Lung tumor may present as :



- Lobulated/solid appearing mass.
- Corona radiata appearance : (extension of tumor into adjacent lung tissues) :
- Hilar lesion (elevated ipsilateral dome of diaphragm) indicates phrenic nerve involvement.



### Pancoast tumor (superior sulcus tumor)

00:36:12

Typical history :

- Elderly male, chronic smoker presents with cough/hemoptysis/weight loss.
- On imaging, mass like opacity in left lung apex, left sided Horner's syndrome (invasion of cervical sympathetic ganglia), left upper limb pain, paraesthesia and weakness (invasion of brachial plexus).

Horner's syndrome :

Partial ptosis, enophthalmus, anhidrosis, miosis.

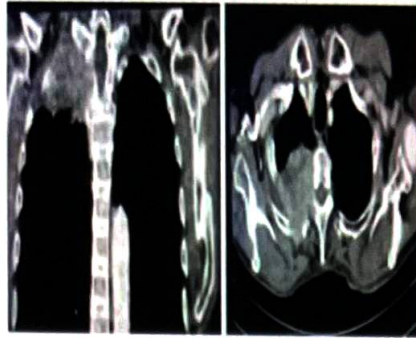
- Investigation of choice : CE-MRI.

kumarankitindia1@gmail.com



Bony destruction on chest X ray indicates lesion is 100% malignant. Eg., Rib destruction.

Active space



CT showing apical lesion with bony erosion.

Clinical scenario :

75 year old male K/C/O renal cell carcinoma. CT reveals ?

Diagnosis :

Cannon ball lung metastasis

(hematogenous spread).

Seen in RCC, choriocarcinoma, germ cell tumors, endometrial carcinoma, prostate cancer.

multiple large nodules

miliary nodules in TB are tiny nodules.



multiple large nodules

Q. 35 year old female presents with persistent cough, expectoration and intermittent hemoptysis along with recurrent chest infections.

Diagnosis : Bronchiectasis.

multiple round cystic lucent areas on both sides → Bronchi dilatation → Bronchiectasis (irreversibly dilated bronchi).

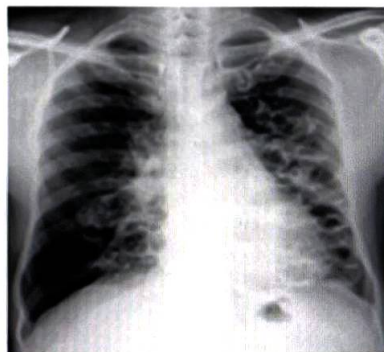
1<sup>st</sup> investigation : Chest X ray.

Best investigation/IOC : HRCT

(Cyst within the lung : Thin walls;

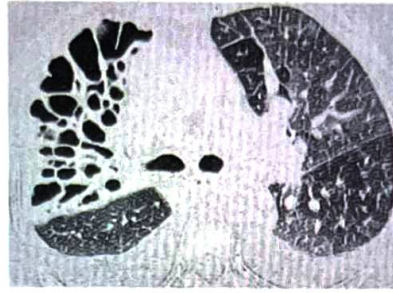
Dilated bronchi (air filled cystic

lucency) : Thick walls



Active space





Bunch of grapes sign

Signs in bronchiectasis :

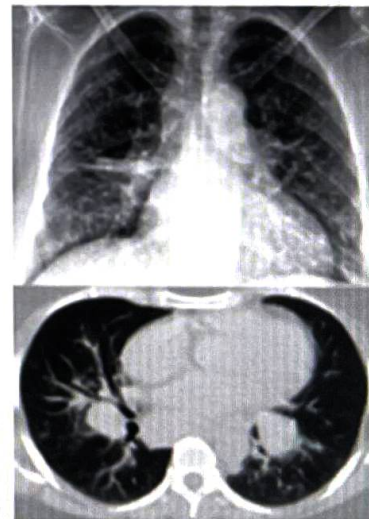
Radiological findings	Appearance/sign
Clumped appearance of bronchi on CT.	Bunch of grapes sign.
Dilated bronchi with straight walls.	Tram track appearance.
Varicose dilatation of bronchial wall.	String of beads appearance.
Bronchi dilatation compared to blood vessel.	Signet ring appearance.
Fluid in bronchiectatic segment (called Bronchocele).	Gloved finger appearance.

**Clinical scenarios**

00:44:48

Q. A 35 year old female patient presented with fever, weight loss and elevated ACE levels. A CXR reveals bilateral convex hilar shadows as shown here. most likely diagnosis is?

- A. TB.
- B. Silicosis.
- C. Sarcoidosis.
- D. Lung cancer



Features on imaging :

Bilateral hilar and paratracheal

lymphadenopathy is a peculiar feature, gives rise

to lambda or 1-2-3 or garlands sign or pawnbroker's sign.

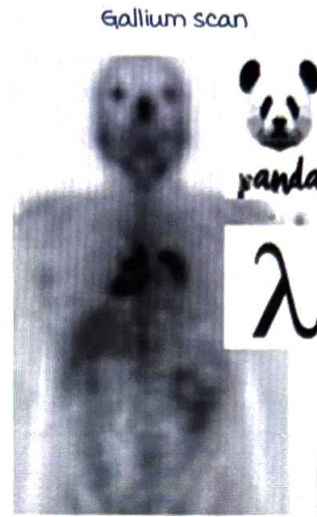
Sarcoidosis : Non caseating granulomatous disease.

Active space

Gallium scan :

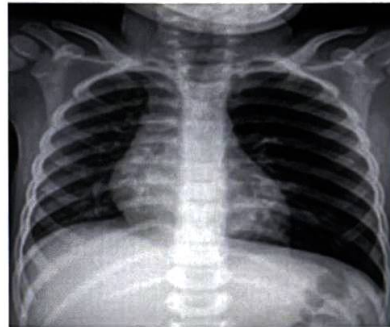
Hot spots are seen → **Panda sign**  
(uptake of gallium within  
**lacrima and parotid glands** with  
superimposed central **normal**  
uptake in the **nasopharynx**).

**Lambda sign** : Right  
paratracheal, right hilar and left  
hilar lymph node involvement.



Q : 2 year old child presented with sudden onset  
breathlessness, wheezing & hyperlucency involving the  
right hemithorax on chest X ray. What is the most likely  
diagnosis?  
kumarankitindia1@gmail.com

- A. Pleural effusion.
- B. Consolidation.
- C. Foreign body  
aspiration.
- D. Pneumothorax



(Child with acute  
onset respiratory distress).

m/c foreign body to be aspirated : **Peanut**.

It is **radiolucent** (not visible on X ray).

Presents with air trapping as bronchi collapses during  
expiration.

In advanced cases, entire lung appears **opaque** due to  
**collapse**.

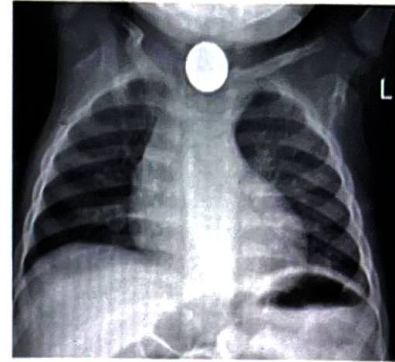


Q. Child with mild discomfort in the neck region and difficulty swallowing.

Diagnosis : Coin in esophagus.

Points in favor :

- No respiratory distress.
- Orientation of the coin is in coronal plane (en face).



coin should be oriented in sagittal plane at the glottis because of its structure to enter the trachea.

Tracheal cartilages hold the coin in the same plane.

Also, child presents with respiratory distress.

Clinical insights :

mediastinal chamber based diagnosis :

- Anterior mediastinal mass with homogenous uniform enhancement, anterior to the great vessels in the prevascular space : **Thymoma**.
- Large lobulated middle mediastinal mass that extends across the compartments : **Lymph nodal mass**.
- most common posterior mediastinal mass : **Neurogenic tumor**.

Investigation of choice for all mediastinal masses is CECT except posterior mediastinal masses (CE-MRI).

For lung tumors, investigation of choice is CECT except Pancoast tumor (CE-MRI).

Sarcoidosis : B/L hilar lymphadenopathy on X ray and lambda & panda sign on gallium scan are specific features. multi system disorder.


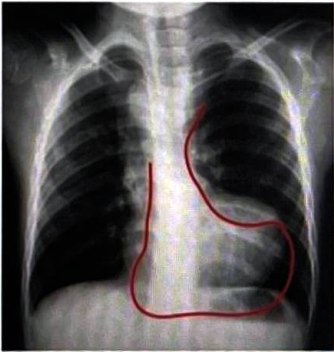
A child with acute onset respiratory distress is a history clincher for foreign body aspiration.



# CONGENITAL HEART DISEASE

## Clinical scenarios & imaging

00:00:08

Clinical Scenario	Radiology
<p>A 30 year old female presented with hypertension, chest pain and cramping of legs. A CXR was done and is shown here. What is the most likely cause of hypertension in this patient?</p> <p>A. Aortic aneurysm.                      B. Aortic dissection.                      C. Coarctation of aorta.                      D. Mitral stenosis.</p> <p>Answer: C.</p>	<p>Chest X ray :</p> 
<p>A child presents with cyanosis. A CXR was done and reveals this finding. most likely diagnosis is?</p> <p>A. Transposition of great vessels (TGA).                      B. Tetralogy of Fallot (TOF).                      C. Ebstein's anomaly.                      D. Total Anomalous Pulmonary Venous Connection (TAPVC).</p> <p>Answer: B.</p>	<p>Chest X ray : Boot shaped heart</p> 

Active space

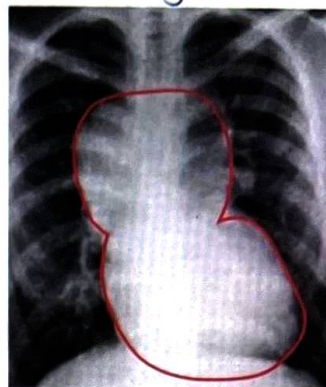


A 12 year old child presented with fever, cyanosis, and fatigue. His chest X ray is shown below. What is the most likely diagnosis?


- A. TAPVC.
- B. TOF.
- C. TGA.
- D. Pericardial effusion.

Answer: A.

Chest X ray :



### Radiology of Congenital Heart Disease (CHD).

Transposition of Great Arteries (TGA).	Radiology
<p>Normal Chest X ray :</p> <p>Pediatric Age :</p> <p>Wide superior mediastinum because of prominent thymus gland.</p> <p>Heart shape : Normal.</p>	<p>60c6b3eaaa8ded0e4e7e5ea7</p> 

In TGA :

Extremely narrow superior mediastinum.

Normally, origin of great arteries lies side by side.

In TGA, they lie one behind the other.

Also, cyanosis due to TGA causes stress and consequent atrophy of the thymus gland.

Heart shape : **Egg on side/ Egg on string appearance.**



Narrow thymus (String)

Broad oval heart (Egg)

kumarankitindia1@gmail.com

**Total Anomalous Pulmonary Venous Return / Connection (TAPVR/C)**

00:05:08

All pulmonary veins normally open into the left atrium.


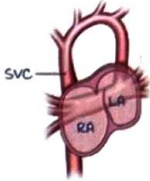
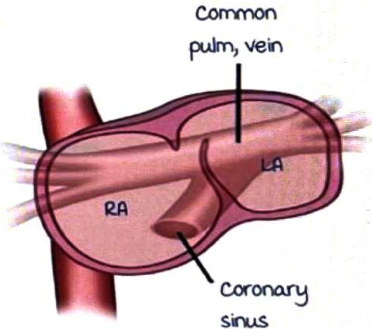
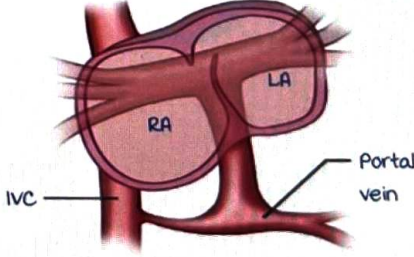
In TAPVR, these veins open into other abnormal sites.

**TAPVR** : When all 4 pulmonary veins drain in an anomalous manner at an abnormal site.

Types based on where they drain.

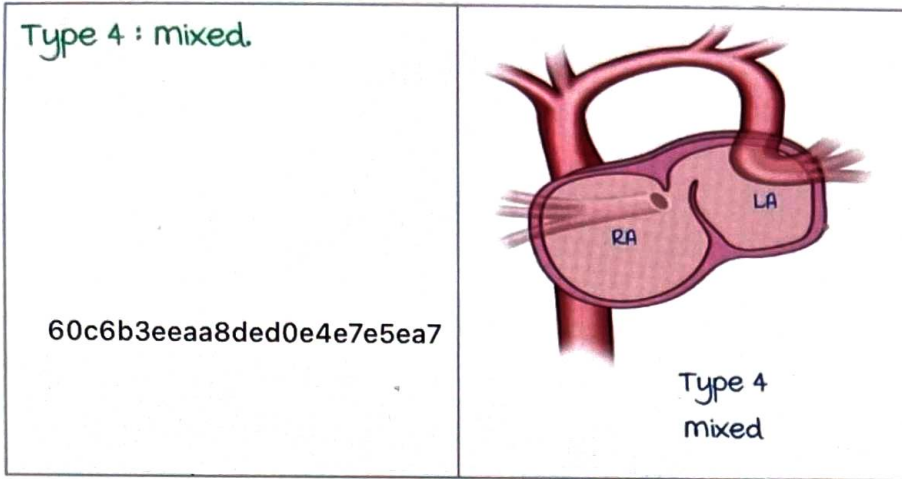
Active space



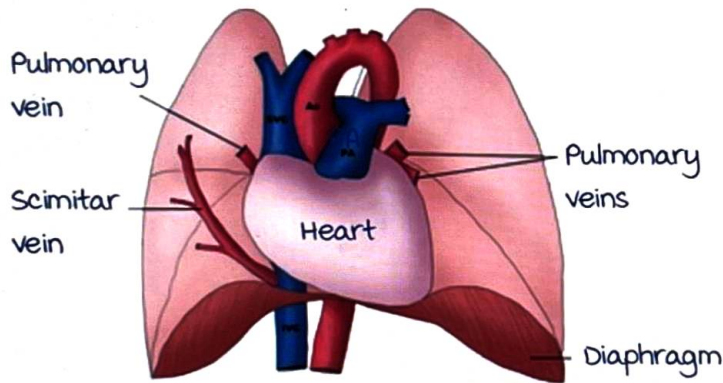
Types of TAPVR.	Features.
<p>Type 1 : Supra cardiac type.                      mc type.</p> <p>Pulmonary veins join to form a common channel behind the heart.</p> <p>This channel forms an anomalous vein, which rises superiorly and joins the innominate vein which eventually drains into the Superior vena cava (SVC).</p>	<p>Snowman's Sign/ Figure of 8 appearance</p>   <p>Type 1 Supracardiac</p>
<p>Type 2 : Cardiac type.</p> <p>When anomalous veins drain within the heart itself into the coronary sinus.</p> <p>Dilated coronary sinus.</p>	 <p>Type 2 Cardiac</p>
<p>Type 3 : Infracardiac type.</p> <p>The anomalous vein develops inferiorly to join the portal vein or the inferior vena cava (IVC) or mixed drainage.</p>	 <p>Type 3 Infracardiac</p>


Active space

60c6b3eaa8ded0e4e7e5ea7



**Partial Anomalous Pulmonary Venous Return (PAPVR) :**  
 3 of the 4 pulmonary veins drain normally into the left atrium and one pulmonary vein drains in an anomalous manner.



PAPVR	Radiology
<p>The anomalous vein is called the <b>Scimitar vein</b>.</p> <p>The scimitar vein usually traverses inferiorly and drains most commonly into the IVC or the hepatic or portal veins.</p> <p>Associated with <b>Scimitar syndrome</b> or <b>hypogenetic lung syndrome</b>. (Scimitar : Turkish sword).</p>	

Active space



**Hypogenetic Lung Syndrome :**

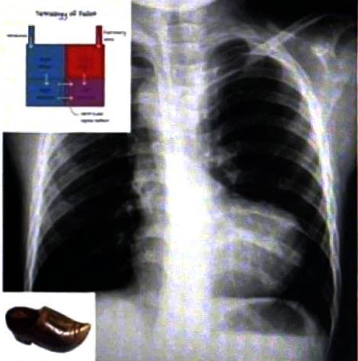
1. Right lung hypoplasia with dextroposition of the heart.
2. Right pulmonary artery hypoplasia.
3. Anomalous blood supply to right lower lobe from Aorta.
4. Scimitar Vein



kumarankitindia1@gmail.com

**Tetralogy of Fallot (TOF)**

00:11:26

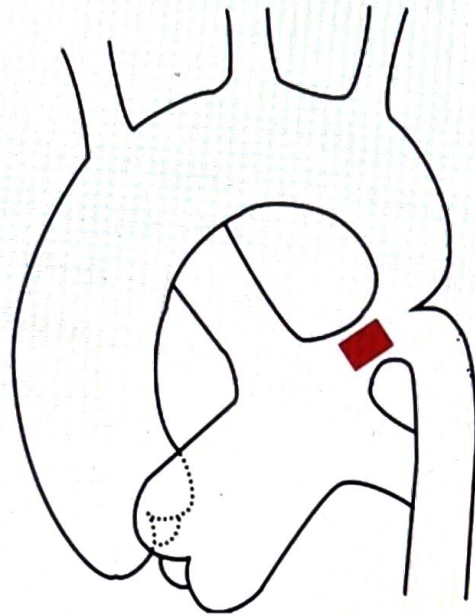
Features	Imaging
<p>Components of TOF are :</p> <ol style="list-style-type: none"> <li>1. Pulmonary stenosis.</li> <li>2. membranous VSD.</li> <li>3. Overriding of the Aorta.</li> <li>4. Right Ventricular Hypertrophy (RVH).</li> </ol> <p>Among these, reason for boot shape : RVH.</p> <p>Cardiomegaly in adults : Left ventricular hypertrophy (in Hypertension) : Apex shifts downwards &amp; outwards.</p> <p><b>RVH : Apex shifts upwards and laterally.</b></p> <p>Associated with right sided aortic arch.</p> <p><b>Heel of the shoe (boot) : Right ventricle.</b></p>	 <p><b>Boot shaped heart or Cor-en-Sabot</b></p>



Coarctation of Aorta:

Narrowing in the Aorta.

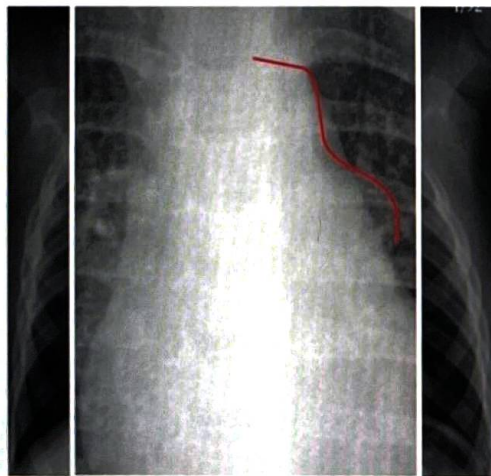
MC: Just distal to the left subclavian, at the attachment of ligamentum arteriosum. 60c6b3eaaa8ded0e4e7e5ea7



Blood supply proximal to coarctation: Good (upper body).

Blood supply distal to coarctation: Poor (Lower body).

Leads to discrepancy in blood pressure between upper and lower limbs, cramping of lower legs and development of collaterals.



Presence of collateral blood supply helps in diagnosis.

Investigation of choice: CT angiogram / MR angiogram.

Gold standard investigation: Catheter angiography.



Chest X ray : **Figure of 3 sign** because of the narrowing and associated dilatation of the proximal subclavian artery and the distal aorta.

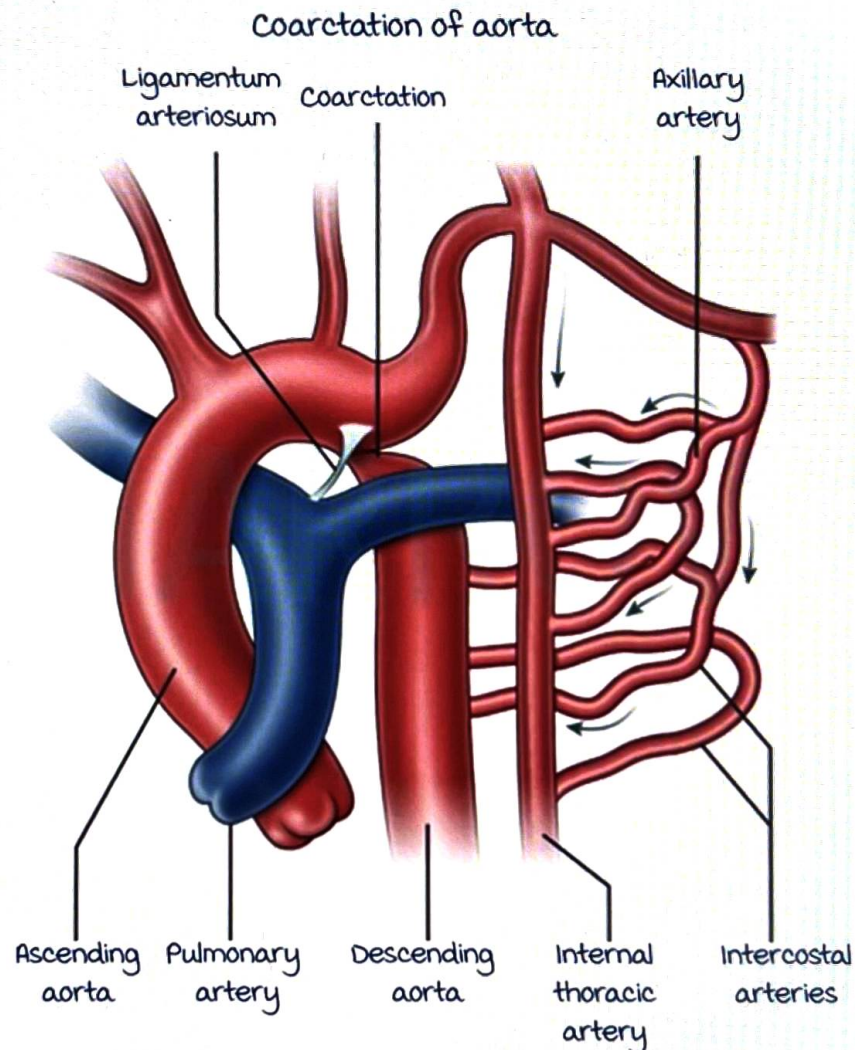
### Reverse 3 sign

00:16:40

Oblique projection in Barium swallow study creates a reverse 3 impression on the **esophagus**.

Collaterals :

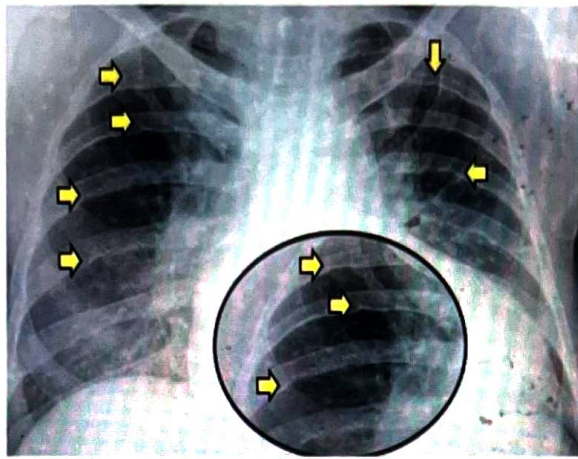
Leads to rib notching called as **Roesler's sign**.



**MC artery** that gives off collateral **Internal thoracic** **mammary artery** that gives rise to intercostal arteries.

The anterior and posterior intercostal arteries (**3<sup>rd</sup>-8<sup>th</sup> Intercostal spaces**) fuse with the distal thoracic aorta and provide blood supply to the lower part of the body.





**Rib Notching :**

The intercostal arteries that form collaterals dilate and become tortuous. These arteries run in the intercostal groove present in the inferior margin of the ribs. The pulsations are transmitted to the inferior margin of the ribs, cause remodeling and produce the inferior rib notching.

Side of Rib notching	Site of Coarctation
<p>Coarctation distal to the left subclavian artery : (mc)</p> <p>Collaterals from right &amp; left subclavian arteries →</p> <p><b>Bilateral rib notching.</b></p>	
<p>Coarctation proximal to left subclavian artery :</p> <p>No collaterals from the left subclavian since it receives less blood supply.</p> <p>Collaterals only from the right subclavian artery.</p> <p>So, only <b>right side rib notching</b> present.</p>	

Active space

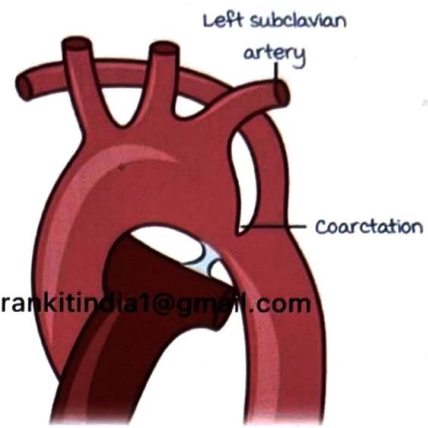


### Aberrant Right Subclavian Artery (ARSA):

Right subclavian artery arising distal to the coarctation site

Collaterals only from the left subclavian artery.

So, only **left side rib notching** present.



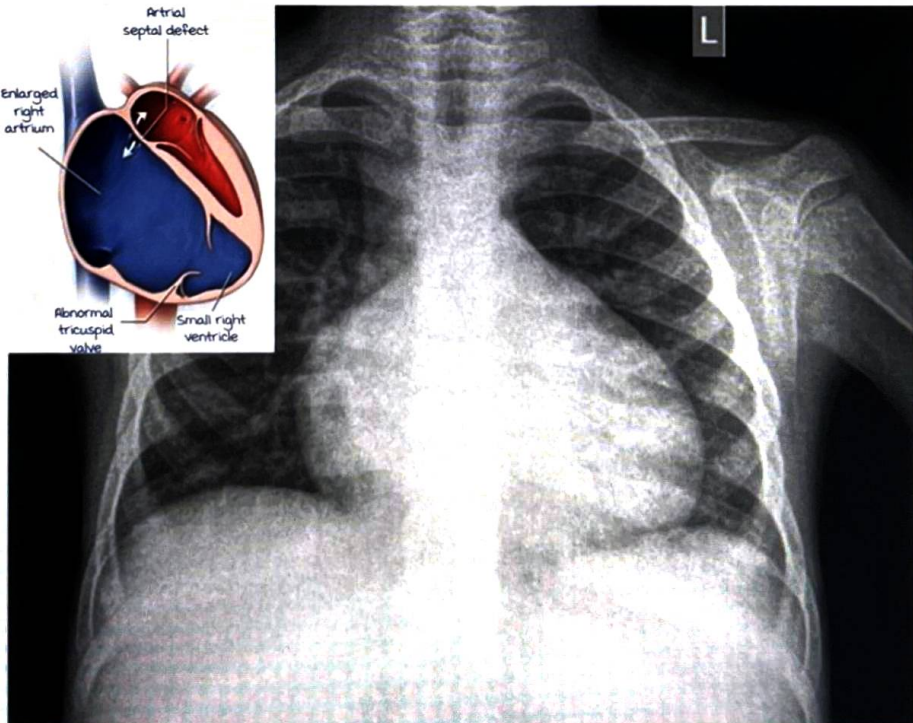
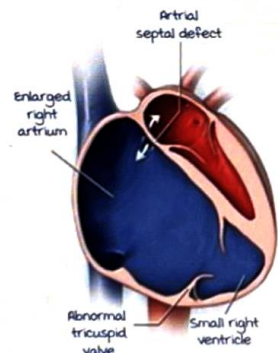
Right subclavian artery arises distal to Coarctation

### Ebstein's Anomaly

00:22:35

**Box shaped heart.**

Pathology: Tricuspid valve displaced more apically. Valve becomes dysplastic and has reflux flow.



ventricles convert into a large atrial cavity called **Atrialization of the right ventricle.**

This leads to the shelved/ box like configuration of the heart.

## Summary :

Cardiac Appearance	Diagnosis
Cor-en-Sabot.	TOF.
Figure of 8/ Snowman's heart.	TAPVC : Supracardiac type. 60c6b3eaa8ded0e4e7e5ea7
Goose neck deformity.	Endocardial cushion defect : Excessive narrowing of the left ventricular outflow tract (LVOT).
Egg on side appearance.	TGA.
Box shaped heart.	Ebstein's anomaly.

Active space

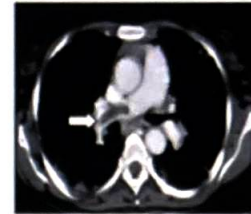


# ACQUIRED HEART DISEASE

## Clinical scenarios

00:00:16

Question 1: 35 year old male with history of 4 weeks of immobilization for fracture femur developed sudden onset chest pain and hemoptysis. ECG shows SI, Q3, T3 pattern. CE-CT was done. Diagnosis?

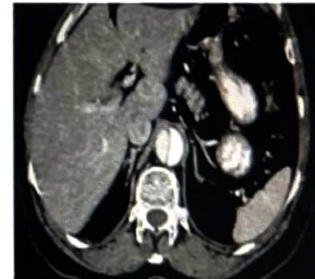


Thrombus is present in pulmonary artery

- A. Acute myocardial infarct.
- B. COPD.
- C. Pulmonary embolism.
- D. Cor pulmonale.

Immobilization for fracture femur → Thrombus due to stasis → Thrombus dislodged from lower limb veins → Into pulmonary vasculature.

Question 2: A 68 year old male, known hypertensive presents with severe tearing sensation and chest pain posteriorly and to the left side. A CE-CT is done and shown here. most likely diagnosis is?



- A. Liver absces.
- B. Aortic dissection.
- C. Aortic aneurysm.
- D. IVC abscess.

In elderly, hypertension is an important risk factor for vascular abnormalities.

In the image, aorta is hyperdense, inside the lumen of aorta: Intimal flap seen (aorta is dissected).

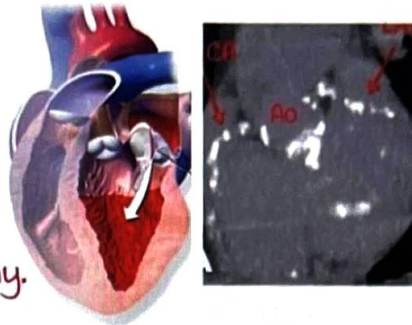
Question 3: True about Agatston score is all except?

- A. Used for estimating the overall calcium burden on the coronary arteries.
- B. Uses NC-CT.
- C. Score < 400 indicates a poor outcome.
- D. Is a semi-quantitative method.

## Mitral stenosis

00:02:21

- mitral valve present in between left atrium and left ventricle gets stenosed.
- m/c valvular lesion in rheumatic heart disease.
- Initial investigation : CXR.
- Investigation of choice for diagnosis : **Echocardiography**.



### CXR findings :

- Earliest sign : LA enlargement (fullness of left atrial appendage beneath the pulmonary artery shadow).
- Elevation of left main bronchus & splaying of carina  $> 90^\circ$ .
- Straightening of left heart border.
- **Third mogul sign** (related to prominences along left mediastinal border).
- **Double density sign** (seen in late stages of LA enlargement) right heart border and enlarged LA .
- Lateral barium esophagus study 4-5 cm **geal impression of enlarged LA** seen (LA is the most posteriorly located, on enlargement it bulges to right, left and posteriorly makes impression due to posterior bulge).
- **Walking man sign** : Related to appearance of bronchi. In a lateral radiograph, it is difficult to differentiate between right and left bronchi as they overlap each other. In mitral stenosis, enlarged LA pushes the Left main bronchus posteriorly, appearing like a walking man.

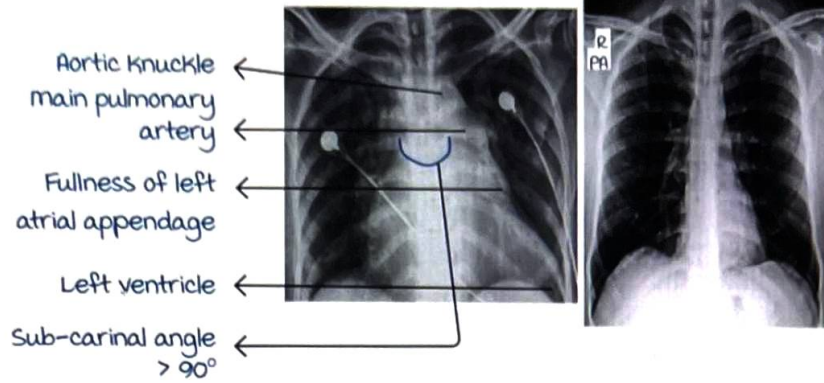
### Echocardiography in mitral stenosis :

- Helps in diagnosis.
- Helps in severity assessment.
- Helps in determining treatment timing.
- Finding : **Valve thickening**.
- **Hockey stick appearance** of anterior leaflet of mitral valve.
- **Fish mouth appearance** of valve orifice.

Active space

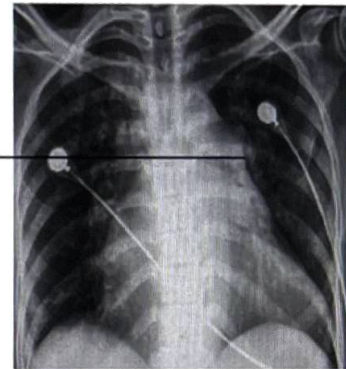


Normal CXR

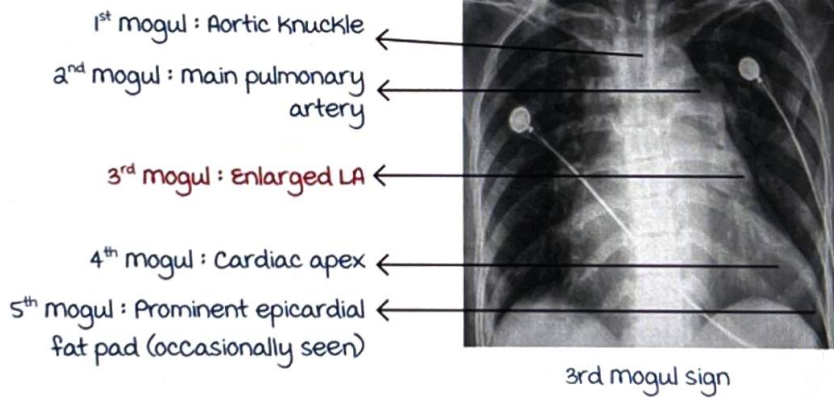


60c6b3eeaa8ded0e4e7e5ea7

Straightened left heart border



mogul : Prominences along left cardiac border

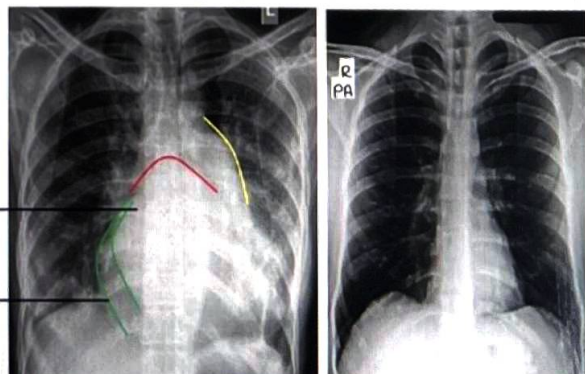


Double density sign

Normal CXR

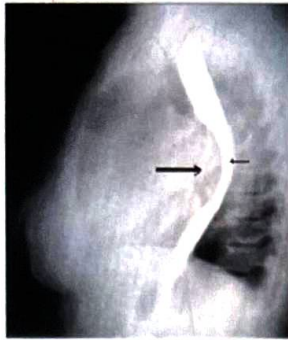
Enlarged LA (projecting on both sides of mediastinum) ←

Normal right heart border ←



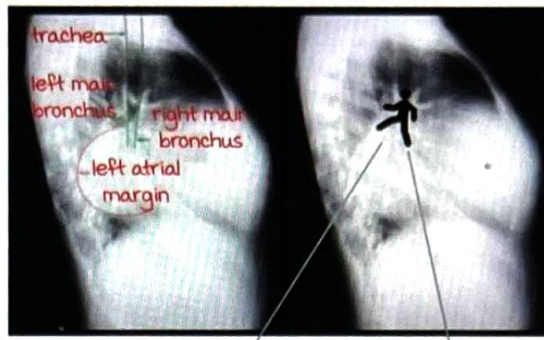
Active space

## Barium swallow



Esophageal impression of enlarged LA.

## Walking man sign



Represents left main bronchus

Represents right main bronchus

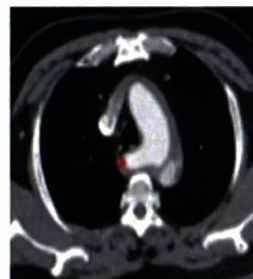
Q. Radiological features of LA enlargement are ?

- Boot shaped heart (seen in TOF).
- Straightening of left heart border.
- Outward shifted apex (apex formed by right ventricle).
- Double atrial shadow (double density sign).
- Splaying of carinal angle.

Answer : B, D, E.

Q. A patient is diagnosed as a case of "dysphagia lusoria" based on this CT image. Identify the image marked by the arrow here?

- SVC.
- Aortic arch.
- Vertebral artery.
- Aberrant right subclavian artery.



Dysphagia lusoria : Dysphagia due to extrinsic compression on esophagus because of abnormal vascular structure  
**Aberrant right subclavian artery (ARSA)**. ARSA is also known as **Arteria lusoria**.

### Congestive cardiac failure

00:19:10

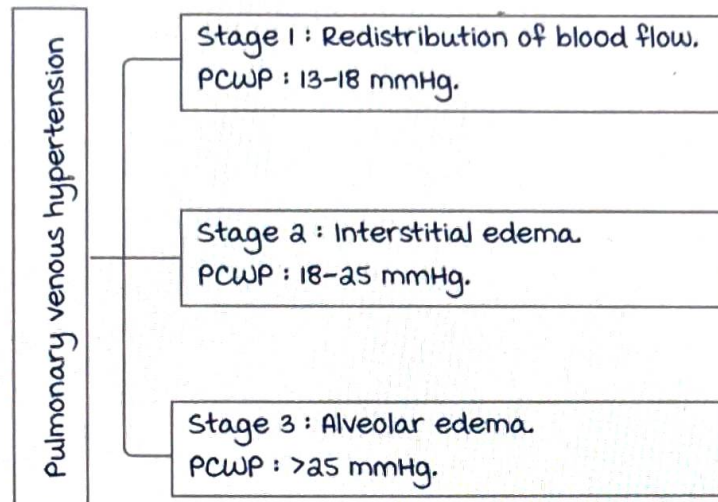
CXR : Initial imaging modality.

Echocardiography : most commonly done, **overall IOC for CCF diagnosis** (as it shows movement of ventricular valves, measures actual ejection fraction, cardiac output, stroke volume).



CT/MRI : Rarely done when there is poor echocardiac window.

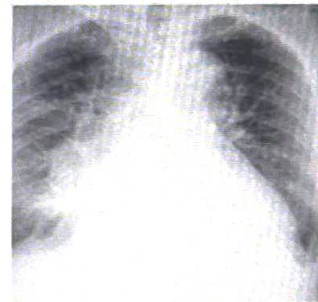
CXR based staging of CCF :



Stage 1 : Redistribution of blood flow.  
PCWP : 13-18 mmHg.

Findings :

- Cephalization of blood flow (prominence of upper lobe veins due to stagnation of blood flow in superior pulmonary veins).



This is called Stag Antler sign/Hands-up sign/Inverted moustache sign.

- Cardiomegaly.

Persistence of this rise in pressure for weeks can cause transmission of pressure to pulmonary capillaries which can leak and cause edema.

Stage 2 : Interstitial edema.

PCWP : 18-25 mmHg.

Findings :

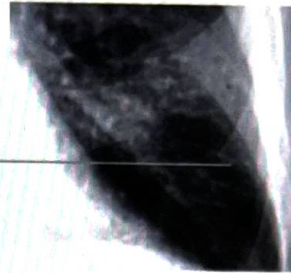
- There are thin septae within lung parenchyma that are normally not seen on CXR.
- Fluid accumulation (as a result of fluid leak from capillaries)



leads to thickening of deep interlobular septa : Seen as lines in CXR known as **Kerley B lines**.

Kerley B lines

Few short horizontally oriented lines perpendicular to the overlying pleural surface. Seen in peripheral lung fields in the lung base.



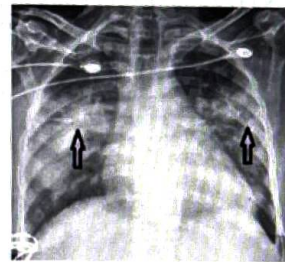
Stage 3 : Alveolar edema

PCWP :  $> 25$  mmHg (fluid leaks into alveoli).

Findings :

**Bat wing opacities/Angel wing opacities :**

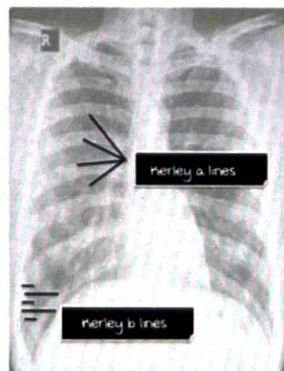
- Seen due to pulmonary edema.
- They are central peri-hilar distribution of opacities, lung apices & lung base are spared.



Types of Kerley lines :

Kerley lines seen due to thickening of interlobular septae.

Kerley A lines	Centrally located, non-branching lines (radiating from hilum towards periphery).
Kerley B lines	In lung base/lung periphery, shorter than Kerley A lines, horizontally oriented & perpendicular to the overlying pleural surface.
Kerley C lines	Reticular opacities or spider web-like appearance over the entire lung field.
Kerley D lines	They are nothing but Kerley B lines seen on lateral CXR.





## Imaging of pericardial effusion

00:32:25

Pericardial effusion : Abnormal collection of fluid within pericardial cavity.

Normally 15-30 cc of fluid.

Seen as thin layer around the heart in echocardiography.

Pericardial layer thickness in CT/MRI : < 1 mm (seen only during systole).

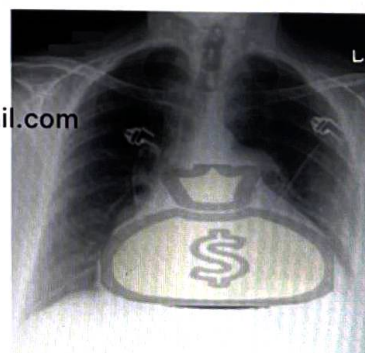
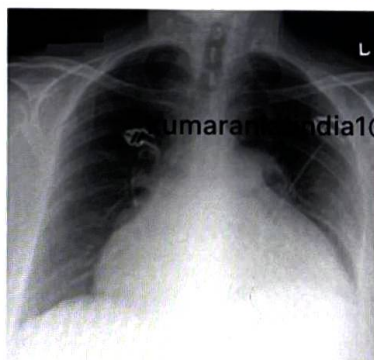
Initial investigation : CXR.

**IOC : USG** - Quantifies the amount of fluid, USG guided pericardiocentesis can also be done.

CXR :

- **Water bottle heart/flask shaped heart/moneybag heart.**
- **Oreo cookie sign** : Seen on lateral CXR (fluid in pericardial cavity separates pericardial and epicardial fat pad - fat appears relatively dark, fluid appears white in CXR).
- Echocardiography : Hypoechoic fluid seen around the heart.
- Cardiac swinging - **1:1 swing** (1 swing/cardiac cycle).
- **2:1 swing** (2 swing/cardiac cycle) - Feature of pericardial tamponade.

Pericardial effusion : CXR



money bag appearance

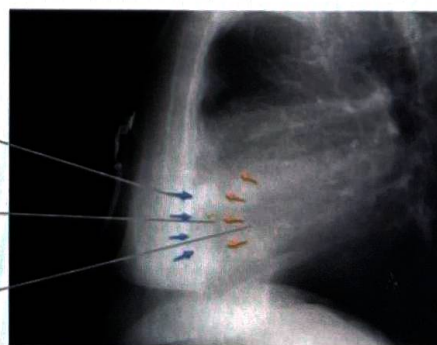
Oreo cookie sign



Pericardial fat pad

Fluid within pericardial cavity

epicardial fat pad





## Pericardial effusion : Echocardiography

Pulmonary arterial hypertension

00:37:51

Pulmonary arterial pressure = 20 - 25 - 30 (to remember).

Normal : < 20 mmHg.

If pressure > 25 at rest or > 30 during/immediately after exercise : Pulmonary arterial hypertension.

CXR findings :

- Dilated pulmonary arteries.
- Pruning of peripheral vessels.

(At the centre, vessels are prominent, at the periphery, vessels not seen).

Initial investigation : CXR.

IOC : Echocardiography.

Role of CT :

- To detect the underlying causes (like thrombus/ interstitial lung disease).
- measures the sizes of pulmonary arteries.
- main pulmonary artery diameter : > 29 mm.
- Right descending pulmonary artery diameter : > 16 mm.
- Left descending pulmonary artery diameter : > 15 mm.
- The ratio of main pulmonary artery (mPA) to the ascending aorta (AA) can be seen.
- If  $mPA/AA : > 1$  - Pulmonary arterial hypertension.

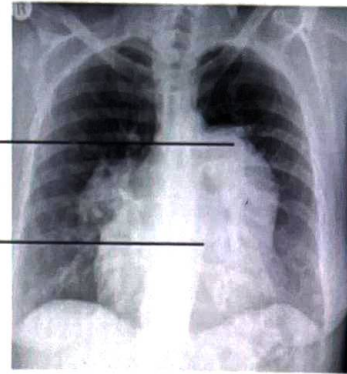
} cut off for dilated pulmonary artery



Pulmonary arterial hypertension : CXR

Bulge in the area of main pulmonary artery ←

Prominent appearing shadow along the right hilum (right pulmonary artery) ←

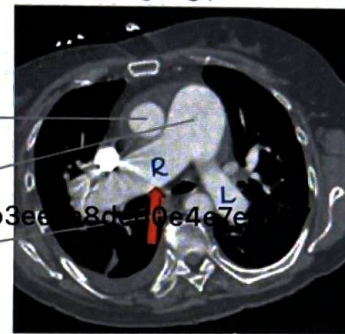


CE-CT

Ascending aorta ←

main pulmonary artery ←

Descending aorta ←



Q. 68 year old male presents K/c/o HTN presents with severe tearing sensation and chest pain posterior & to the left side. CECT shown here, most likely diagnosis is?

- A. Liver abscess.
- B. Aortic dissection
- C. Aortic aneurysm.
- D. IVC thrombosis.

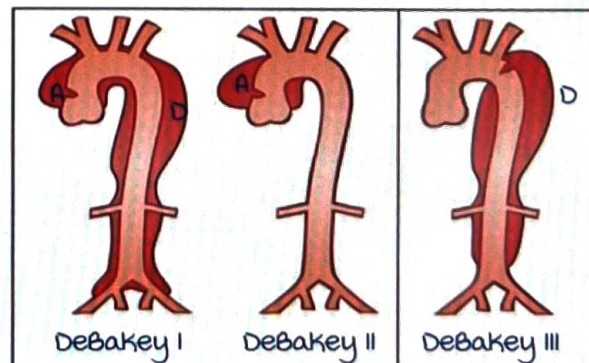
Things to describe in aortic dissection :

- Extent of dissection.
- Branches of aorta involved.
- Type of lumen involved.
- 2 separate lumens : True lumen and false lumen.
- False lumen larger than true lumen.
- True lumen opacifies first.



Types of aortic dissection :

De Bakey types :  
 I - Both ascending and descending aorta involved.  
 II - Only ascending aorta involved.  
 III - Only descending aorta involved.



Stanford A

Stanford B

Active space



Treatment :

If ascending aorta is involved, surgical treatment is required (Dacron graft reconstruction).

Investigations :

**Trans-esophageal echocardiography (TEE)** : Only in emergency cases. It shows involvement of aortic root, coronary artery. It is severely operator dependent.

**IOC** : CT angiography/ MR angiography.

MR angiography is better as there is no radiation exposure.

CT angiography is time saving procedure, cheaper and is more commonly done clinically.

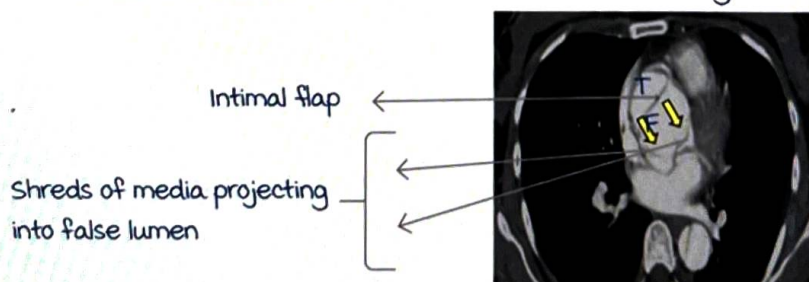
Gold standard investigation for any vascular abnormality in the body : **Invasive angiography.**

60c6b3eaa8ded0e4e7e5ea7

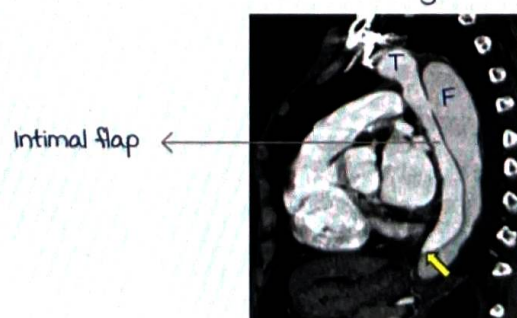
Radiological signs in aortic dissection :

- **Cobweb sign** : Refers to shreds of media projecting in false lumen.
- **Beak sign** : Acute angle between flap and the aortic wall; seen usually at terminal end of the dissection.
- **mediastinal widening (CXR)** : Superior mediastinum becomes excessively wide.
- **Calcium sign (CXR)** : In normal artery, intima is calcified. In dissected artery, calcification is displaced into the lumen (separated from outer margin of the vessel) is seen. If the displacement distance  $> 5$  mm - Suggestive of aortic dissection.

Cobweb sign



Beak sign



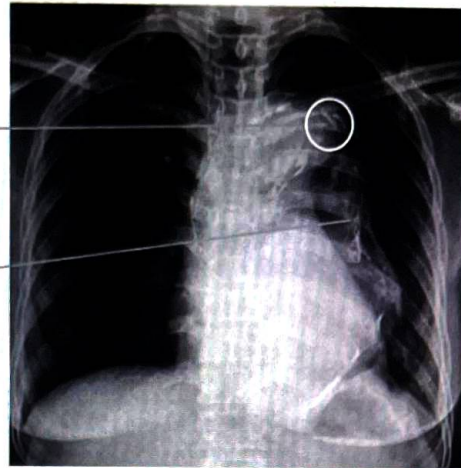
Active space



Aortic dissection : CXR

Intimal calcification  
displaced into the  
lumen

Superior mediastinal  
widening



Question :

Assertion : multi detector CT is IOC test for aortic dissection.

Reason : In case of skilled person, even TEE has sensitivity and specificity as much as multi detector CT.

- Both assertion and reasons are true and the reason is the correct explanation for the assertion.
- Both assertion and reasons are true but the reason is not the correct explanation for the assertion.
- Assertion is true but the reason is false.
- Assertion is false but the reason is true.
- Both assertion and reason are false.

Answer : B.

kumarankitindia1@gmail.com

## Aortic aneurysm

00:52:19

It is an abnormal focal dilation of a blood vessel.

True aneurysm involves all the layers of vessel wall.

False aneurysm/pseudoaneurysm does not involve all the vessel wall layers.

By definition : Size of luminal diameter should be  $> 50\%$  of normal lumen size.

Absolute size cut off for aneurysm involving

- Ascending aorta :  $> 5\text{cm}$ .
- Descending aorta :  $> 4\text{cm}$ .
- Abdominal aorta :  $> 3\text{cm}$ .

most common site : Abdominal aorta (infrarenal).

Thoracic aortic aneurysm are less common than abdominal aortic aneurysm but thoracic aortic aneurysms are more likely to rupture.

Investigations :

CXR : mediastinal widening.

IOC : CT/MR angiography.

CT angiography : Quickly and more commonly done.

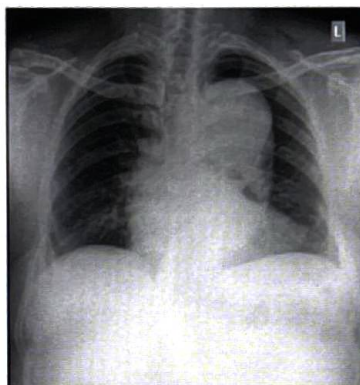
MR angiography : For follow up of known patients.

Gold standard investigation : Invasive catheter angiography.

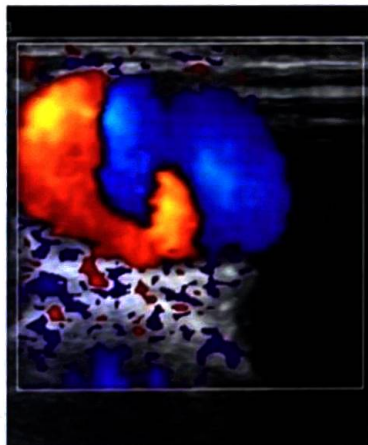
Radiological signs : Yin and Yang sign (doppler)

Aortic aneurysm CXR :

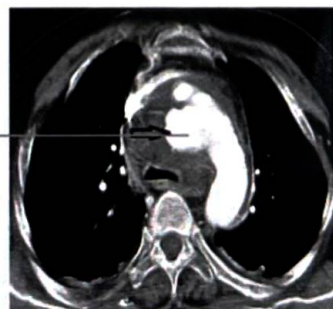
Diffuse mediastinal widening



Aortic aneurysm : Yin & Yang sign (doppler)



Saccular aneurysm ←



Fusiform aneurysm : Expansion seen on both sides of vessel.

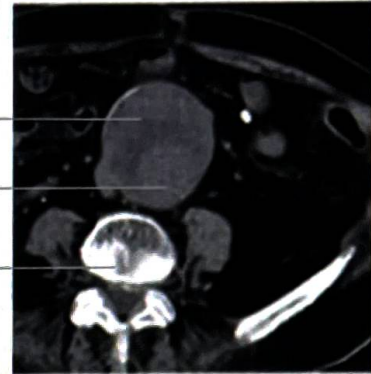


Question : A known case of aortic aneurysm undergoes a follow up CE-CT. The clinician wants to know whether there are any signs of impending rupture of the aneurysm. Looking at the following images, what would you opine ?

Crescent like appearance involving the wall of aorta (darker sometimes) known as : **Crescent sign** ←

Aortic aneurysm ←

vertebral body ←



Aorta drapes the vertebral body instead of being in round shape : **Draped aorta sign** ←



Signs of impending rupture :

- **Crescent sign** : Insinuating blood along walls of aneurysm and formation of thrombus.
- Draped aorta sign.
- Rapid increase in size  $> 10\text{mm}/\text{year}$ .
- Periaortic fat stranding.
- Tangential calcium sign.
- Thrombus fissure sign.

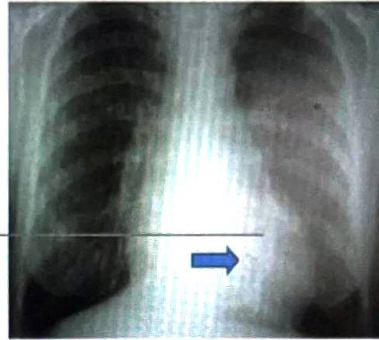
Question : A 62 year old female presents with dyspnea, orthopnea, hepatomegaly and ascites. A CXR & CT chest was done. Diagnosis?

- Pneumothorax
- Pericardial effusion.
- Constrictive pericarditis.**
- Cardiomegaly.

Dense layer of calcification around the pericardium : **egg in cup appearance of constrictive pericarditis**. Pericardial calcification leads to diastolic dysfunction of heart (Right

heart failure). This causes symptoms of dyspnea, orthopnea, hepatomegaly and ascites.

Dense layer of calcification  
around the pericardium :  
Feature of constructive  
pericarditis : **egg in cup**  
appearance.



Dense layer of calcification  
around the pericardium :  
**Egg in cup** appearance.



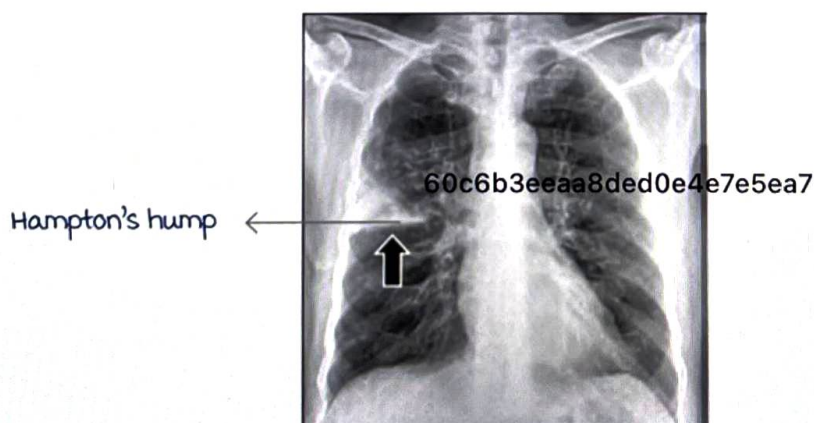
## Pulmonary embolism

01:02:22

When a thrombus from one of the systemic veins comes more commonly from IVC into the right side of the heart & gets impacted in the main pulmonary artery or one of its branches, It gives rise to acute onset respiratory complaints.

This is a complication of deep venous thrombosis.

In most cases of pulmonary embolism, CXR : Normal.



Pulmonary embolism CXR findings :

- **Hampton's hump** : **Triangular** wedge shaped opacity. Base towards periphery & apex towards centre. It is due to the infarct within the lungs as a result of pulmonary embolism.



- Over the time, this infarct resolves first from the periphery then towards the centre like a melting ice cube. Hence it is called 'melting ice cube sign'.
- **Fleischner's sign** : Enlarged/prominent right main pulmonary artery.
- **Palla's sign** : Prominent right descending artery.
- **Chang's/Knuckle sign** : Prominent right descending artery with an abrupt cut off.
- **Westermarck sign** : Focal oligemia (blood supply to particular area cut off. Hence decreased/less prominent vascular markings seen).

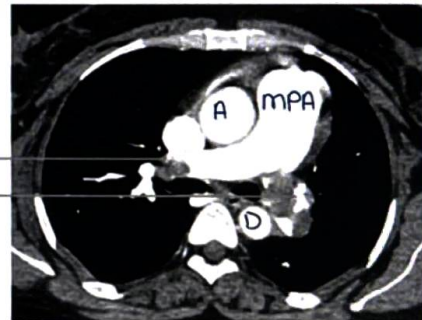
### IOC : CE-CT/CT-PA.

Thrombus seen directly in pulmonary artery as a non-enhancing filling defect.

**Polo mint sign** is seen when thrombus lies at the centre of the blood vessel.

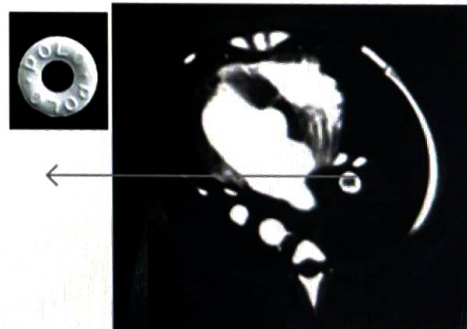
Pulmonary embolism CE-CT/  
CT-PA

Thrombus  
(non-enhancing filling  
defect)



Polo mint sign

Thrombus appears as  
filling defect surrounded  
by contrast in all its sides  
and looks like polo mint.



60c6b3eeaa8ded0e4e7e5ea7

Active space

In older days, for diagnosis of pulmonary embolism : **V/Q scan** (Ventilation-Perfusion scan).

V/Q scan :

ventilation means air reaching the alveoli. Perfusion means capillary level blood flow.

Lung ventilation is assessed by **radioactive gases** like xenon, Krypton, Technegas.

Lung perfusion is assessed by **Tc labelled macro aggregated albumin**.

In normal lung,  $v/Q$  ratio = 1.

In **pulmonary embolism** :

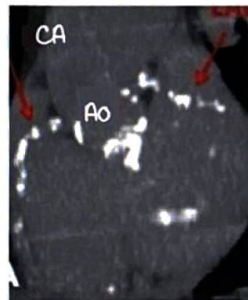
$v = 1$  because,  $Q = \text{Decreased/absent}$ ,  $v/Q = > 1$  or infinity.

Finding in  $v/Q$  scan : **mismatch defect**.

## Agatston score

01:09:42

- Semi quantitative method to estimate calcium burden on the coronary arteries. 60c6b3eeaa8ded0e4e7e5ea7
- Done using NC-CT.
- **Weighted density score** = HU score x Volume.
- Denser the calcification higher the Hounsfield units (HU).
- Score **< 100** : Normal.
- Score **100-400** : moderate.
- Score **> 400** : Poor prognosis.



Imaging in acute aortic abnormalities :

- IOC : CTA/ MRA.
- CTA done more.
- Exceptional : **T&E** in aortic dissection if patient is hemodynamically unstable.
- For follow up : MRA is preferred.
- Gold standard : Invasive catheter angiography.

Suspected congestive heart failure (CHF) :

- Diagnosis based on clinical assessment.
- CXR can be initial investigation.
- IOC : Echocardiography.

Suspected pulmonary embolism :

- **D-Dimer test** : Screening test. High negative predictive value.
- CXR : Normal in most cases.
- IOC : CT angiography/ CT pulmonary angiography.
- $v/Q$  scan :  $v/Q$  ratio is increased/infinity, mismatch defect.
- Gold standard : Invasive pulmonary angiography.

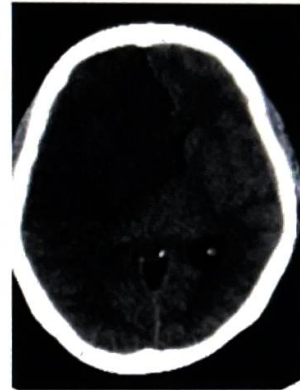


## CNS : STROKE IMAGING

Clinical scenarios :

1. A 67 year old hypertensive and diabetic male presents with left sided hemiplegia. Diagnosis based on this CT is ?

- A. Hypertensive bleed.
- B. Ischemia.
- C. SAH.
- D. Lacunar infarct.

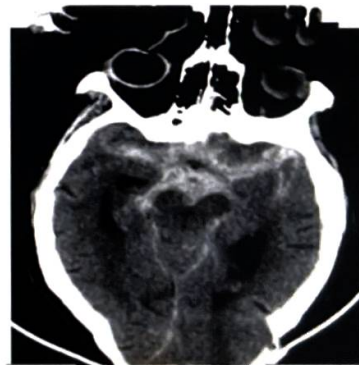


Answer : B. Ischemia.

Acute stroke could be due to ischemia or hemorrhage.  
Diagnosis is made by CT.

2. A 42-year-old patient with sudden onset headache, neck rigidity without any obvious history of trauma. What is the most likely diagnosis based on this CT image?

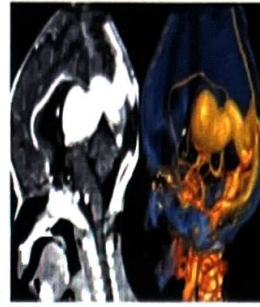
- A. meningitis.
- B. SAH.
- C. Intraparenchymal bleed.
- D. SDH.



Answer : B. SAH.

3. A new-born male baby presented with congestive heart failure. On examination, enlarged fontanelles, a loud cranial bruit and following radiological finding was noted. The most likely diagnosis is :

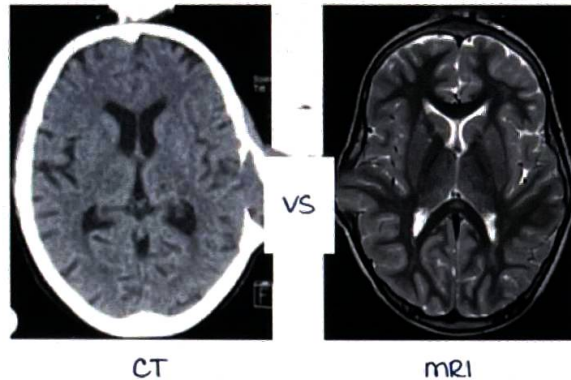
- A. Sinus pericranii.
- B. Arachnoid cyst.
- C. Vein of Galen malformation.
- D. Dandy walker malformation.



Answer : C. Vein of Galen malformation.

## CT vs MRI

00:03:28



MRI is one of the best imaging modalities available today. Multiplanar, excellent soft tissue and contrast resolution and different **types of sequences** (DWI for infarct, SWI for bleeds, spectroscopy for chemical composition of brain).

Disadvantage of MRI :

Time requirement : Non-contrast MRI (20-30 min) ; contrast MRI (20 min). Roughly, **1 hour** is required for a detailed MRI.

Biggest advantage of CT is **less time requirement** : It takes maximum 5 minutes for CT scan & interpretation.

If time is crucial (emergency conditions) : **DO CT**.

If time is not crucial for diagnosis : **DO MRI**.

Imaging for conditions :

- Brain tumour : MRI (to know extent, type & grading of tumor).
- Multiple sclerosis : MRI (white matter plaques are seen with better resolution).
- Child with developmental delay/mental retardation : MRI



(to study cortical structure abnormalities, dysmyelination, metabolic disorders).

Disadvantage : Child needs to be sedated before MRI.

- Convulsion 1 week back : MRI (to find focus of seizure).
- Acute stroke : CT.
- Head trauma : CT.

kumarankitindia1@gmail.com

Question :

A patient presents with left hemiplegia since 3 hours. What investigation will you do in this patient?

Answer : CT.

CT scan can diagnose an infarct only after 6 hours.

Diffusion weighted imaging MRI is the earliest modality available today to diagnose an infarct (in 30 minutes).

### CT in acute stroke

00:12:42

Acute stroke could be ischemic or hemorrhagic.

Hemorrhage is seen in both CT and MRI.

Diffusion weighted imaging (DWI) MRI detects an infarct as early as 30 minutes from onset.

But MRI + interpretation takes around 30 minutes even with diffusion, T1, T2, gradient, flair sequences.

CT will appear normal between 0-6 hours of infarct.

But CT + interpretation takes around 5 minutes. Hence, CT is done first to rule out hemorrhage and not diagnose infarct.

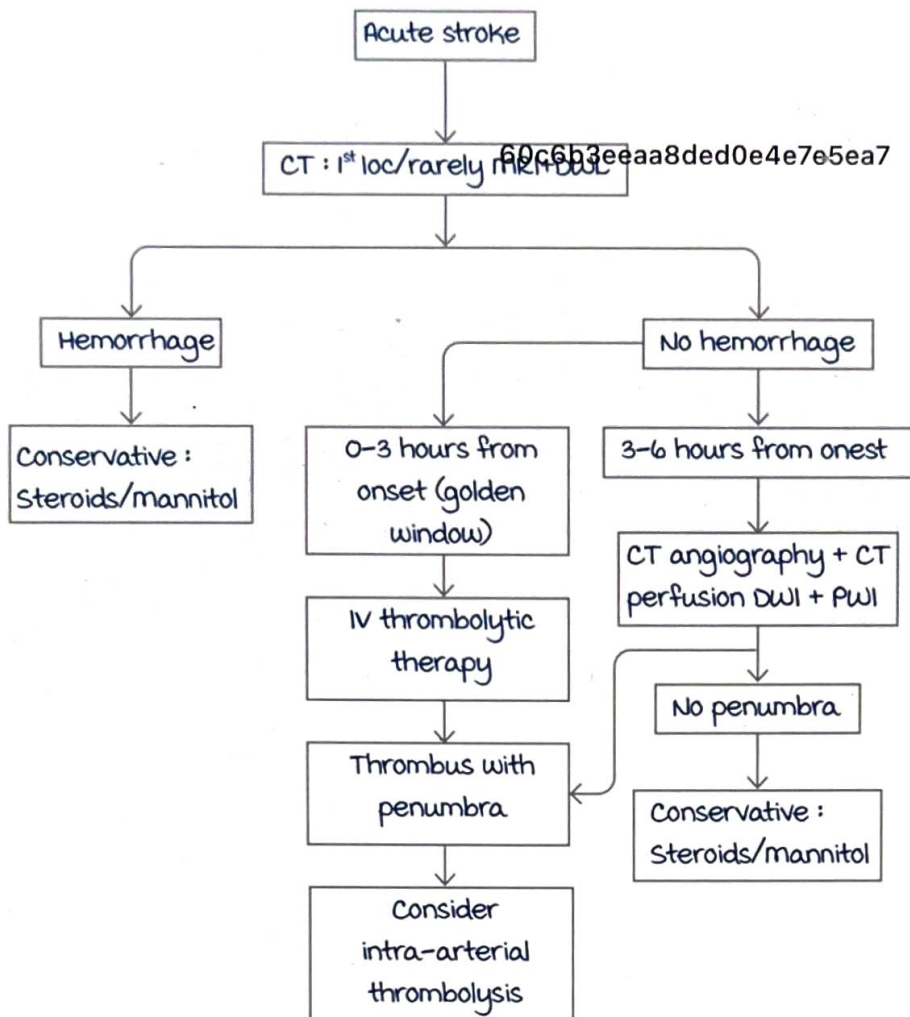
Acute stroke imaging :

First/overall investigation of choice : CT scan (to rule out hemorrhage).

Earliest modality to detect acute infarct : Diffusion weighted imaging MRI.

Best MRI sequence to detect acute infarct : Diffusion weighted imaging MRI.

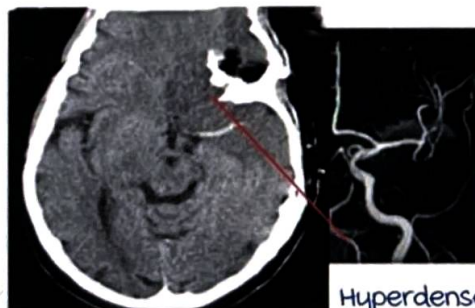
## Stroke imaging protocol :



## Hyperacute Stroke (0-6 hours) :

- **Hyperdense MCA sign** : MCA appears hyperdense due to **thrombus** inside the lumen.

Thrombus/blood clot has a density greater than the normal blood, hence appears bright/hyperdense on CT.



Hyperdense MCA sign

**Sylvian dot sign** : Bright dot within the sylvian fissure.

**Hyperdense basilar artery sign** : Bright spot in basilar artery cross section.

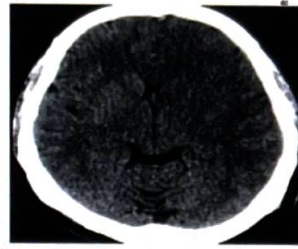
**Disappearing basal ganglia sign** :

Gray matter structures of basal ganglia : Caudate nucleus,



lentiform nucleus, insular cortex are **hypodense** on the affected side compared to the normal side.

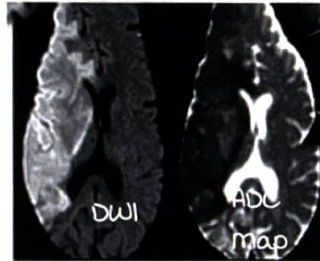
Loss of insular cortex is also known as loss of **insular ribbon** (very susceptible to MCA occlusion because of poor collateral)



Disappearing basal ganglia sign

**Restricted diffusion on DWI**: Area appearing **hyperintense** on DWI will be **dark** on ADC map → Signifies an infarct.

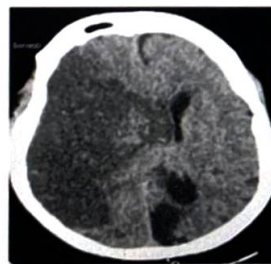
**DWI** is the earliest modality to diagnose an acute infarct in brain parenchyma (as early as 30 minutes).



Restricted diffusion on DWI

### Appearance of acute right MCA infarct on CT

00:25:44



Wedge shaped area  
Diffuse hypo density  
Gm + wm  
Loss of G - W  
differentiation.  
mass effect

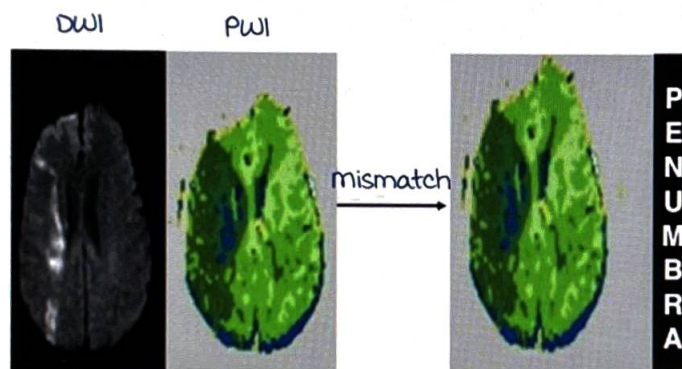
- **Wedge/triangular shaped area of diffuse hypodensity** (shape of arterial territory: MCA)  
Draw a line going outwards from frontal horn & atrium of ventricles. Area between 2 lines is MCA territory. Anterior to this area is ACA and posterior is PCA.
- **Hypodensity** is seen as affected brain parenchyma is edematous (Edema = fluid).
- Both grey and white matter are supplied by same artery.

Hence, there is involvement of both grey and white matter with loss of grey-white matter differentiation.

- mass effect is due to edematous brain parenchyma causing midline shift.

Diffusion - perfusion mismatch in acute ischemic stroke :  
Perfusion weighted Imaging (PWI) shows capillary level blood flow/volume.

- In DWI, affected area is small.
- In PWI, affected area is large.
- mismatch is due to **ischemic penumbra**.  
Penumbra : Ischemic brain parenchyma without infarct, which is salvagable.
- Larger the diffusion perfusion mismatch, larger is the penumbra and stronger is the indication for **thrombolytic therapy**.



### Subacute-chronic ischemic stroke

00:31:58

CT fogging phenomenon is seen in subacute infarct.

Gliosis with ex-vacuo dilatation of ventricles :

In chronic infarct, Parenchyma shrinks and a cavity filled with CSF is seen (gliosis). On CT, CSF appears hypodense with enlargement of adjacent lateral ventricle.



Gliosis with ex-vacuo dilatation of ventricles

kumarankitindia1@...il.com

Question :

A 42-year-old male has left hemiparesis without any cortical signs such as aphasia/agnosia. What is the diagnosis?

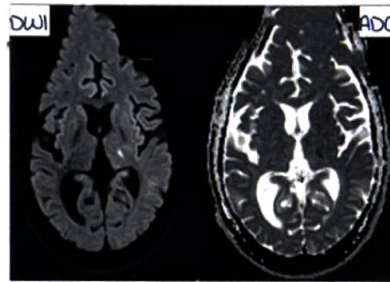
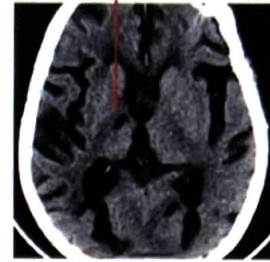
Active space



Pure motor stroke syndrome.

Diagnosis : Lacunar infarct (artery distribution is a small round area, hence the appearance)

- Lacunar infarcts are small infarcts < 20 mm in size.
- They occur due to blockage of lenticulo-striate/thalamo-perforating arteries that supply small round parts of the brain.
- Lacunar infarcts are seen within basal ganglia/thalamus/corona radiata (subcortical white matter)/internal capsule.
- most common lacunar stroke syndrome is **pure motor stroke syndrome**.
- It presents with motor manifestations without cortical signs.

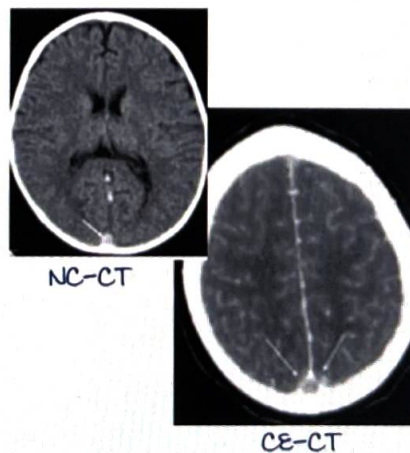


Lacunar infarct

Restricted diffusion on DWI suggestive of lacunar infarct.

Clinical scenario :

A 32-year-old male presents with severe persistent headache and vomiting. A plain + contrast CT is done. The diagnosis?



Diagnosis : **Superior sagittal sinus thrombosis.**

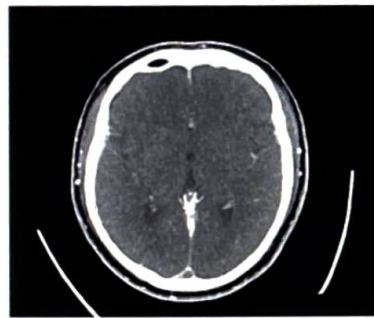
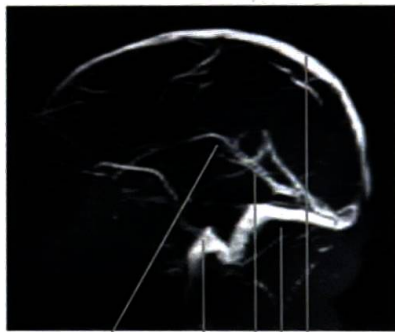
- **Non contrast CT** : Superior sagittal sinus is appearing

hyperdense due to clot inside the sinus (triangle shaped density) → **Delta sign** of superior sagittal sign thrombosis.

- **Contrast enhanced CT** : Dura and sinus walls are enhanced but central part of sinus is not enhanced. Delta sign seen on non-contrast CT appears empty on contrast enhanced CT → **Empty delta sign**.

Venous sinus thrombosis :

Investigation of choice for venous sinus thrombosis is **MR venography** (multiplanar) > CT venography.



Empty delta sign

Inferior sagittal sinus

Superior sagittal sinus

Transverse sinus

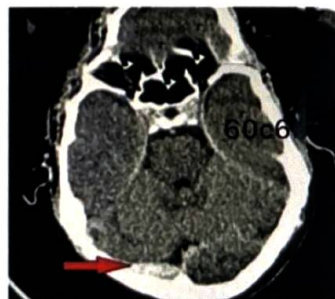
Sigmoid sinus

Sigmoid sinus

Normal MR venography image

If there is a blood clot in the transverse sinus, axial section at the level of transverse sinus will show hyperdensity along its long axis → **Cord sign**.

Venous sinus thrombosis cord sign



6006...eaa8ded0e4e7e5ea7

Global cerebral hypoperfusion :

Occurs in prolonged cardiac arrest/prolonged hypoxia or anoxia (drowning)/prolonged hypotension.

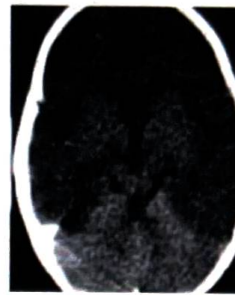
White matter is slightly hypodense compared to grey matter in a normal brain.



In global cerebral hypoperfusion, white matter appears slightly brighter compared to cortical grey matter. This is known as reversal sign. It signifies poor prognosis.



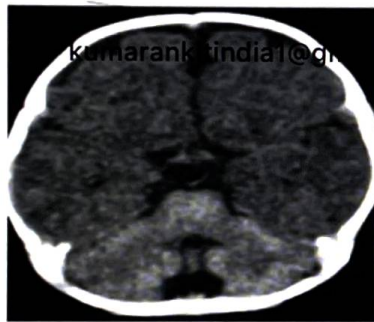
Normal



Reversal sign

**White cerebellum sign** : Posterior circulation is relatively spared. So, cerebellum appears normal while entire cerebrum is hypodense.

Indicates entire cerebrum is damaged and signifies poor prognosis.



White cerebellum sign

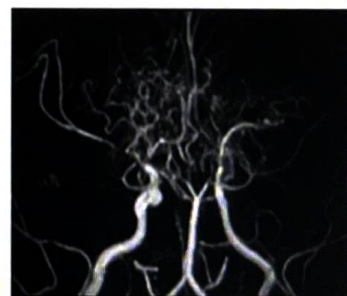
Clinical scenario :

A 7-year-old child presents with multiple episodes of fainting. Now, the child developed left sided hemiplegia.

MRI brain + angiography reveals a large tuft of basal collateral arteries (puff of smoke appearance). What is the diagnosis?

Diagnosis : **moya-moya disease**

Non-atherosclerotic progressive occlusive disorder involving the internal carotid artery (supraclinoid portion).





Formation of fine mesh like collaterals at the base of brain gives the **puff of smoke appearance** on conventional angiography/MR angiography.  
(moya-moya is a Japanese term for puff of smoke).

Identify the basal ganglia :

Basal ganglia is present in between the frontal horn of lateral ventricle and the posterior horn.

Components :

C : Head of caudate nucleus.

T : Thalamus.

G : Globus pallidus.

P : Putamen.

3 : Third ventricle.

Globus pallidus + putamen =

Lentiform nucleus.

Basal ganglia bleed is

**hypertensive bleed.**

Sites of hypertensive bleed :

Putamen (mc site) >> thalamus > pons.



Insular  
Cortex

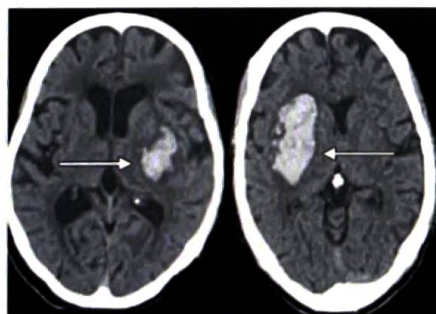
Genu

External capsule

## Hemorrhagic stroke

00:48:28

Acute bleeding appears hyperdense (blood) with a hypodense rim (due to edema).



Acute basal ganglia hypertensive bleed

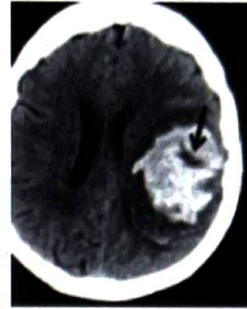
Swirl sign in acute hemorrhage : Hypodensity within a bleed.  
It suggests **continuous acute bleeding** : Predictor for further enlargement of bleed.

Active space

kumarankitindia1@gmail.com



Swirl sign in acute hemorrhage



Case scenario :

Adult male presents with severe headache (thunderclap headache/worst headache of life) followed by altered sensorium. CT shows the following finding :



60c6b3eaa8ded0e4e7e5ea7

Aneurysmal Bleed -SAH

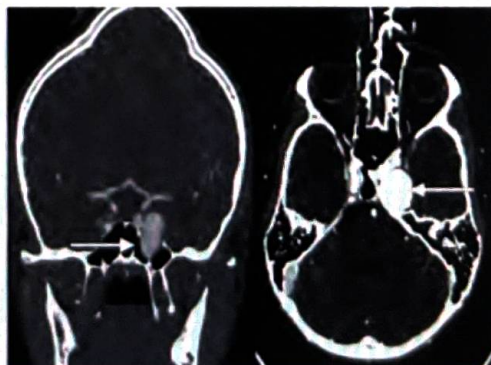
Area of the basal cisterns is hyperdense indicating bleeding : Subarachnoid bleed (normally hypodense CSF).

Diagnosis : **Subarachnoid hemorrhage due to rupture of berry aneurysms.**

Investigation of choice for subarachnoid hemorrhage is CT scan.

Berry aneurysms occur at the branching points along the circle of Willis (internal carotid artery/ anterior middle cerebral artery). most common site for development of berry aneurysm is anterior communicating artery > Posterior communicating artery

Left internal carotid artery aneurysm :



Left ICA Aneurysm



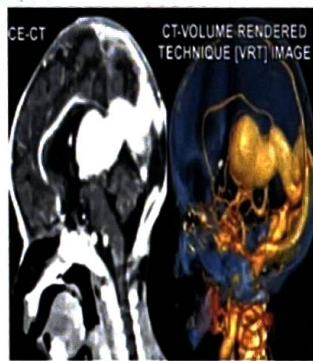
Investigations of choice :

- Acute subarachnoid hemorrhage : **CT scan.**
- Subacute-chronic subarachnoid hemorrhage : **MRI**
- Berry aneurysms : **CT angiography or MR angiography** (Old method).

Gold standard is **digital subtraction angiography** (invasive angiography).

Clinical scenarios :

1. A new-born male baby presents with congestive heart failure, enlarged fontanelles and a loud cranial bruit.



vein of galen malformation

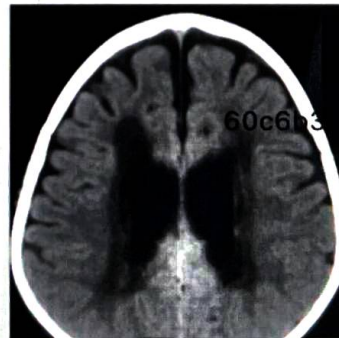
Sagittal reconstructed post contrast CT image : Dilated tortuous central vascular channel in the posterior part of brain opening in the region of confluence of sinuses.

Diagnosis : **Vein of Galen malformation.** Embryologically, vein of Galen is median prosencephalic vein of markowski .

2. A 10 month old male baby presents with seizures, h/o preterm birth with suspicion of birth asphyxia.

CT shows

periventricular hypodense changes with ventricular dilatation. What is the diagnosis?



Periventricular  
Leukomalacia (PVL)

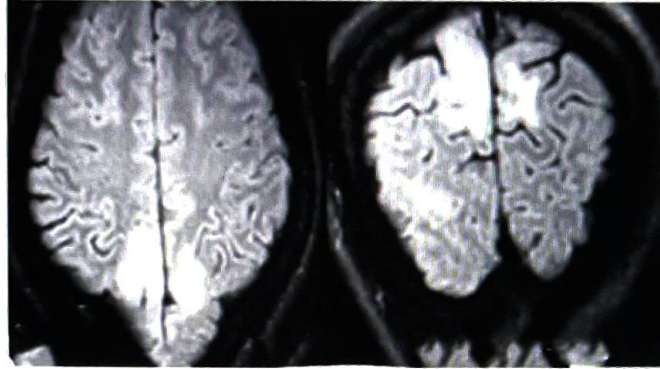
Active space



White matter along the ventricular margins are affected due to hypoxic ischemic encephalopathy.

Diagnosis : **Periventricular leukomalacia (PVL)**.

3. A  $G_2P_1$  diagnosed with severe pre-eclampsia presents with altered sensorium. MRI-FLAIR shows hyperintensities in the parieto-occipital lobes. What is the diagnosis?



Posterior Reversible Encephalopathy Syndrome (PRES)

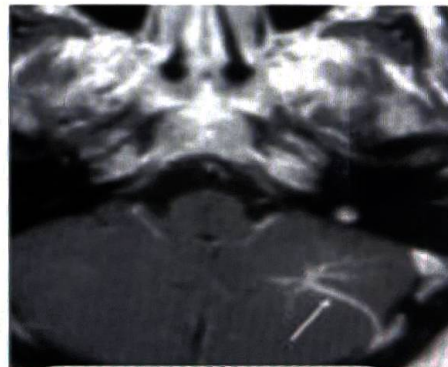
Diagnosis : **Posterior reversible encephalopathy syndrome (PRES)**. It is most commonly associated with eclampsia/pre-eclampsia though not specific.

It is also seen with bone marrow/organ transplant.

It is reversible as there is no infarction.

It can also involve the anterior part.

4. Incidentally detected lesion has medusa head appearance/caput medusae sign on contrast enhanced MRI. What is the diagnosis?



Diagnosis : **Developmental venous anomaly (DVA)/venous angioma** (feeding vessel with multiple divisions).

These are asymptomatic. No active treatment required.

Clinical insights :

- Acute stroke is a critical emergency.
- Investigation of choice : CT scan (to rule out hemorrhage).
- Role of MRI : MR angiography/subacute hemorrhage.
- DWI MRI : Earliest modality to detect an infarct : 30 mins.
- Infarct vs hemorrhage on CT : Infarct appears diffusely hypodense (dark). Hemorrhage appears hyperdense with a hypodense rim.
- Basal ganglia hemorrhage is always hypertensive bleed.
- Acute onset thunderclap headache/worst headache of life is due to aneurysmal subarachnoid hemorrhage (rupture of berry aneurysms).

kumarankitindia1@gmail.com

Active space



## CNS : TRAUMA IMAGING

### Clinical scenarios

00:00:58

**Question :** A young male was found unconscious on the roadside after a bike accident. He regained consciousness and was sent for a CT scan. During the CT scan he again deteriorated and showed altered sensorium. The CT image is shown here. Your diagnosis is ?

- A. Extradural hematoma.
- B. Subarachnoid hematoma.
- C. Subdural hematoma.
- D. Hemorrhagic contusion.



Unconscious – conscious – unconscious : The period of consciousness in between is called lucid interval. It is associated with extradural bleed. Source of bleed : middle meningeal artery.

**Question :** A 22 year old male following an RTA was brought to the emergency room. On examination, his GCS was E4M4V3. He had no fractures and with no hydrocephalus or raised ICP. NCCT was performed and was found to be normal except few tiny petechial hemorrhages and effacement of basal cisterns. The likely diagnosis is ?

- A. Diffuse axonal injury.
- B. Post-concussion syndrome.
- C. Extra dural hemorrhage.
- D. Herniation of brain.

60c6b3eaa8ded0e4e7e5ea7

Active space

Clinical findings : Severe,  
imaging : minimal (cerebral edema).  
This mismatch is typically seen in diffuse axonal injury.

**Question :** NC-CT is usually the IOC for head trauma imaging. For which of the following is MRI the IOC – thus making it an exception to this rule ?

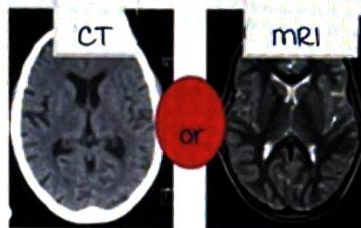
- A. EDH.
- B. Pneumocephalus.
- C. Diffuse axonal injury.
- D. Leptomeningeal cyst.

## Head trauma imaging

00:03:35

IOC : Non Contrast CT (time saving).

Exception : Diffuse axonal injury.  
(MRI is the IOC).



ACR Appropriateness criteria – head trauma : 2021 update :

GCS score	Classification	Time to do CT
13-15	mild TBI	Do CT only if additional findings are present.
9-12	moderate TBI	Do CT scan right away.
3-8	Severe TBI	
Penetrating cranial injury		

TBI : Traumatic brain injury.

GCS 13-15 : mild TBI. <sup>kumarankitindia1@gmail.com</sup> The additional findings required to do CT are :

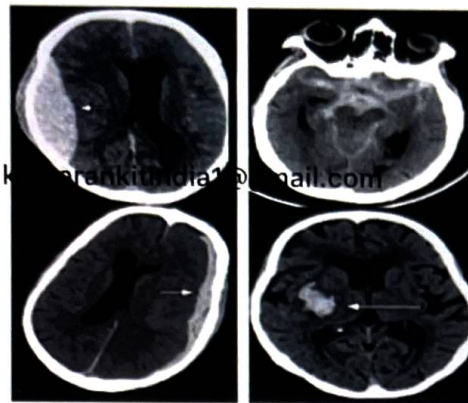
- Headache.
- Vomiting.
- Age > 60 years.
- Drug or alcohol intoxication.
- Deficits in short-term memory.
- Physical evidence of trauma above the clavicle.
- Post-traumatic seizure.
- Focal neurologic deficit.
- Coagulopathy.

Active space

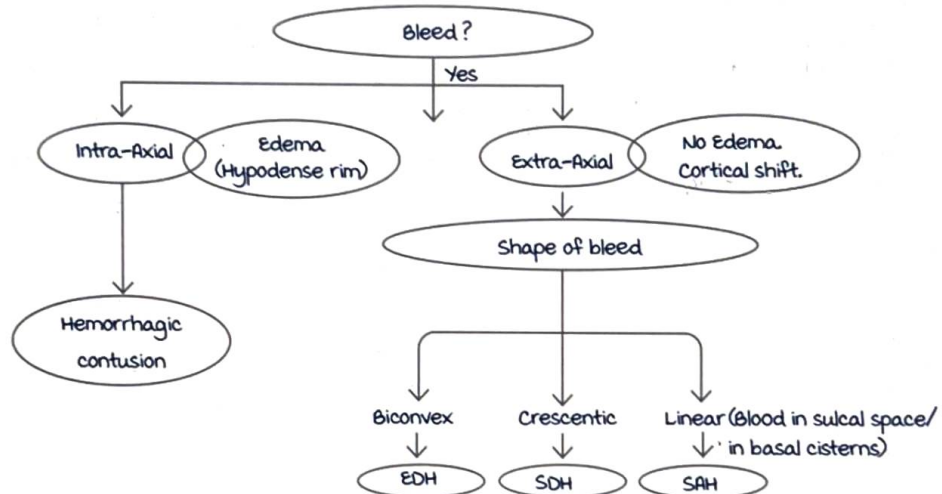


Identifying bleed on CT brain :

**Hyperdense** appearing area within the cranium.



CT interpretation protocol :



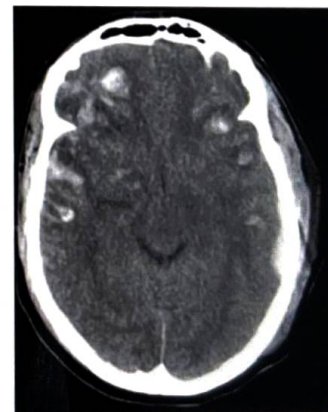
In the image :

Bleed : Present.

**Hypodense rim of edema** : Present → Intra axial (hemorrhagic contusions).

Diagnosis : **Bilateral frontotemporal hemorrhagic contusions.**

Hemorrhagic contusions most commonly seen in **frontal and temporal regions.**



Active space

In this image :

Bleed : Present.

No edema. Cortical shift seen.

→ Extra axial bleed.

Shape of the bleed : **Biconvex** (EDH).

Diagnosis : **Right sided acute**  
**extradural hemorrhage.**



In this image :

Bleed : Present.

No edema.

Cortical shift seen → Extra axial bleed.

Shape of the bleed : **Biconvex** (EDH).

Diagnosis : **Acute left extradural**  
**hemorrhage.**



### Reason for biconvex shape of EDH

00:16:00

- Outer layer of dura is closely attached to the inner table of skull vault except at certain places where there is an arterial radical (**middle meningeal arterial radical**).
- Whenever there is a skull fracture, the arterial radical is damaged.
- Bleeding occurs outside outer layer of dura (Extradurally).
- Bleeding (arterial origin) : High pressure and is limited to the extradural space, as dura is anchored to the inner table in **limited space**.
- The arterial blood tries to separate the dura from the table of skull.
- **EDH cannot cross skull sutures but can readily cross the**  
60c6b3eeaa8ded0e4e7e5ea7  
**midline.**

Clinical peculiarities associated with EDH :

- **Lucid interval.**
- **Talk and die syndrome.** (Patient will be normal & talking after the accident, suddenly the arterial bleed enlarges & compresses the respiratory structures → collapse & die).

Active space



In this image :

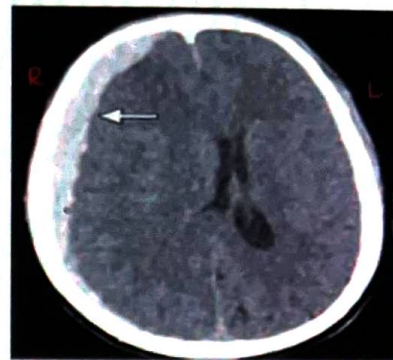
Bleed : Present.

No edema. Cortical shift seen.

→ Extra axial bleed.

Shape of the bleed : **Crescentic**  
(SDH).

Diagnosis : Acute right subdural  
hemorrhage.



In this image :

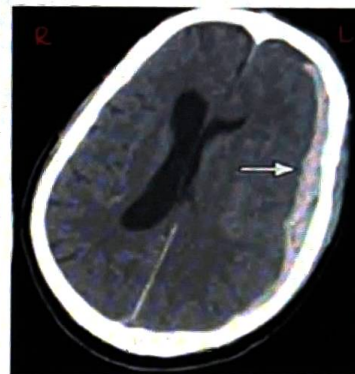
Bleed : Present.

No edema. Cortical shift seen.

→ Extra axial bleed.

Shape of the bleed : **Crescentic**  
(SDH).

Diagnosis : Acute left subdural  
hemorrhage.



Reason for concavo-convex shape of SDH :

- Source of bleed : **Bridging cortical veins**.
- If brain parenchyma atrophies, it shrinks inwards and veins are stretched.
- In elderly, even with trivial trauma, these veins rupture.
- Venous blood : Low pressure, not a limited space.
- Hence blood accumulates on the surface of brain and a crescentic shape appears.

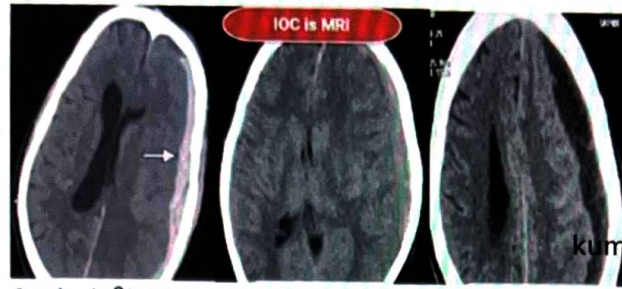
Clinical peculiarities associated with SDH :

- Often asymptomatic.
- Common in **elderly with trivial trauma**.

Bleed stages on CT :

Acute bleed	Sub-acute bleed	Chronic bleed
Few hours to days	Few days to weeks	Few weeks to months
Hematoma/clot forms : Bright white/ hyperdense.	Hematoma/ clot broken down & phagocytosed by macrophages. ↓ density : Isodense/grey.	All degraded products are phagocytosed & empty space filled with fluid/ CSF : Hypodense.





Acute left SDH

Sub-acute  
bleed

Chronic bleed

kumarankitindia1@gmail.com

In this image :

Bleed : Present.

No edema → Extra axial bleed.

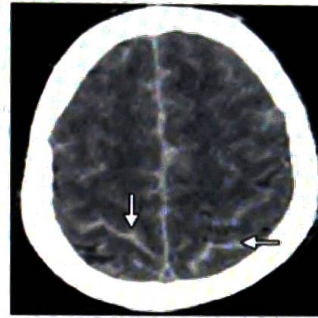
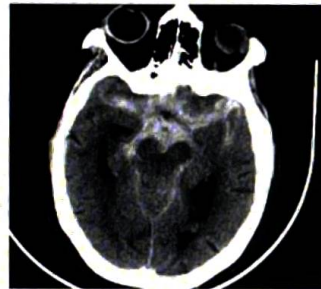
Shape of the bleed : **Linear**  
(SAH : Bleed within **sulcal space**).Diagnosis : **Bilateral acute SAH**.

Image (not a case of head trauma) :

Bleed : Present.

No edema → Extra axial bleed.

Shape of the bleed : **Linear**  
(SAH : Bleed within **basal cisterns**).Diagnosis : **Acute SAH**.

## Diffuse axonal injury

00:28:38

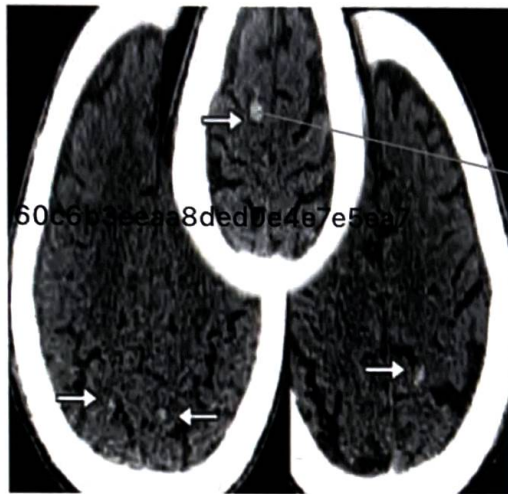
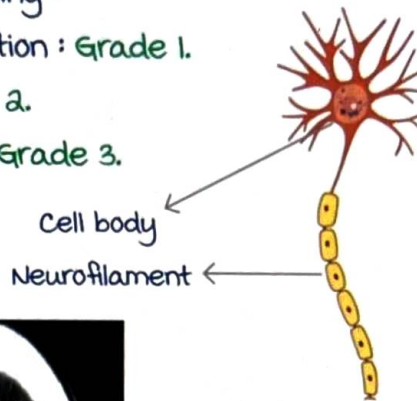
usual history of :

- Non-improving altered sensorium, in a head injury patient with **normal early CT brain**/sometimes mild edema (**petechial hemorrhages**).
- When there is shearing force exerted on neuronal structure, neuron gets stretched and **breaks at its weakest point** (junction of cell body and neuro-filament). This is called axonal injury.
- As time passes by, a tiny petechial hemorrhage at the site of breakage develops.
- Diagnosis of diffuse axonal injury is made by detection of these **multiple tiny petechial haemorrhages**.
- **MRI is IOC**.

Active space

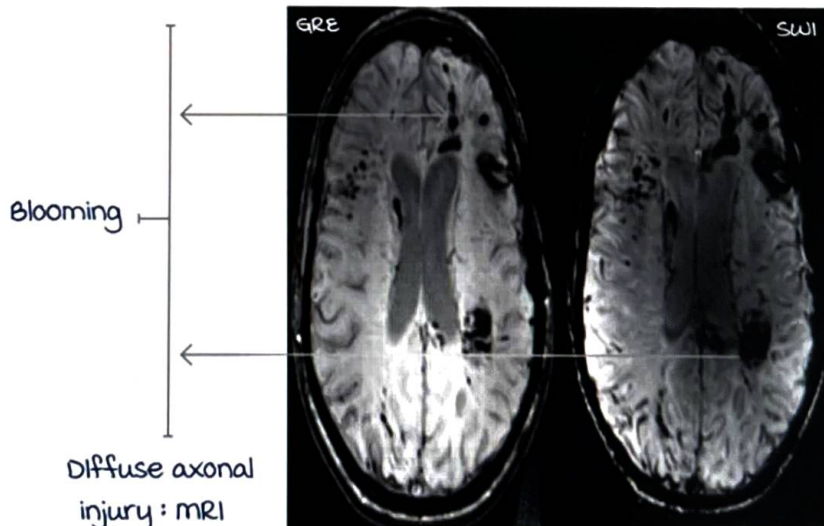


- Specific types of MR sequences : Gradient Echo (GRE) or Susceptibility Weighted Imaging (SWI).
- Black spots of petechial hemorrhages (blooming) is seen on GRE/SWI.
- most common site of blooming :
  1. Grey-white matter junction : Grade 1.
  2. Corpus callosum : Grade 2.
  3. Dorsolateral brainstem : Grade 3.



Petechial hemorrhages

Diffuse axonal injury : CT



Active space

In this image :

Bleed : Present.

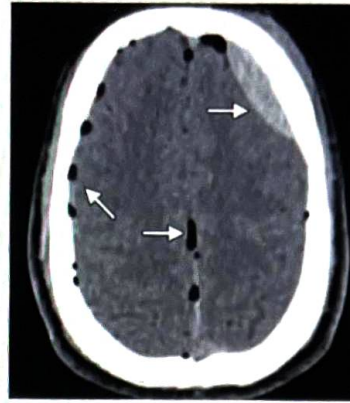
No edema → Extra axial bleed.

Shape of the bleed : Biconvex (EDH).

Diagnosis : Acute SAH.

Jet black coloured spots seen : Free air within intra-cranial

cavity called **pneumocephalus**  
(due to skull base fracture).  
Source of air : **Paranasal sinus**  
(most commonly : frontal sinus).



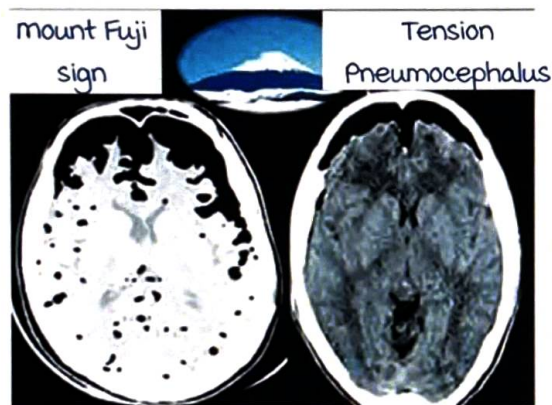
Pneumocephalus : **Surgical emergency**, fracture has to be closed.

If more air enters, it leads to **tension pneumocephalus**.

Tension pneumocephalus :

When the air within the cranial cavity creates a compression/  
mass effect on the brain, it assumes **peaked appearance**.

This is called **mount Fuji sign**.



## Skull fractures

00:36:07

Skull xray : **No role**.

IOC : **CT**.

Depressed fracture ←

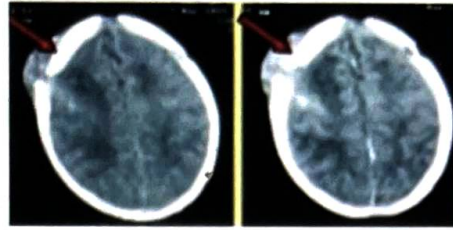


Growing skull fractures/  
leptomeningeal cyst :  
**Non-union of skull vault**  
fracture.

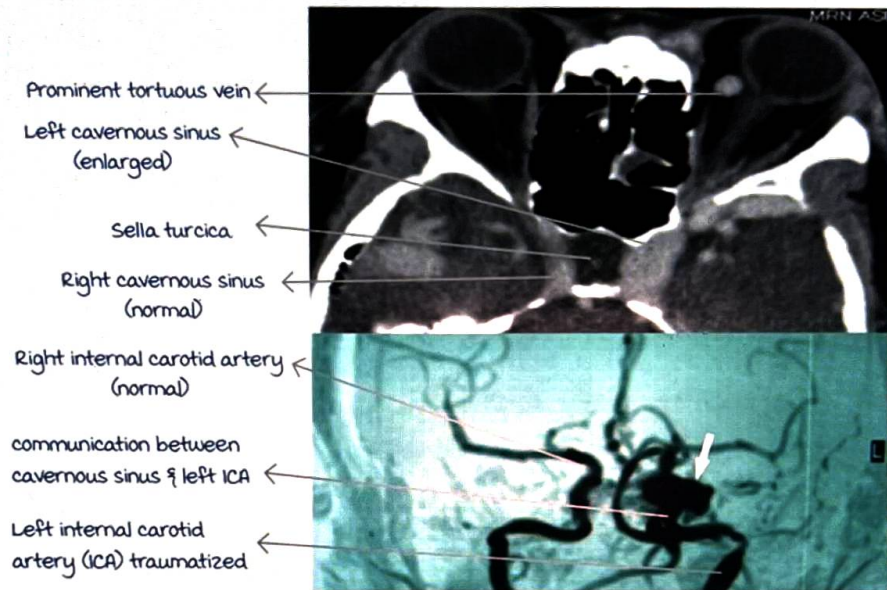
Skull fracturedural tear → Arachnoid + Pia (leptomeninges)  
both **herniate** → Non-union at the site of fracture → Over  
the time, **widens/ grows**.



Growing skull fractures/  
leptomeningeal cyst



Question : A 52 yr old male with head trauma and skull base fracture presents with chemosis + pulsatile proptosis. A CT brain + DSA is shown here. Diagnosis ?



Diagnosis : **Carotico-cavernous fistula** (here, communication develops between cavernous sinus and left internal carotid artery).

Clincher of diagnosis : Pulsatile proptosis. It is because of superior ophthalmic vein communicating with cavernous sinus gets the arterial flow (Retrograde arterial flow in superior ophthalmic vein).

IOC : MR angio/CT angio.

Gold standard : Invasive catheter angiography/ Digital subtraction angiography (DSA).  
kumarankitindia1@gmail.com

Clinical insights in head trauma :

Head trauma : Critical emergency.

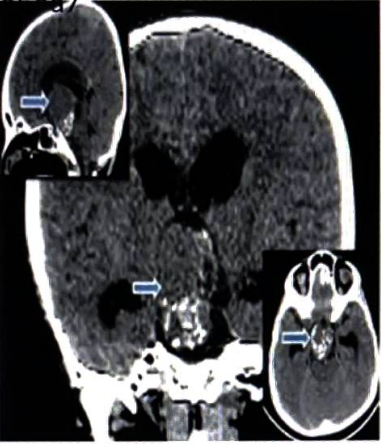
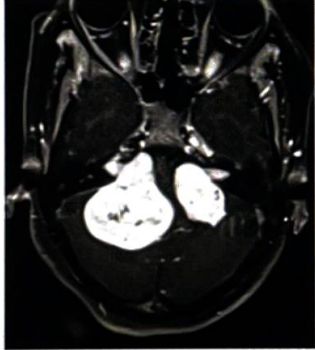
IOC : NC-CT.

Role of MRI : Only in Diffuse axonal injury (DAI).

# CNS : TUMOR IMAGING

## Clinical Questions

00:00:51

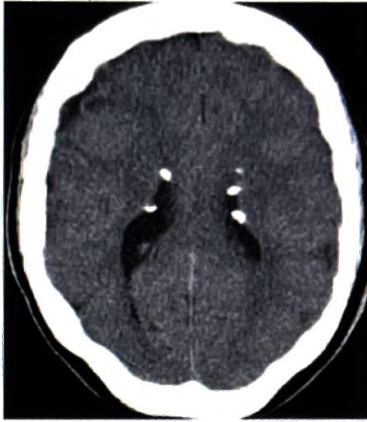
Clinical question	Radiology
<p>Q. 9 year old female child with history of headache and visual disturbance. What could be your possible diagnosis?</p> <p>A. Craniopharyngioma.</p> <p>B. Optic nerve glioma.</p> <p>C. Hypothalamic hamartoma.</p> <p>D. Pituitary macroadenoma.</p>	 <p>Calcification with solid &amp; cystic components.</p>
<p>Q. This imaging finding will suggest a diagnosis of?</p> <p>A. Sturge-Weber syndrome.</p> <p>B. NF 1.</p> <p>C. NF 2.</p> <p>D. Dandy Walker malformation.</p>	 <p>Tumour at CP angle with a characteristic ice cream cone appearance.</p>

Active space



Q. A 12-year-old child presents with recurrent seizures. A CT reveals multiple calcified nodules along the lateral ventricular margins, white matter lesions and few cortical tubers. This patient is likely to develop which of the following tumour with time?

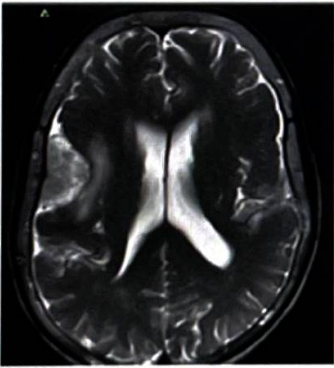
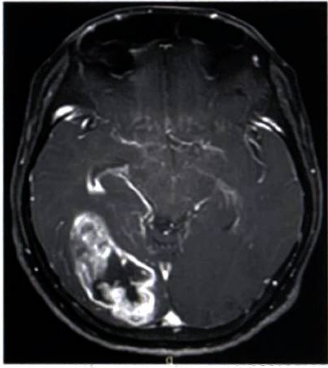
- A. Optic nerve glioma.
- B. Acoustic schwannoma.
- C. Ependymoma.
- D. Subependymal giant cell astrocytoma.



multiple calcifications in the sub-ependymal space.

60c6b3eeaa8ded0e4e7e5ea7

Brain tumors :

Extra axial tumors	Intra axial tumors
	
<p>Tumors located outside the brain parenchyma.</p>	<p>Tumors located inside the brain parenchyma.</p>
<p>E.g., meningioma (mc). Schwannoma. Dermoid. Epidermoid. Lipoma.</p>	<p>E.g., Glioma metastasis.</p>

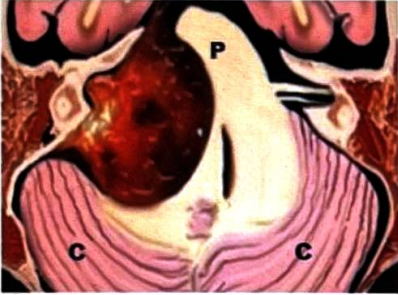

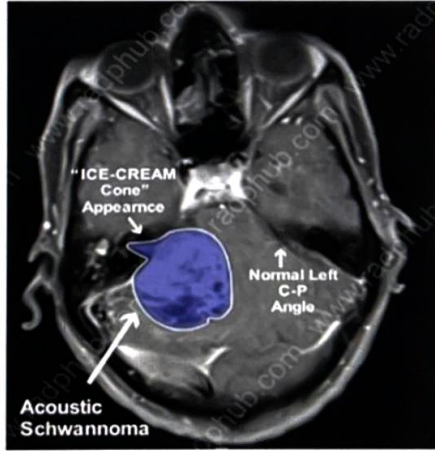
Active space

Features	Extra axial tumors	Intra axial tumors
Broad base towards dura	Seen	Not seen
Dura tail	Seen	Not seen
CSF cleft	Seen	Not seen
Cortical buckling	Seen	Not seen
Displaced vessels	Seen	Not seen

## Brain tumors & location clinchers

00:05:38

kumarankitindia1@gmail.com

Brain tumors : Location	Radiology
<p>Cerebello-Pontine (CP) angle tumors :</p>  <ul style="list-style-type: none"> <li>Acoustic schwannoma (mc)/vestibular schwannoma :</li> </ul> <p>Has a tail extending into the internal acoustic meatus. Indicates that this tumor arises and spreads along the vestibular nerve. Usually along the inferior vestibular nerve.</p> <p>B/L acoustic schwannomas :</p> <p><b>Neurofibromatosis Type 2.</b></p> <ul style="list-style-type: none"> <li>meningioma : 2<sup>nd</sup> mc.</li> <li>Epidermoid cyst.</li> <li>Arachnoid cyst</li> <li>Dermoid.</li> </ul>	 <p>Angle tumour : Acoustic Schwannoma.</p>  <p>Acoustic Schwannoma : <b>Ice cream cone appearance.</b></p>

Active space



### Sellar-Parasellar region tumors :

- Adults :

**Pituitary macroadenoma (mc).**

- Child :

**Craniopharyngioma (mc).**

- Meningioma.
- Rathke's cleft/cyst.
- Germinoma.
- Epidermoid cyst.
- Dermoid cysts.



Tumour arising from the sellar region.



Figure of 8/snowman appearance of pituitary macroadenoma.

Pituitary macroadenoma (> 10 mm in size) :

Extends beyond the sella through the **diaphragma selli** that produces a constriction in the middle and gives it the characteristic **figure of 8 sign/snow man appearance**.  
mass effect on the optic chiasma : **Bitemporal hemianopia**.  
Trans sphenoidal excision can be attempted.

### Pituitary microadenoma

00:12:12

<10 mm in size.

Special technique for visualization because its enhancement pattern is different : **Dynamic Contrast Enhanced MRI**.

Contrast injected using a pressure injector very rapidly and images are acquired over certain duration of time.

60c6b3eeaa8ded0e4e7e5ea7

Tumour appears slightly hypoechoic than the pituitary.

Craniopharyngioma :

**mc sellar-parasellar tumor in children.**

Has 2 peaks of age when it can present,

**10-14 years (mc)** or >50 years.

Partially cystic.  
Central calcifications.

Calcified solid cystic mass in  
children in sellar-parasellar region.

Impinges on the optic chiasma :  
Bitemporal hemianopia.



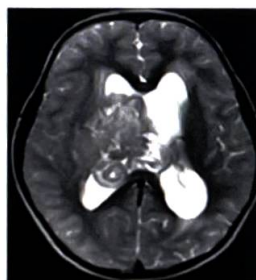
Craniopharyngioma

Location	Brain tumors
Intra ventricular tumors :	Ependymoma. } In 4 <sup>th</sup> medulloblastoma. } ventricle ventricle. Central Neurocytoma. Sub ependymoma. Colloid cyst. Choroid plexus papilloma. Subependymal Giant Cell Astrocytoma (SGCA).

Central Neurocytoma :

Multiple cystic spaces.  
Located in the body of the lateral  
ventricle close to the septum pellucidum.

Occurs between 20-40 years.  
Can lead to hydrocephalus.



Central Neurocytoma



Subependymal nodules :

Appears along the ependymal margin of the ventricular  
system.

Pathognomonic for **tuberous sclerosis**.

These nodules can progress to become a SGCA.



Subependymal nodules	Subependymal Giant Cell Astrocytoma (SGCA)
	

**Colloid cyst/paraphyseal cyst**

00:18:08

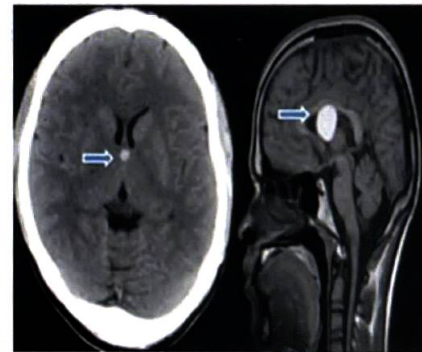
Located at the level of **foramen of monro**.

CT : Hyperdense lesion as it contains **dense mucin**.

TI weighted imaging : **Hyper intense** lesion at the level of foramen of monro.

Creates **obstruction to the flow of CSF** causing dilatation of the lateral ventricles. Hydrocephalus leads to headache.

Treatment : Complete excision.



Location	Tumours
Intraventricular : <b>4<sup>th</sup> ventricular tumors.</b>	<b>Pilocytic Astrocytoma (mc).</b> medulloblastoma. Ependymoma. Subependymoma.

**Pilocytic astrocytoma (mc) :**

Commonly seen in **children**.

Brain stem tumor that extends into the 4<sup>th</sup> ventricle.

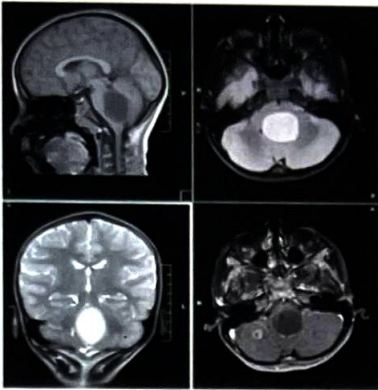
may present as cystic lesion with mural enhancing nodule.

TI : Hypo intense.

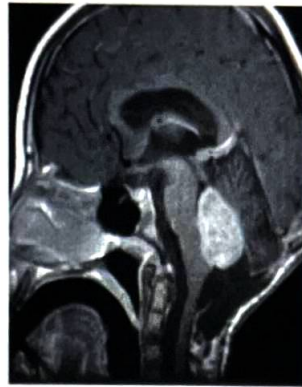
Active space

T2 : Hyper intense.

Very minimal enhancement as it is a low grade glioma.



Pilocytic astrocytoma



Ependymoma

Ependymoma :

Occurs in children usually in the 2<sup>nd</sup> decade.

Occurs around the 4<sup>th</sup> ventricle.

**Plastic tumour** : Very flexible and extends into any space available. So, it can extend through the Foramen of magendie & Lushka from the 4<sup>th</sup> ventricle and enter the basal CSF spaces.

Important parameter : Origin of the tumor from floor or roof of the 4<sup>th</sup> ventricle.

Always arise from the **floor of the 4<sup>th</sup> ventricle**.

medulloblastoma/Primary Neuro Ectodermal Tumor :  
60c6b3eaa8ded0e4e7e5ea7

Very aggressive tumor.

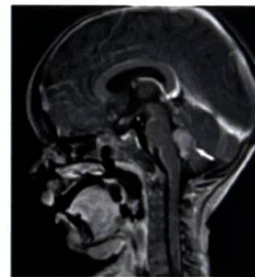
WHO Grade 4 tumor.

Arises from the **roof of 4<sup>th</sup> ventricle**.

Can show **CSF drop metastasis** along the spinal cord.

**Zuckerguss** : Cake icing like metastatic deposits along the surface of the spinal cord due to CSF dissemination.

Treatment : Craniospinal irradiation.



medulloblastoma  
(PNET-MB)

Ependymoma	medulloblastoma
Arise from the floor of the 4 <sup>th</sup> ventricle.	Arise from the roof the 4 <sup>th</sup> ventricle.
Seen in 2 <sup>nd</sup> decade of life.	Seen in 1 <sup>st</sup> decade of life.



## Meningioma

00:24:55

Prototype **extra-axial lesion**.

**MC non-glial tumor**.

Seen in **middle aged females**.

Can have **progesterone receptors**. So in **pregnant females**, can significantly **increase in size**.

Always close to the meningeal surface, either along hemispheres or along faux cerebri.

Common locations : Parafalcine, CP angle.

Findings :

**Broad base** towards the dura.

**Dural tails**.

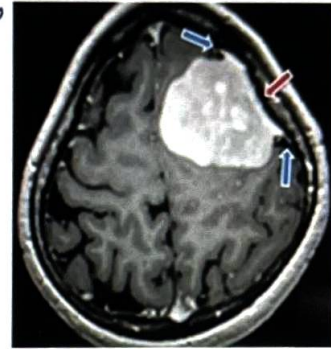
Contrast Enhanced CT (CECT) : **Intense enhancements**.

Non Contrast CT (NC CT) : Appears **hyperdense/white** on non-contrast studies.

Associated with **hyperostosis (thickening)** of bone as it is located close to the dural surface.

**Pneumosinus dilatans** : Dilation of adjacent paranasal sinuses.

**Basifrontal-frontal sinus enlargement**.



meningioma



NC-CT



CECT

Blood supply of meningioma :

Internal carotid artery : **Pial vessels** supply **periphery**.

**External carotid artery** : vessels supply **central core**.

Angiography : vessels get opacified and produce a **spoke wheel pattern** or **sunburst appearance**.

**mother-in-law sign** : Extensive vascularity causes contrast to come in early & fill up meningioma and stays for a long time.

Magnetic Resonance (MR)

**Spectroscopy** : Elevated **alanine** peak at 1.4 ppm.

Syndromic associations :

1. Neurofibromatosis 2
2. NISME syndrome :

**Multiple Inherited Schwannoma**

**meningioma Ependymoma**

Tumors that appear hyperdense on non-contrast CT :

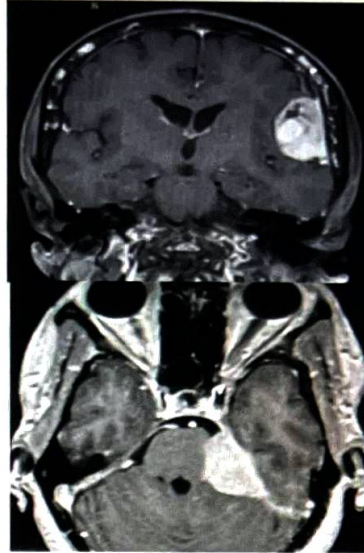
meningioma.

Colloid cyst.

medulloblastoma.

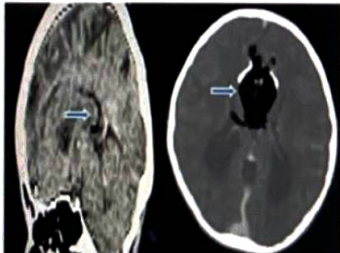
Certain types of lymphomas.

Certain types of metastasis.



## Clinical Quiz

00:32:43

Questions	Radiology & answers
<p>Q. This "<b>Bracket shaped</b>" calcification is seen in ?</p> <p>A. Colloid cyst. B. Germinoma. C. <b>Corpus callosal lipoma</b>. D. Meningioma.</p> <p>kumarankitindia1@gmail.com</p> <p>Corpus callosal lipoma occurs in 2 forms :</p> <p><b>Curvilinear form</b> (along the splenium of corpus callosum). <b>Tubulo-nodular form</b>.</p>	 <p>Bracket shaped calcification in corpus callosal lipoma : Tubulo-nodular form.</p>

Active space



most common intra axial tumors :

Children	Adults
Overall MC : <b>Astrocytoma</b> 2 <sup>nd</sup> : medulloblastoma 3 <sup>rd</sup> : Ependymoma	Overall MC : <b>metastasis</b> . MC Primary tumor : Gliomas.

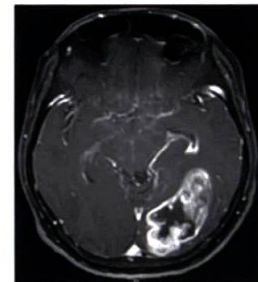
Grading of gliomas :

kumarankitindia1@gmail.com



Glioblastoma multiforme (GBM) :

**most aggressive** type of glioma.  
WHO Grade IV.



GBM with central necrosis

Finding :

Intra axial intensely but heterogenously enhancing mass lesion.

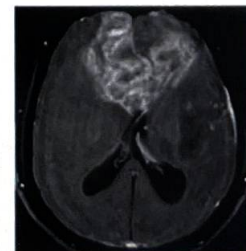
No central enhancement because of **central necrosis** (radiological & pathological hallmark).

Peripheral thick rim of enhancement around the central necrosis.

Seen in elderly (45-65years).

Can lead to **drop metastasis**.

Associations : **Turcot Syndrome** : Brain tumour + multiple intestinal polyps.



Butterfly glioma

**Butterfly glioma** : Starts in one hemisphere then spreads across the genu to the other hemisphere.  
Extremely poor prognosis.

## Oligodendroglioma

00:37:53

Low grade glioma with better prognosis.

CT findings :

Location : Cortical.

Calcifications present.

(MC intracranial tumor to calcify).

Seen in middle aged patients.

Clinical vignette : middle aged patient with a cortical lesion that has calcifications.

Well differentiated tumours commonly in the frontal lobe.

60c6b3eaa8ded0e4e7e5ea7

Retinoblastoma (RB) :

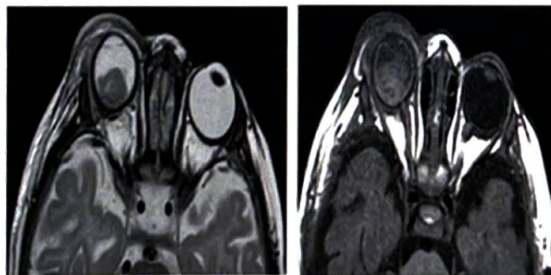
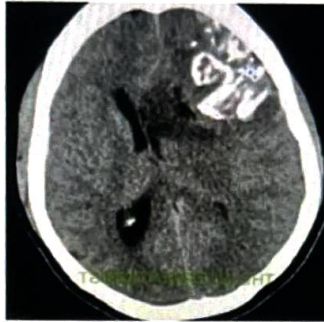
MC intra ocular tumor.

Affects children.

Presents with white ocular reflex :

Leukocoria.

IOC for staging : MRI.

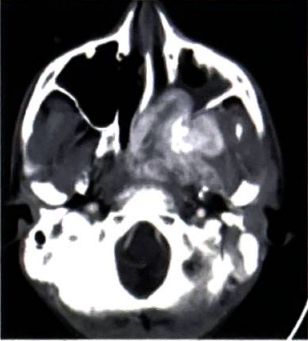
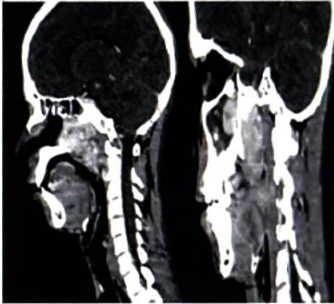


Retinoblastomas

**Trilateral RB** : Combination of bilateral RB + Pineoblastoma.



## Clinical Quiz :

Question	Radiology
<p>14 year male with epistaxis + nasal blockade.</p> <p>Answer : <b>Juvenile Nasopharyngeal Angiofibroma (JNAF).</b></p> <p>Adolescent male + epistaxis + mass lesion. Seen only in adolescent males.</p>	 <p>JNAF</p>
<p>Arises from spheno-palatine foramen. Extends into the nasal cavity, infra temporal fossa, and cranial cavity.</p> <p>Intense lesion as it is a vascular tumor.</p>	 <p>JNAF extending into maxillary sinus</p>
<p><b>Hollman Miller Sign :</b> 60c6b3eeaa8ded0e4e7e5ea7</p> <p>When tumor extends into the infra temporal fossa, pushes the posterior wall of maxillary sinus anteriorly.</p> <p>MRI : <b>Salt &amp; Pepper appearance.</b></p> <p>Management : Pre-operative embolization done.</p> <p>MC blood supply : Internal maxillary artery. Tumor made avascular and then excised.</p>	

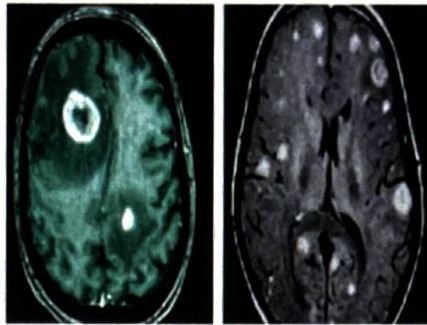
Q. 74 years male, K/c/o Lung carcinoma with confusion, altered sensorium & seizures.

Answer :

multiple heterogeneously enhancing lesions : **Brain metastasis**, usually in the grey-white matter junctions.

MC primaries : **Lungs > Breast.**

**melanoma metastasis** appear **hyperintense / bright** on T1 weighted images due to **melanin**.



Brain metastasis

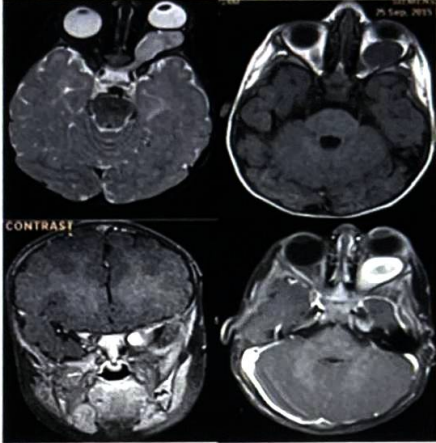
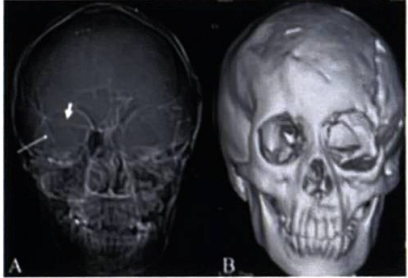
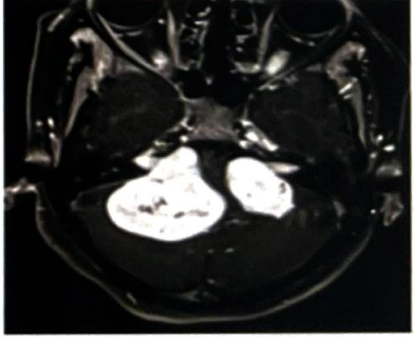
kumarankitindia1@gmail.com

Active space



## Familial Brain tumor Syndromes

00:44:04

Syndromes & associated tumors	Radiology
<p><b>Neurofibromatosis Type 1:</b> Optic gliomas.</p> <p>T1: Bright. T2: Iso intense/hypointense. Post contrast study: Intense enhancement.</p> <p>Associated with: Plexiform neurofibromas (all along the body surfaces). Brain stem glioma. Kyphoscoliosis. Posterior vertebral scalloping. Lisch nodules. Café-au-lait spots.</p> <p><b>Bare orbit sign:</b> Absence or dysplasia of greater wing of sphenoid makes the orbit bare.</p>	 <p>Optic glioma</p>  <p>Bare orbit sign</p>
<p><b>Neurofibromatosis Type 2:</b></p> <p>Bilateral Acoustic Schwannomas: Ice cream on a cone appearance.</p> <p><b>MISME Syndrome:</b> Multiple Inherited Schwannomas, meningiomas &amp; Ependymomas.</p>	 <p>Bilateral acoustic schwannoma</p>

Active space

kumarankit10dia1@gmail.com

### Von Hippel Lindau syndrome (VHL):

Mnemonic : HIPPEL

Hemangioblastoma of cerebellum, spine & retina.

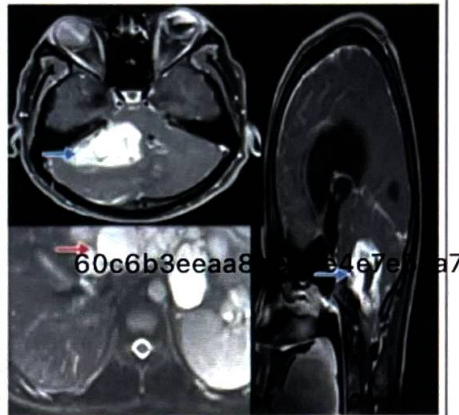
Increased risk of renal cell cancer.

Pancreatic cysts, cancer, adenomas.

Pheochromocytoma.

Epididymal papillary cystadenoma.

Liver/spleen : multiple cysts.



Cerebellar hemangioblastoma

### Tuberous Sclerosis :

Subependymal nodules (SEN)  
SGCA.

Associated with renal lesions like

Angiomyolipomas.

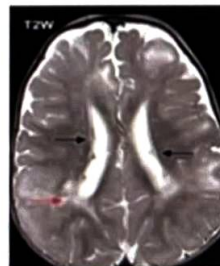
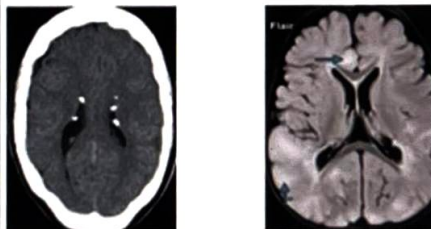
Renal cell cancers.

Renal oncocytoma.

Lymphangiomyomatosis of lungs (LAM) : multiple cysts.

Can be detected antenatally.

Rhabdomyoma in infants.

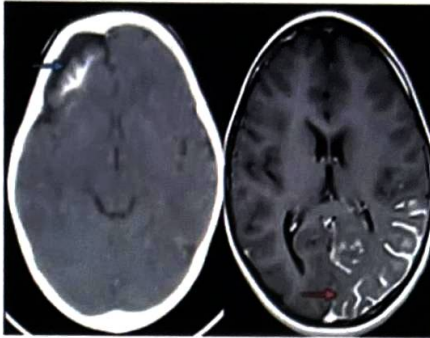


(SEN) → SGCA



## Clinical quiz

00:51:38

Question	Answer
<p>Q. 1 year old male child, port-wine stain on the upper face, refractory seizures + developmental delay &amp; visual disturbances.</p> <p>Ans : <b>Sturge Weber Syndrome.</b></p> <p>Port wine stain usually along V<sub>1</sub>/ophthalmic division of trigeminal nerve.</p> <p>Imaging shows multiple subcortical calcifications and cortical atrophy &amp; pial angiomas.</p> <p>→</p> <p>On X rays, appears as tram track appearance.</p>	 <p>multiple subcortical calcifications &amp; pial angioma</p>
<p>Q. Radiological features of NF-1 include? (PGI may 2018 pattern)</p> <p>A. Posterior scalloping of vertebral bodies.</p> <p>B. Sphenoid wing dysplasia.</p> <p>C. Narrowing of neural foramina.</p> <p>D. Scoliosis.</p> <p>E. microcephaly.</p> <p>Ans : <b>A, B and D.</b></p>	

Clinical insights : most common tumors.

Adult brain tumors :

Adults	Brain tumors
MC overall	metastasis
MC primary tumor	Glioma
2 <sup>nd</sup> MC primary tumor	meningioma
MC non-glia tumor	meningioma
MC intracranial tumor to calcify	Oligodendroglioma

Child brain tumors :

Children	Brain tumors
MC tumor	Pilocytic Astrocytoma
2 <sup>nd</sup> MC brain tumor	medulloblastoma
3 <sup>rd</sup> MC brain tumor	Ependymoma
MC posterior fossa tumor	Pilocytic astrocytoma

Location clinchers :

Site of tumor	Brain tumors
MC cerebello-pontine angle tumor	Acoustic schwannoma
MC suprasellar tumor in children	Craniopharyngioma
MC suprasellar tumor in adults	Pituitary macroadenoma

Syndromic associations to brain tumors :

Brain tumor	Syndrome
meningioma	NF 2 (NFS1)
Glioblastoma	Turcot syndrome
Optic nerve glioma	NF-1
Subependymal giant cell astrocytoma	Tuberous sclerosis (SEN → SGCA)
Cerebellar hemangioblastoma	Von Hippel Lindau syndrome
Bilateral acoustic schwannoma	NF 2

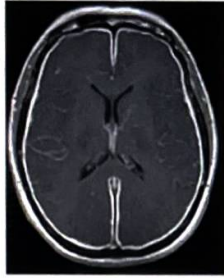
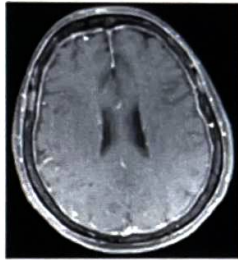


# CNS : INFECTIONS AND MISCELLANEOUS

## Meningitis basics

00:02:28

60c6b3eeaa8ded084e7e6ea7

Types	Leptomeningitis	Pachymeningitis
Image		
Involvement	Arachnoid + Piamater	Dura mater
Feature	Thin serpiginous enhancement extending within the sulcal spaces	Band like enhancement confined to the surface of brain

Brain infections :

**Cerebritis** : Focal infection of the brain parenchyma without formation of a capsule/pus. usually, bacterial in origin.

**Encephalitis** : Diffuse and direct infection of the brain parenchyma. usually, viral in origin.

**Empyema** : Focal pus/infective collection in available spaces (subdural/epidural).

Investigation of choice (IOC) for meningitis is **CSF examination**.

Imaging in meningitis : **CE - CT/ CE - MRI** is done to look for complications :

- **Hydrocephalus.**
- **Abscess/empyema.**
- **Cerebral venous sinus thrombosis.**

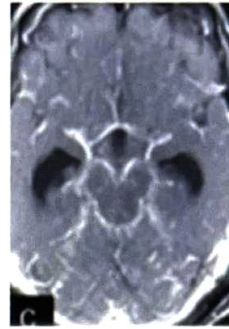
## Tubercular meningitis

00:06:31

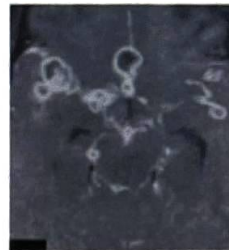
Classical findings : 4.

### 1. Basal enhancing exudates :

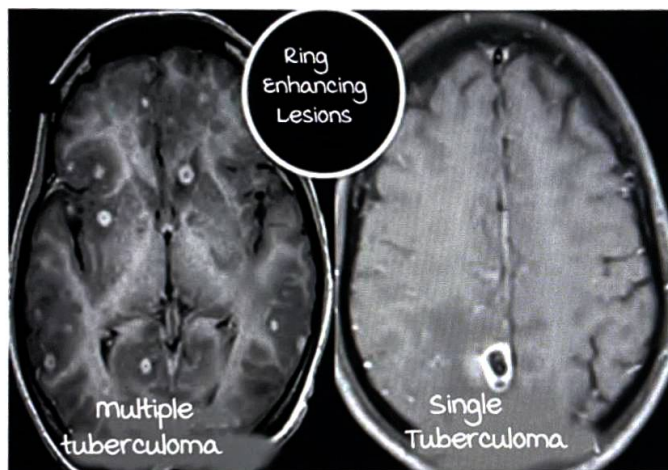
Normally, basal cisterns are filled with CSF. In TB meningitis, entire basal cisterns get clogged with infective exudates. On giving contrast, there is extensive dirty contrast enhancement in basal cisterns.



### 2. Hydrocephalus : Due to impaired CSF flow because of blocked basal cisterns.



### 3. Tuberculoma : Disc/ring enhancing lesions.



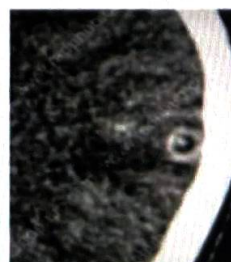
### 4. Vasculitic basal ganglia infarcts :

Blood vessels that supply the brain lie along basal cisterns. In the presence of infective exudates, vasculitis occurs. Vessels that supply the basal ganglia are end arteries and are more severely affected by vasculitis, leading to vessel occlusion and infarcts.

## Other ring enhancing

00:09:44

Q. A 32 year old male presents with 1 episode of seizure and headache. He has no fever, and his vitals are stable. A CE CT is done. Diagnosis is ?

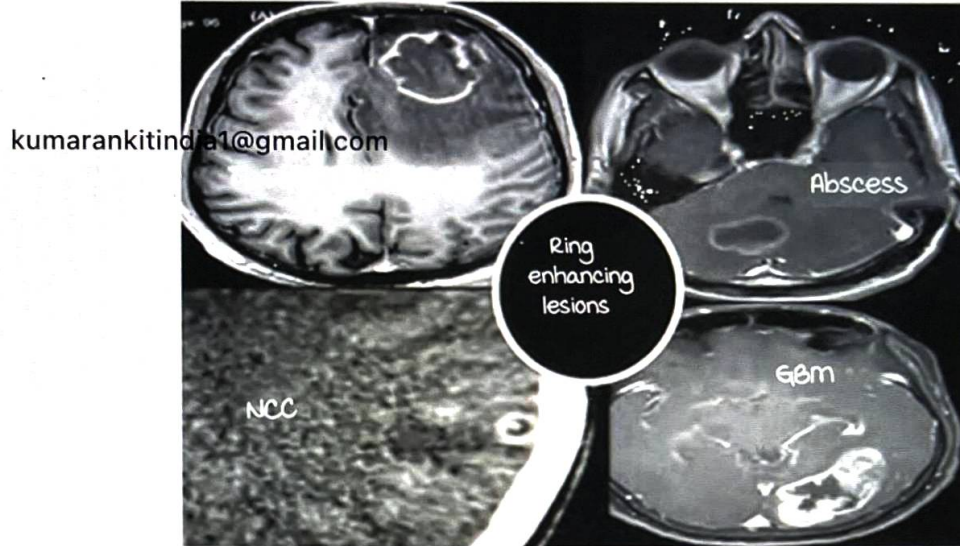


Active space



- A. TB.
- B. GBM.
- C. Neurocysticercosis.
- D. Toxoplasmosis.

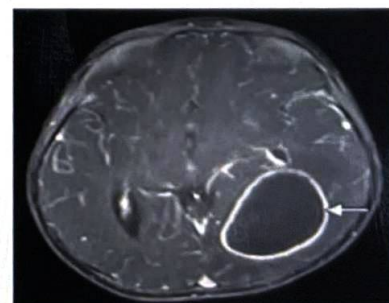
Eccentric dot within a ring enhancing lesion is clincher for neurocysticercosis. The eccentric dot is the scolex of the parasite & differentiates it from a tuberculoma.



Ring enhancing lesion : An area of peripheral enhancement with a central non-enhancing portion.

Central non-enhancing portion due to	Disease
Cystic/ liquified component	Neurocysticercosis (NCC) Abscess
Necrotic component	Tuberculoma Glioblastoma multiforme Toxoplasmosis metastasis Radiation induced necrosis
Haemorrhagic	Haemorrhagic metastasis

Brain abscess :  
usually seen in a child with CSOM, chronic/ recurrent ear infections, ear ache & ear discharge.



Active space

Presents with fever & altered sensorium.

Ring enhancing lesion mostly present in **temporal lobe**.

CE MRI : Peripheral ring enhancement.

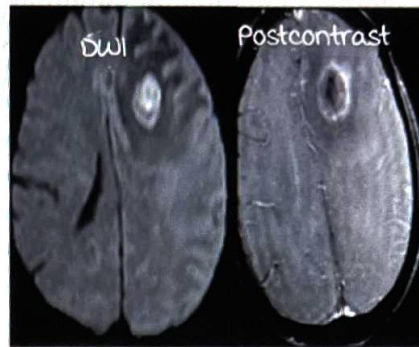
Brain abscess shows **restricted diffusion** on Diffusion Weighted Imaging (DWI).

Appears hyperintense on DWI.

Other conditions that show

restricted diffusion on DWI :

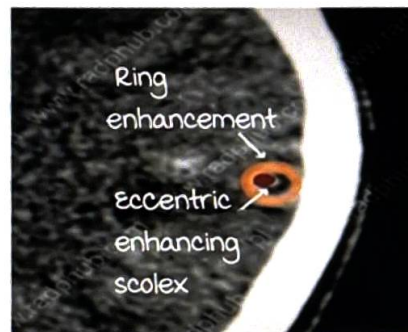
- Acute ischemic infarct.
- Epidermoid cyst.
- Intracranial lymphomas.
- Hematoma (diffuse axonal injuries).



**Neurocysticercosis vs tuberculoma :**

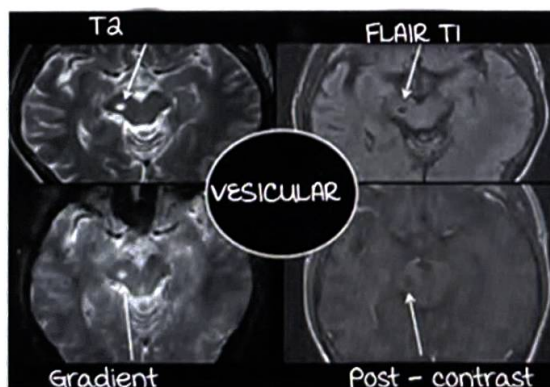
Neurocysticercosis :

Characterised by cyst with a dot/target/dot in a hole sign, which represents the eccentric enhancing scolex.



**Escobar's staging of neurocysticercosis :**

- 1) Acute/vesicular stage : No edema/ inflammation/ contrast enhancement.



60c6b3eeaa8ded0e4e7e5ea7

T2 : Cyst is bright.

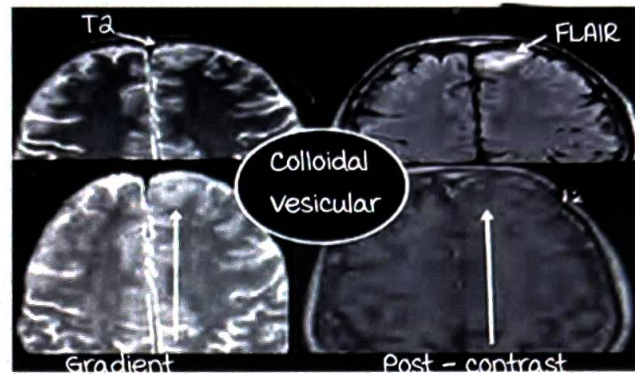
T1 : Cyst is hypointense/dark.

Gradient : No calcification.

Post contrast : No enhancement.



- 2) Early subacute/colloidal vesicular stage : Parasite degenerates → Parasitic antigens diffuse into surrounding brain → Immune reaction → maximum edema/inflammation/contrast enhancement.



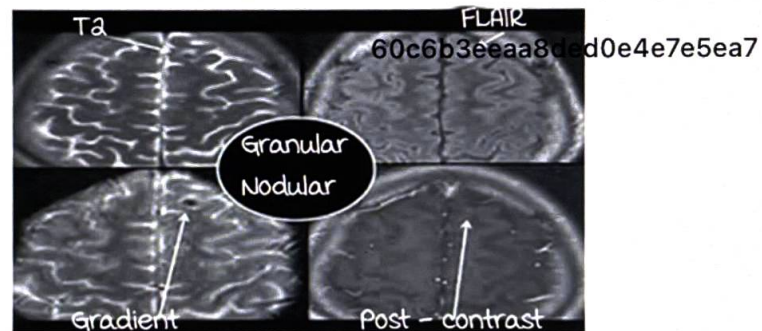
T2 : Dot with hyperintense edema around it.

Flair : Dot with hyperintense edema around it.

Gradient : No calcification/blooming.

Post contrast : Ring enhancing lesion in frontal cortex.

- 3) Late subacute/granular nodular stage : Decreasing edema/inflammation/contrast enhancement.



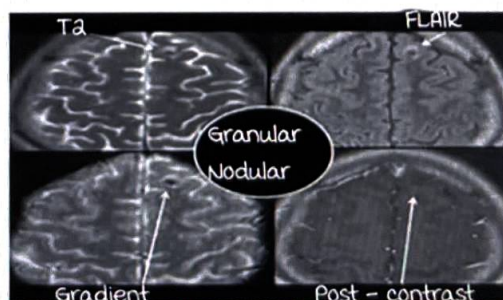
T2 : Hyperintense edema decreased.

Flair : Edema decreased.

Gradient : Early calcification has occurred.

Post contrast : Enhancement reduced.

- 4) Chronic/nodular calcified stage : Dead calcified parasite (no edema)/inflammation/enhancement.



Gradient : Black appearance of calcified parasite.

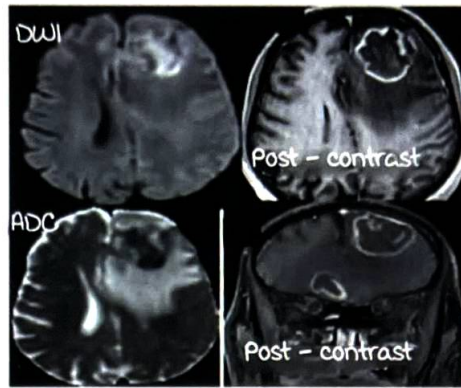
Toxoplasmosis : HIV positive/ICS patient presents with :

- Headache.
- Seizures.
- Altered sensorium.

In HIV positive or immunocompromised patients, **MC opportunistic infection is toxoplasmosis.**

India : TB.

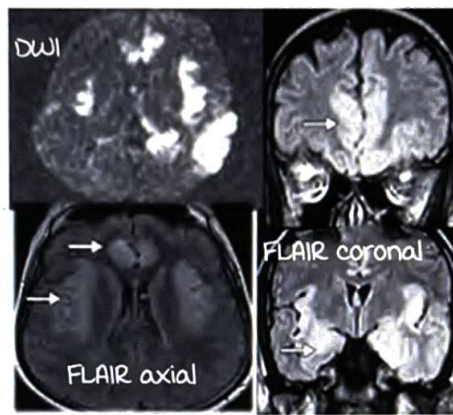
**Irregular ring enhancing lesion with an eccentric enhanced broad based central nodule : Eccentric target sign.**



viral encephalitis :

Elderly patient presents with :

- Headache.
- High grade fever.
- Altered sensorium.



On flair and diffusion weighted MRI, bright appearance in cingulate gyrus involving insula is seen.

Involvement of **limbic system**, fronto-temporal cortex, opercular areas is suggestive of viral encephalitis : **Herpes encephalitis due to HSV-1.**

kumarankitindia1@gmail.com

IOC for herpes encephalitis is **diffusion weighted MRI.**

Early diagnosis is important : **Treatment with IV Acyclovir** to be started as early as possible for good prognosis.

## Multiple sclerosis

00:23:15

Young male with :

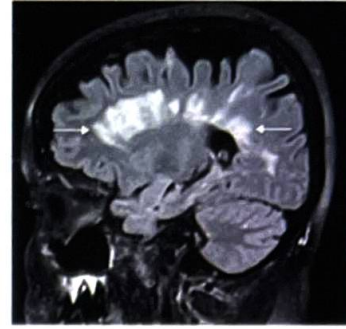
- Multiple neurodeficits.
- Cranial nerve palsies.
- Remitting & recurring symptoms.

MRI : On parasagittal flair image, multiple white matter plaques are seen which are oriented parallel to pyramidal tract.

Active space



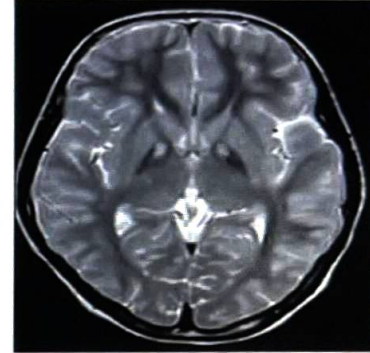
These are demyelinating plaques known as **Dawson's fingers**. Seen in **multiple sclerosis**.



CNS Spotters :

In globus pallidus : Hypointense area are seen due to mineral/iron deposition with bright gliosis in the centre : **Eye of Tiger sign**. Seen in **Hallervorden Spatz syndrome**.

60c6b3eaa8ded0e4e7e5ea7

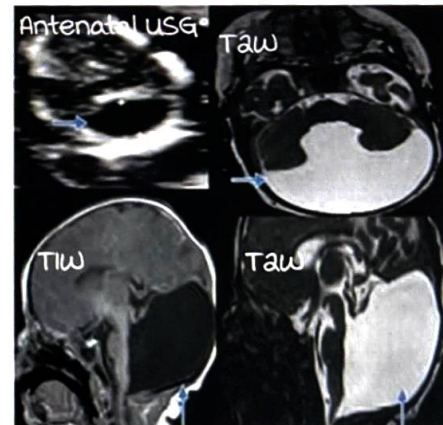


Dandy Walker malformation :

In antenatal USG, posterior fossa appears black due to presence of a cyst.

In Taw MRI, cerebellar hemispheres appear widely separated as vermis is not developed.

So, 4<sup>th</sup> ventricle communicates with large sized posterior fossa cyst.



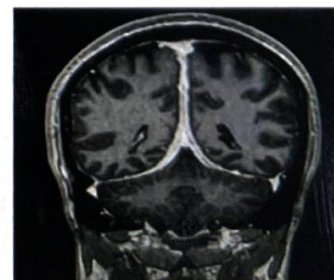
Features seen in Dandy Walker malformation :

- Vermis hypoplasia.
- Dilatation of 4<sup>th</sup> ventricle.
- Large posterior fossa.

Hypertrophic pachymeningitis :

In coronal postcontrast image :

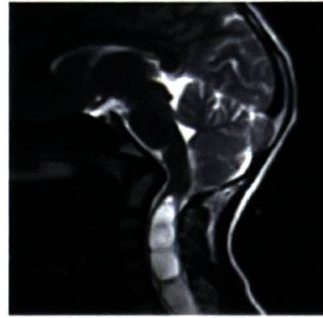
The tentorium cerebelli continues with falx cerebelli (**Eiffel tower by night sign**).



Arnold Chiari type 1 :

Peg shaped cerebellar tonsil  
(pointed tonsil).

Hyperintense change in spinal  
cord because of cyst formation :  
Syrinx formation.

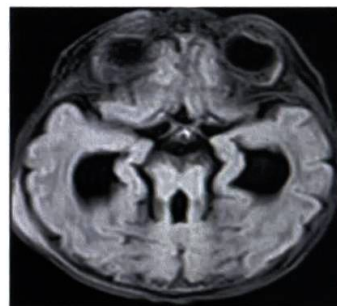


Arnold Chiari type 2 :

- Corpus callosum dysgenesis.
- Small posterior fossa.
- Low lying cerebellum with herniation.
- Lumbar meningocele.
- Tear drop shaped lateral ventricles (colpocephaly).



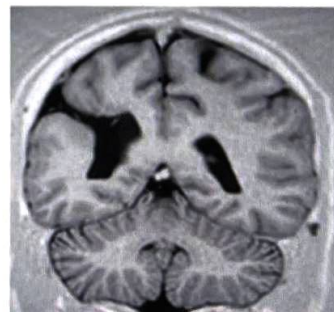
Elongation of cerebellar pedicles :  
molar tooth appearance (Joubert  
syndrome).



Cleft in cerebral cortex :

**Schizencephaly**

Close lipped if minimal separation  
between lips of brain  
parenchyma across the cleft.  
Open lipped if there is wide  
separation.



## Conditions in chronic alcoholics

00:30:04

History of chronic alcoholic :

1. **Wernicke's encephalopathy** : Classic triad of

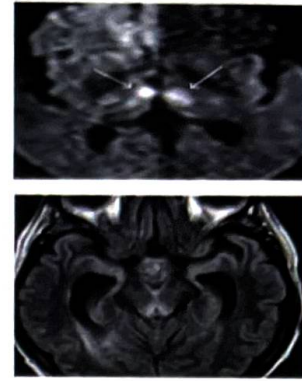
- Acute confusion.



- Ataxia.
- Ophthalmoplegia.

Imaging : Hyperintense signal involving thalami, mamillary bodies, periaqueductal grey matter.

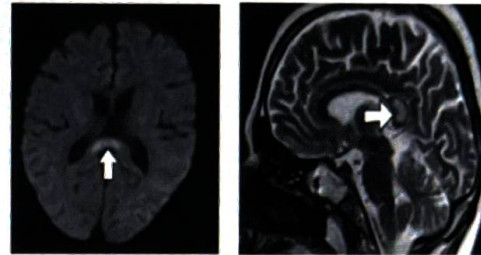
kumarankitindia1@gmail.com



2. Marchiafava Bignami disease :

Non specific clinical features like motor/ cognitive disturbances/ seizures/apraxia.

Imaging : Hyperintense of corpus callosum (splenium).



3. Central pontine myelinolysis :

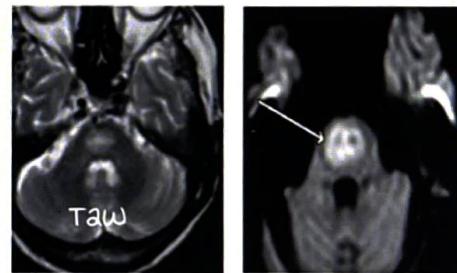
Chronic alcoholic presents with altered sensorium. Labs indicate hyponatremia.

Rapid correction done.

↓  
Transient improvement.

↓  
Sudden deterioration.

↓  
Indicative of central pontine myelinolysis.



Imaging : T1w central pons appears bright, peripheral spared because of demyelination.

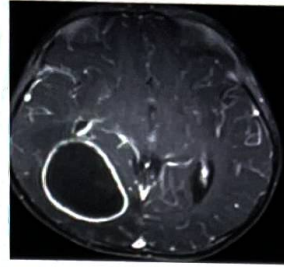
Ring enhancing lesion clinchers :

Characteristic clincher	Diagnosis
Ring lesion with eccentric dot	NCC
Ring lesion with basal enhancing exudates	TB meningitis
Ring lesion in HIV	Toxoplasmosis/ TB
Ring lesion with chronic ear infection	Abscess
Ring lesion with known non-CNS primary tumour	metastasis

Active space

Q. A 13 year old child who has a history of chronic right ear discharge presents with headache, fever & altered sensorium. A CE-MRI was done. What is the diagnosis ?

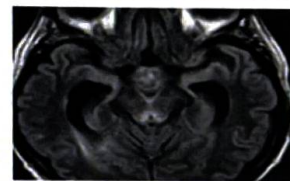
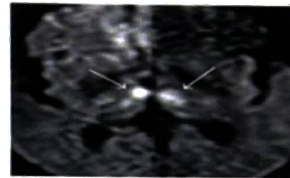
- A. Cerebellar abscess.
- B. Extradural abscess.
- C. Temporal lobe abscess.
- D. meningitis.



This is a classic complication of CSOM : Intracranial infection which spread from middle ear. most commonly affects temporal lobe.

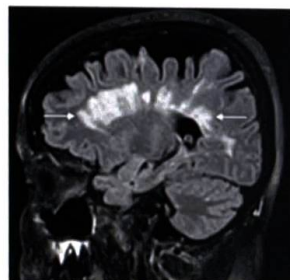
Q. A chronic alcoholic presents with acute onset confusion, ataxia & ophthalmoplegia. An MRI brain reveals hyperintensities involving the mammillary bodies and thalami. Diagnosis?

- A. Pontine myelinolysis.
- B. Wernicke encephalopathy.
- C. Marchiafava Bignami disease.
- D. multiple sclerosis.



Q. A 25 year old male presented with diplopia, recurrent VI nerve palsy and urinary incontinence. An MRI brain done reveals white matter hyperintense plaques. most likely diagnosis is ?

- A. Herpes encephalitis.
- B. TBM.
- C. Multiple sclerosis.
- D. PRES.



MRI : white matter hyperintense plaques that are oriented longitudinally along the pyramidal tracts and are called Dawson fingers. Demyelinating plaques seen in demyelinating disorders (multiple sclerosis)

kumarabhirindia@gmail.com



# MRI : BLOOD APPEARANCE

## Stages of bleeding on MRI

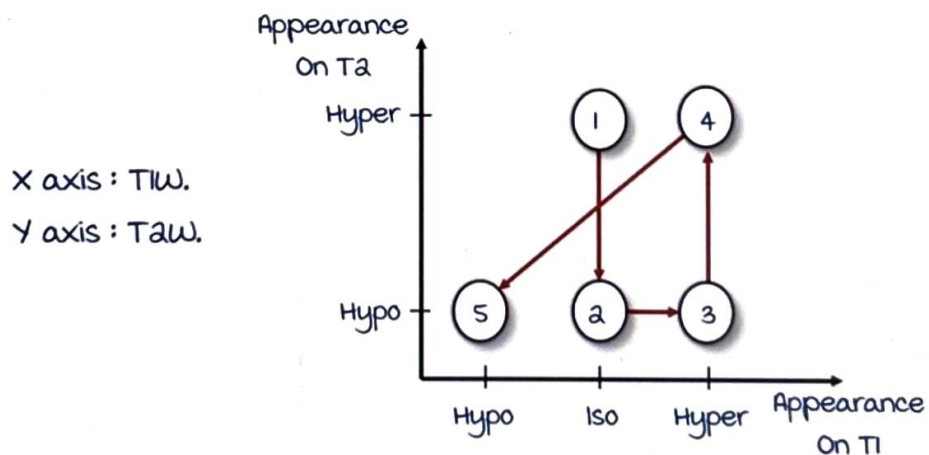
00:00:15

There are various stages of bleeding in every organ especially in the brain.

Different metabolites of Hb present in the tissue at the point of taking MRI, gives rise to different imaging appearances on T<sub>1</sub> and T<sub>2</sub> weighted images.

Stage	Time from Onset	Hemoglobin metabolite
Hyper-acute	<24 hours	Oxyhemoglobin
Acute	1-3 days	Deoxyhemoglobin
Early sub-acute	>3 days	Intracellular methemoglobin
Late sub-acute	>7 days	Extracellular methemoglobin
Chronic	>14 days	Hemosiderin

Visual graphic approach :



On X axis : Hypointense : Dark.

Isointense : Grey.

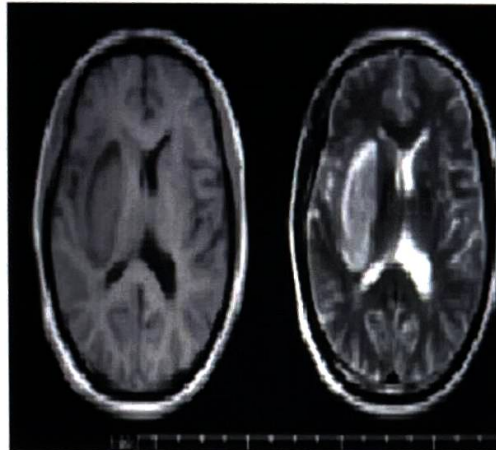
Hyperintense : Bright white.

On Y axis : Hypointense : Dark.

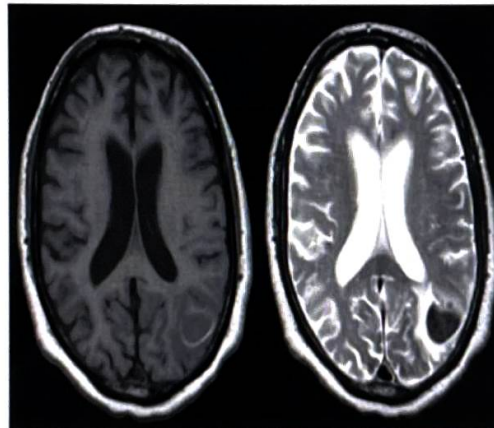
Hyperintense : Bright white.

Stage	T <sub>1</sub> W	T <sub>2</sub> W
Hyper acute	Isointense	Hyperintense
Acute	Isointense	Hypointense
Early sub- acute	Hyperintense	Hypointense
Late sub- acute	Hyperintense	Hyperintense
Chronic	Hypointense	Hypointense

Isointense lesion on T<sub>1</sub>W  
and hyperintense lesion  
on T<sub>2</sub>W → Hyper acute  
stage.



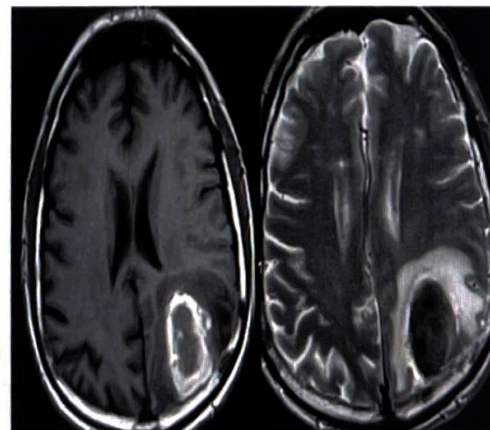
Isointense lesion on T<sub>1</sub>W  
and hypointense lesion on  
T<sub>2</sub>W → Acute  
Hemorrhage.



White area on T<sub>2</sub>W is due  
to edema.

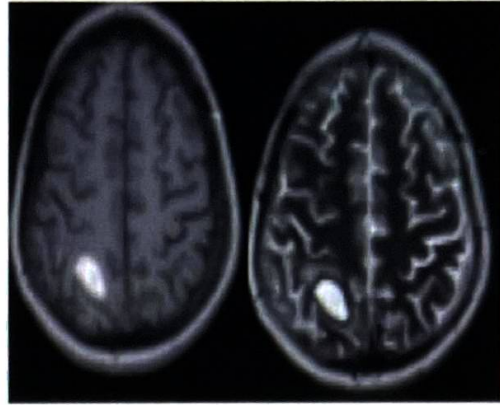
The rim in T<sub>2</sub>W is  
appearing hypointense.

Hyperintense on T<sub>1</sub>W and  
hypointense on T<sub>2</sub>W →  
Early sub acute.

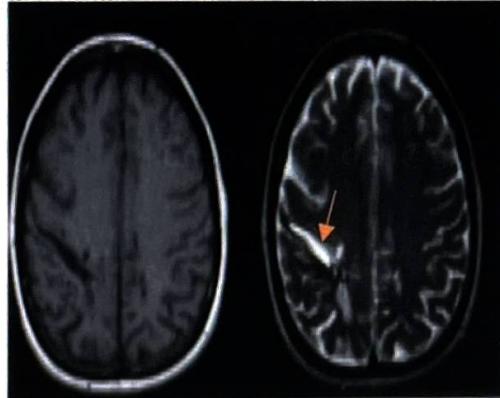




Hyperintense on both  $T_1W$   
and  $T_2W$  → Late sub  
acute stage.



Hypointense on both  $T_1W$   
and  $T_2W$  → Chronic stage.  
CSF in the gliosis on  $T_2W$   
shows hyperintensity.



kumarankitindia1@gmail.com

# GUT : CONVENTIONAL PROCEDURES

## Conventional procedures in GUT

00:02:37

Intravenous urography (IVU)/ Intravenous Pyelography (IVP) :

Entire urinary tract can be visualised.

Antegrade pyelography :

Externally, a percutaneous nephrostomy tube is passed into the kidney from the back in the lumbar region.



IV contrast is injected directly into the renal pelvis.



Goes into the ureter.



Gives anatomical visualisation of renal pelvis + ureter + bladder.

Retrograde pyelography :

Cystoscopy is done.



ureter is cannulated at ureterovesical junction.



Contrast is injected.



Contrast goes retrogradely into renal pelvis.

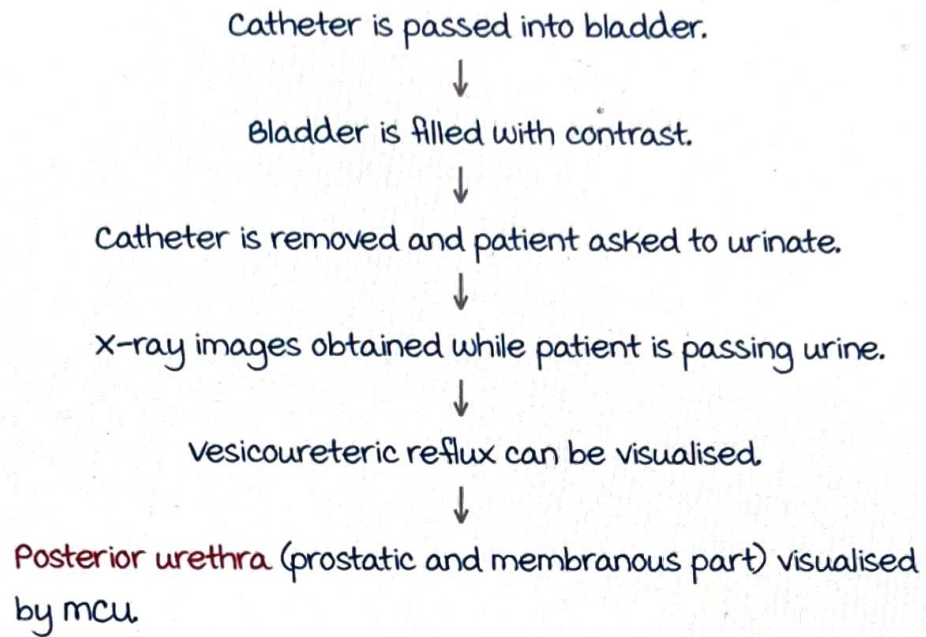


Gives anatomical visualisation of ureter + renal pelvis.

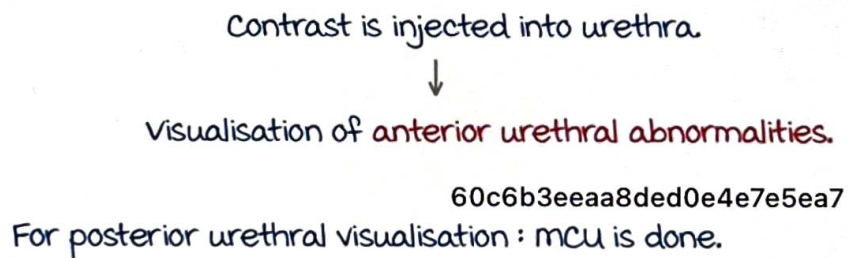
Active space



### micturating Cystourethrography :

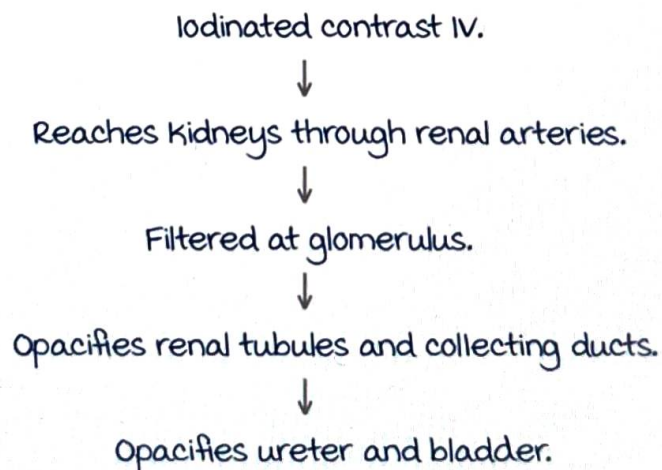


### Retrograde urethrography (RGU) :



### Intravenous Urography/Pyelography (IVU/IVP)

00:05:56



Plain KUB radiograph is done first, to visualize presence of any calculus.

## Normal IVU study :



Plain KUB

At 0 min : Kidney  
appears bright/dense.  
Image is known as  
nephrogram.At 5 mins :  
Renal calyces and  
small part of ureter  
get opacified.15 mins prone :  
Renal calyces,  
pelvis and ureters are  
opacified.Full bladder  
(30-45 mins later) :  
Bladder is  
opacified.

Post void

## Renal calculi on IVU :

Plain X-ray KUB :  
Hyperdense well defined  
abnormality with increased  
density seen in right lumbar  
region, likely to be a renal pelvic  
calculus.





Plain KUB



At 5 min



At 15 min

5 min : Calyces of left kidney is normal.

Calyces of right kidney are dilated. Signs of hydronephrosis present.

15 min : Right side visualised well.

massive dilatation of calyces in left kidney. No opacification in left ureter.

Signs seen :

Rim sign : Thin appearing cortex with opacification of cortex

Crescent sign : Opacification at collecting duct seen as crescent shaped.

**Antegrade pyelography :**

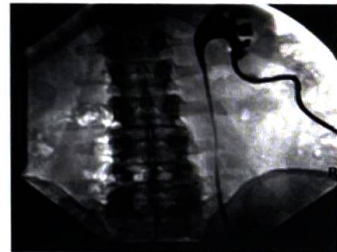
Percutaneous nephrostomy passed into kidney in lumbar region



Contrast injected through the tube.



Visualised renal calyces, pelvis and ureter in antegrade manner.



**Retrograde pyelography :**

Catheter is passed in bladder



ureter is cannulated using cystoscopy



Contrast is injected



visualises bladder, ureter and kidney in retrograde manner.



## Horseshoe kidney

00:11:43

Clinically asymptomatic.  
Kidneys appear slightly low at the level of L2-L3 and close to midline.

Flower vase appearance.



60c6b3eeaa8ded0e4e7e5ea7

**Horseshoe kidney** : Lower poles of both kidneys are fused.

Ascent of the kidney during embryological period is arrested by inferior mesenteric artery.

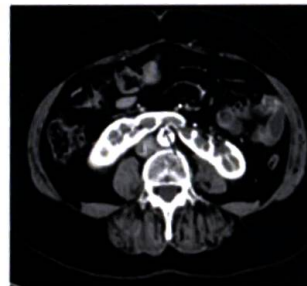
**Handshake sign** : Due to fusion at lower poles.

**Sigmoid kidney** : Due to fusion at both upper and lower poles.

**Pancake kidney** : Entire kidney as a round pelvic structure due to fusion of both poles.

Q. A patient presents with vomiting & colicky abdominal pain. A CT study was done & is shown here. What is the diagnosis ?

- A. Ectopic Kidney
- B. Pancake Kidney
- C. Cross fused ectopic kidney
- D. Horseshoe Kidney.



Ans : D. Horseshoe Kidney. Both kidneys are fused with each other across the midline.

Clinical implications of horseshoe kidney :

- Increased risk of traumatic injury.
- Increased risk of transitional cell carcinoma.

Because of altered configuration of pelvicalyceal system, increased risk of urinary stasis → Predisposes to UTI.

**Crossed fused ectopic kidney** :

One kidney has crossed over to other side and fused with the other kidney.

Active space



Image shows cross fused ectopic left kidney.  
Clinically asymptomatic.



## Duplex pelvicalyceal system

00:16:27

kumarankitindia1@gmail.com

Incidentally detected.  
Two ureters arise from the same pelvicalyceal system.  
Bifid variant (least severe).



**Wiegert-meyer law :**  
Upper moiety has a medial & inferior insertion into bladder.  
Prone to formation of ureteroceles.

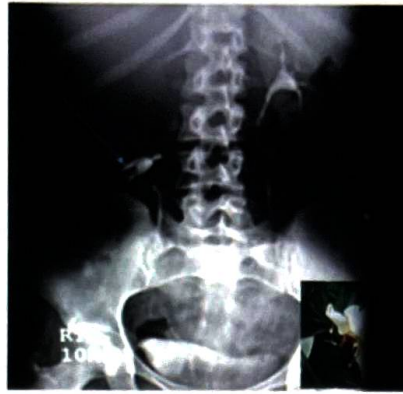
Lower moiety inserts at normal site but lax/wider insertion to urinary bladder.  
Prone to develop vesicoureteral reflux.



→ upper moiety  
→ lower moiety

**Drooping lily sign :** A duplex pelvicalyceal system with obstructed dilated hydronephrotic upper moiety which pushes down the lower moiety (drooping lily).





### CT urography :

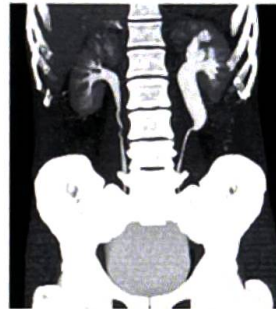
CT equivalent of IVP.

Can visualise kidney, ureter bladder very well.

Also shows the renal parenchymal abnormalities like tumour, cysts.

Hence better than IVP.

Disadvantage : Radiation exposure is relatively high.



In the image, a dilated hydronephrotic left renal calyceal system with dilated renal pelvis is seen due to a ureteral stricture involving the narrowing of the proximal ureter.

### Pelviureteric junction obstruction

00:21:38



IVU : Gross hydronephrosis on the left side with no opacification of left ureter.

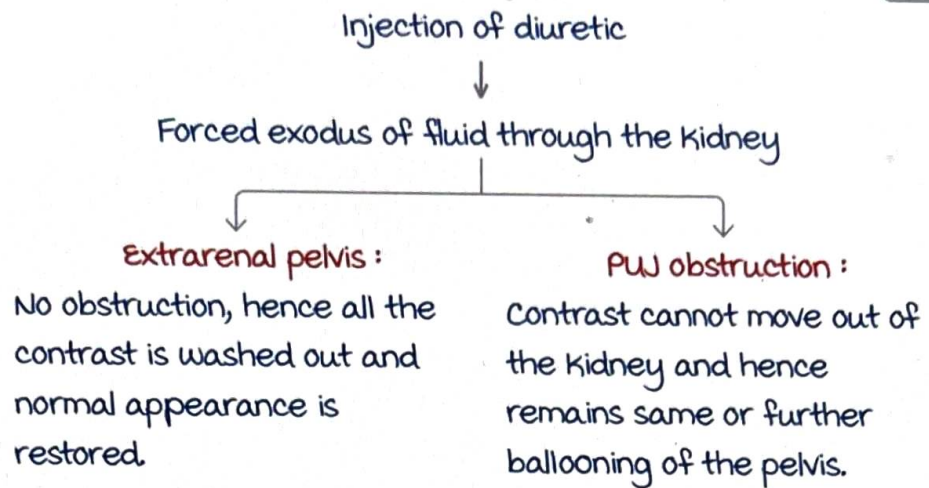


CT KUB : Right kidney is markedly dilated with dilated pelvis and abrupt cut-off of contrast.

**Balloon on string appearance.**

Diuretic renography : Done to distinguish between extrarenal pelvis vs PUJ obstruction.





## Ureterocoele

00:24:03

Dilatation of the ureter at the ureterovesical junction.

**Cobra head/adder head appearance.**

**Spring onion appearance.**



Can predispose to UTI.

Smooth, thin, uniform halo around the ureterocoele is seen.

Irregular halo : Pseudoureterocoele caused by ureteric tumours.

### Retrocaval ureters :

Ureter passing behind inferior vena cava.

60c6b3eeaa8ded0e4e7e5ea7  
Anomaly of IVC development.

Fish hook/J shaped ureter.



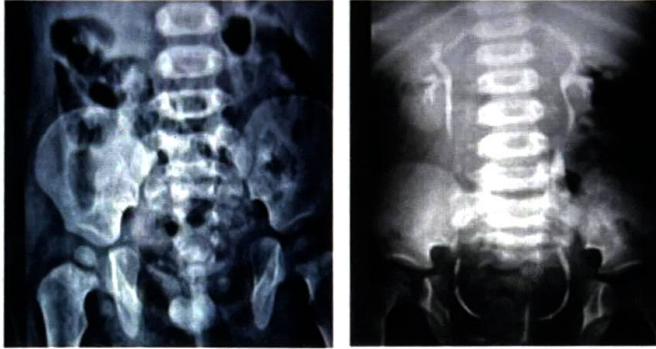
**Bladder exstrophy :**

In a pelvic radiograph,

- Pubic symphysis is widened.
- Bladder is small and irregular or non visualisation of bladder.

Associated with pubic diastasis.

Bladder extruding out of the body.



**manta ray appearance.**

**Hurley stick appearance** of the ureter.

**Micturating cysto-urethrography (MCU)/****Voiding cysto-urethrography (VCUG)**

00:27:59

urinary bladder is catheterised



Distended with contrast and catheter removed



Patient asked to micturate



Spot radiographs obtained during micturition (RAO/LAO)



- most distensible part of urethra : **Prostatic urethra.**  
kumarankitindia1@gmail.com
- Shortest and narrowest part which pierces urogenital diaphragm : **membranous urethra.**
- Within the penile shaft : **Penile urethra.**
- Between membranous & penile urethra : **Bulbar urethra.**
- Bulbar + Penile urethra : Anterior urethra.

MCU for visualising posterior urethra : Prostatic/ membranous.

Retrograde urethrography for visualising anterior urethra.



## Vesicoureteric reflex

00:30:00

Q. A 2 year old male child presents with recurrent UTI. Which of the following test will you advice next in this patient?

- A. USG.
- B. MCU.
- C. Radionuclide MCU.
- D. IVU.

Ans. A. Initial imaging investigation of recurrent UTI : USG.

Suspect VUR → Pelvicalyceal system dilated → Hydronephrosis (seen on USG)

kumarankitindia1@g



USG



MCU

MCU : Initial IOC for diagnosis of VUR.

Shows reflux of contrast into the ureter.

Gives good anatomic investigation.

IOC for follow up : Radionuclide cystography.



Grade 1 : Reflux is limited only to the ureter.

Grade 2 : Reflux extends up to renal pelvis.

Grade 3 : mild dilatation of pelvicalyceal system.

Grade 4 : Tortuous ureter with blunting of calyces with maintained forniceal impressions.

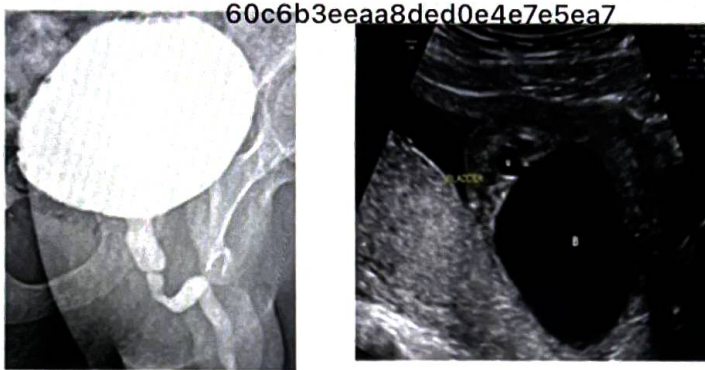
Grade 5 : Grossly tortuous dilated with severe hydronephrosis and loss of papillary impressions.

**Posterior urethral valve :**

Dilated posterior urethra with a slit like valve.

Antenatal USG : Keyhole appearance.

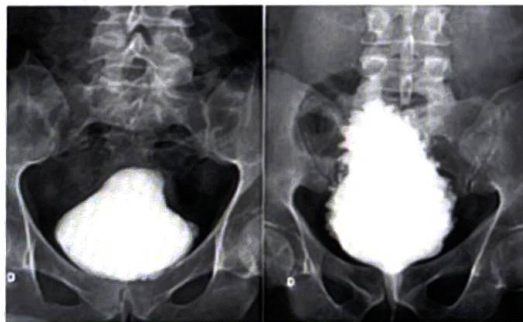
Clinical presentation : A male neonate presents with narrow urinary stream.



Q. Posterior urethral valve is diagnosed by using ?

- A. MCU.
- B. Prenatal USG.
- C. PET scan.
- D. Postnatal USG.
- E. CT scan.

Ans. A, B, D.

**Bladder shapes :****Pear shaped/tear drop bladder :**

Extrinsic compression usually by : Pelvic hematoma/  
lipomatosis/ lymph node mass.

**Christmas tree shaped bladder :**

Neurogenic bladder with increased sphincter tone.



Investigations in bladder trauma :

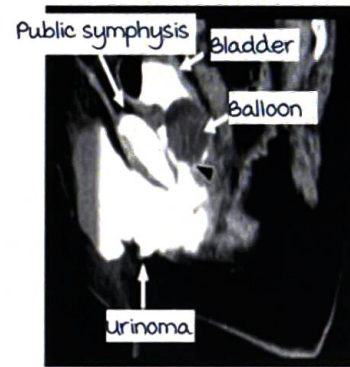
**Intraperitoneal rupture :**

- Distended bladder + blunt trauma abdomen, bladder ruptures at its dome.
- Urine goes into peritoneal cavity.
- IOC for bladder injury : **Cystography (CT or conventional).**
- Treatment : **Surgical.**



**Extraperitoneal rupture :**

- Occurs due to pelvic fracture or penetrating trauma.
- Bladder ruptures at its base.
- No communication with peritoneal cavity.
- Contrast comes out into prevesical space in the perineum.
- Management : **Conservative.**



**Retrograde urethrography (RGU)**

00:38:14

Catheter is placed into tip of urethra and contrast is injected.

Good for visualising anterior urethra (penile/bulbar).



urethral stricture



urethral rupture

Active space



urethral rupture :

- Extravasation of contrast.
- Associated with pelvic fractures.
- Blood at external urethral meatus.
- Patient unable to pass urine.

Clinical insights :

IVU	MCU	RGU
Assess entire urinary tract - KUB. Kidneys : Horse shoe kidney. Hydronephrosis. Renal agenesis. Ureter : Duplex pelvicalyceal system. Double ureter. J shaped/ fish hook ureter. Retrocaval ureter. Ureterocele. Bladder : Bladder filling defects. Bladder mass.	main investigation for vesico ureteric reflux. Best technique for posterior urethral abnormalities. most important : Posterior urethral valve.	Investigation of choice : Anterior urethral abnormalities. Eg, Anterior urethral stricture. Anterior urethral rupture.

Q. Patient with pelvic trauma, unable to pass urine, blood at urethral meatus and high riding prostate on DRE. Next investigation?

Ans : Retrograde urethrography to rule out urethral injury.

**Never pass a foleys catheter.**

Drain urine by suprapubic catheterisation.

Q. A 6 month old female child presents with UTI. An IVU study was done & is shown here. most likely diagnosis is ?

- VUR
- Transitional cell carcinoma.
- Ureterocele.
- ureteric calculus.



kumarankitindia1@gmail.com

Active space



Ans : In the image, there is a cystic dilatation where the ureter enters the bladder, this is known as **ureterocolocele**.

Q. A patient complains of incomplete evacuation of urine and frequent micturition. Identify the diagnosis in this image ?

- A. Urethral stricture.
- B. urethral fistula.
- C. urethritis.
- D. urethral diverticulum.

Ans : Image shown here is of Retrograde urethrography (RGU).

The contrast is

introduced through the urethra. Here, a narrowing is seen in the urethra which indicates a **urethral stricture**.



Q. A patient with recurrent UTI undergoes an IVU study shown here. Can you identify the site of insertion of the ureter arising from the right superior moiety ?

- A. Above the trigone.
- B. Infero-medial to the trigone.
- C. Penile urethra.
- D. Perineum.

Ans. According to Wiegert Meyer rule, ureter arising from superior moiety inserts **infero-medial to trigone**.



kumarankitindia1@gmail.com

# GUT IMAGING

## Clinical quiz

00:00:24

1. A 35 year old patient presented with dull aching pain in the back and sterile pyuria. His KUB radiograph is given here. What is the most likely diagnosis ?

- A. Staghorn calculus.
- B. Putty kidney.
- C. Nephrocalcinosis.
- D. Psoas abscess.



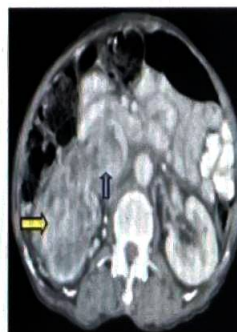
2. A 45 year old patient presents with vague abdominal pain. USG revealed a Bosniak grade 3 cystic lesion. A CE-CT was done and is revealed here. Most likely diagnosis is ?

- A. Renal colic.
- B. RCC.
- C. Renal angiomyolipoma.
- D. Renal cysts.



Bosniak classification is used for classification of complex renal cysts.

3. USG of a 54 year old man depicted a complex cystic lesion in right kidney with an exophytic mass. The intravascular extension of this mass may be best image using which of the following imaging modality ?
- A. IVP.
  - B. CE-CT.
  - C. MRI.
  - D. Invasive catheter angiography.



Active space



## Urolithiasis

00:03:30

X-ray KUB is an initial investigation. It is not the investigation of choice.



60c6b3eaa8ded0e4e7e5ea7

Types of renal calculi :

Calcium oxalate calculi : **most common**.

Associated with hypercalciuria and hyperoxaluria.

Struvite/triple phosphate calculi :

**magnesium ammonium phosphate** calculi.

Large calculi that completely fill up the renal pelvi-calyceal system : **Staghorn calculi**.

Occurs due to recurrent UTI by urease producing organisms such as **Klebsiella, pseudomonas**.

Uric acid calculi : Pure uric acid calculi are **radiolucent**.

Cystine calculi : **Hardest** calculi.

Cannot be treated with Extracorporeal Shock Wave Lithotripsy (ESWL).

Drug related calculi : Indinavir, atazanavir, silica containing drugs.

Staghorn calculus :

**Struvite/triple phosphate** calculus.

**Clinically silent** in most of the cases.



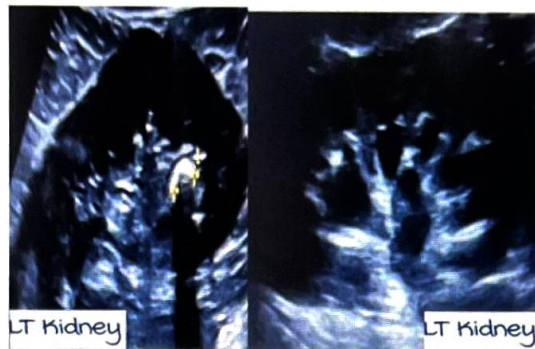
USG :

First investigation in **acute renal colic** (loin to groin pain).

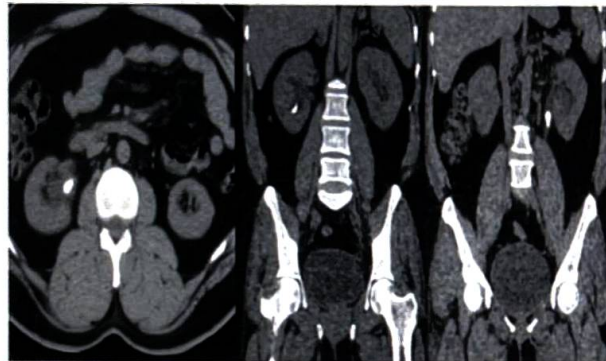
Investigation of choice for detection of **hydronephrosis**.

Calculi appears hyperechoic with posterior dense shadow.

If obstruction → Calyceal system will be dilated → Dilated calyceal system filled with fluid → Hydronephrosis.  
 Doppler flow ultrasound → Calculus shows **Twinkle artefact** (Comet tail artefact).



CT :



**Non-contrast CT** is the investigation of choice for renal/ureteric calculi.

Calculi appears **hyperdense**.

**Dual energy CT** helps to detect calculi composition.

**CT occult calculi** : **Pure matrix calculi** and **indinavir calculi**, these cannot be visualised on CT.

Question :

Which of the following is the investigation of choice for diagnosis of renal stones?

- A. USG.
- B. **Non-contrast helical CT.**
- C. Contrast helical CT.
- D. MRI.

Ureteric calculi :

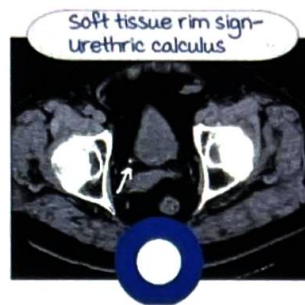
**Soft tissue rim sign** : If a calculus becomes impacted at a particular site in ureter, adjacent ureteric wall becomes edematous and forms soft tissue rim around calculus.

kumarankitindia1@gmail.com

Acute space



In **phleboliths**, soft tissue rim is not seen. Phleboliths are associated with **comet tail artifact**.



Urolithiasis mimic

Nephrocalcinosis :



Calcification of renal parenchyma. It can be medullary (95%) or cortical (5%).

Cortical calcification can show **single pencil line appearance** or **double tram track appearance**.

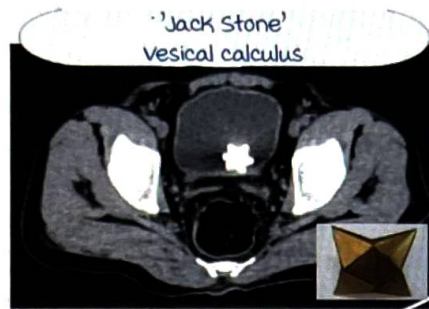
PCN tube and DJ stent :



- **Percutaneous Nephrostomy Tube (PCN tube)** : Can inject contrast and drain obstructive urine. It provides alternate pathway for urinary drainage.
- In ESWL, calculus is fragmented. To avoid small fragments from getting impacted, a stent is placed. Upper end of the stent is in kidney and lower end is in bladder : **Double J stent**.

- multiple fragments can line up along the stent :  
**Steinstrasse appearance** (German for street made up of stones).

Vesical calculus :



**Jackstone calculus** : made up of **calcium oxalate dihydrate**.

Fragile : Easily fragmented.

On an IVU, dense persistent nephrogram :

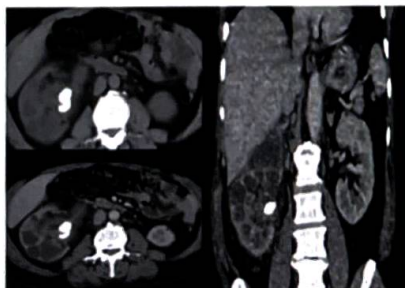


60c6b3eaa8ded0e4e7e5ea7

- Kidney appears **dense** even after 10 minutes of contrast administration due to **persistent hold up of contrast within the kidney**.
- Can be seen in **acute ureteric obstruction, acute pyelonephritis, renal artery stenosis and renal vein thrombosis**.

## Pyelonephritis

00:22:44



- Infection of the kidney.
- Kidney becomes enlarged.
- **Perirenal/perinephric fat stranding** suggests infection.
- Hydronephrosis and calculus may be present.
- Investigation of choice : **CE-CT**.

Active space



Clinical scenario :

A known diabetic with deranged blood sugars presents with fever and turbid urine. He has a pulse of 120, BP of 100/60 mm Hg and his TLC is 32000. A screening abdomen radiograph revealed this finding. most likely diagnosis?

- A. Cholecystitis.
- B. Liver abscess.
- C. Hydronephrosis.
- D. Emphysematous pyelonephritis.



Seen in immunocompromised patients.  
CE-CT is investigation of choice.

Xanthogranulomatous pyelonephritis :



- Seen in chronic calculus disease along with superimposed infection with proteus/e. coli.
- Also associated with staghorn calculus.
- **Bear paw sign** : multiple dilated calyces surround central atrophic renal pelvis.
- Investigation of choice : CE-CT.

Question : kumarankitindia1@gmail.com

Investigation of choice for detection of hydronephrosis/  
pyonephrosis?

- A. IVP.
- B. USG.
- C. X ray KUB.
- D. CT.

## Genito-urinary tract TB

00:28:14

Characteristic clinical feature : **Sterile pyuria.**

Best modality for early diagnosis : **Intravenous urogram (IVU).**

Overall best investigation : **CE-CT.**

most common CT finding : **Renal calcification.**

most valuable radiologic feature : **multiple findings.**

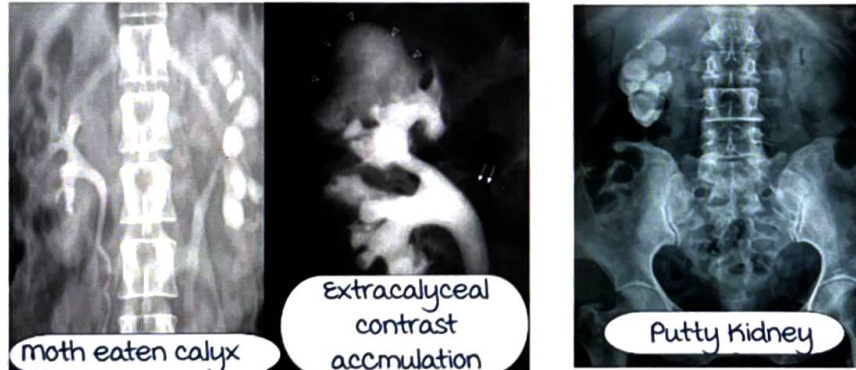
Renal signs :

Early stages :

- **moth eaten appearance** of calyces : Earliest finding.  
Seen on IVU.
- Hydronephrosis.
- Extra calyceal contrast accumulation.

Late stages :

- **Putty kidney** : Densely calcified non-functioning kidney.
- **Auto nephrectomy** (blood supply is diverted to other functioning kidney).



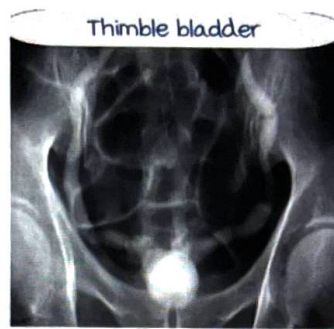
Ureteral signs :

- **Hiked up ureter/pelvis** : Due to fibrosis, ureter is pulled up.
- **Kerr's kink** : Kinking of ureter.
- **Corkscrew ureter** : Tortuous ureter.
- **Pipestem ureter** : Thickening of ureter along the wall.
- **Golf hole ureter** : ureter openings at uretero-vesical junction becomes prominent.



Urinary bladder signs :

**Thimble urinary bladder** : Bladder is contracted (small) due to fibrosis and inflammation.



TB vs Schistosomiasis :

TB involves the entire urinary tract : kidney, ureter, bladder.

Schistosomiasis involves **only urinary bladder**; Shows **fetal skull appearance** on urinary bladder on USG.

## Complex renal cysts

00:36:55

**Bosniak classification** :

It is mainly described on CT scan.

### Bosniak classification of renal cysts

60c6b3eeaa8dad0e4e7e5ea7

Simple benign  
cyst.



Class II

Thin septae with fine  
calcifications in the walls. No  
soft tissue enhancement.

Class III

multiple class II  
features, no soft tissue  
enhancement.



Class III

Irregular or smooth thickened  
walls or septa showing  
measurable enhancement.



Class IV

Class III, with soft tissue  
enhancement independent of  
wall or septal enhancement.

malignancy risk :

Class I : 0.

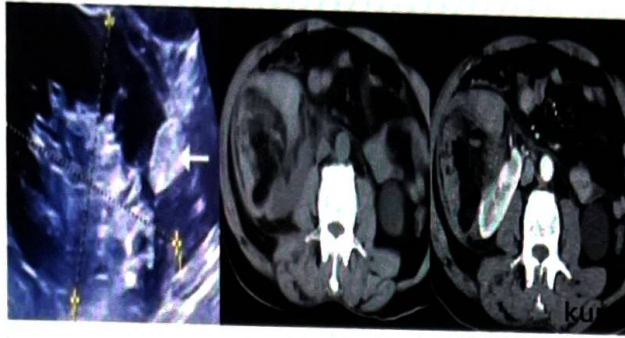
Class 2 : 0.

Class 2F : 5% (F : Follow up is required).

Class 3 : 50-60%.

Class 4 : 90-100%.

## Renal angiomyolipoma :



rankitindia1@gmail.com

USG : Renal cortex shows bright hyperechoic area.

CT : Heterogenous mass with central fat density.

Seen in young age group.

Associated with **tuberous sclerosis**.

Also associated with **NF-1/VHL syndrome**.

usually asymptomatic, may present with **spontaneous retroperitoneal hemorrhage** (pain, nausea, vomiting, shock and hypotension).

## Renal oncocytoma :

Central stellate scar



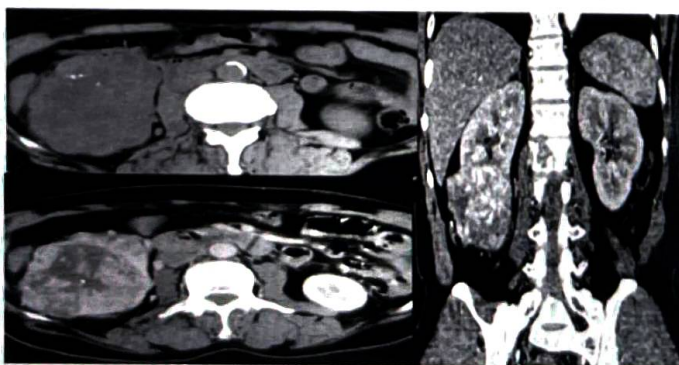
most common renal solid benign tumor.

Central non-enhancing **stellate scar** is the peculiar feature.

**Spoke wheel pattern** of vascularity is seen on angiogram.

## Renal cell carcinoma (RCC)

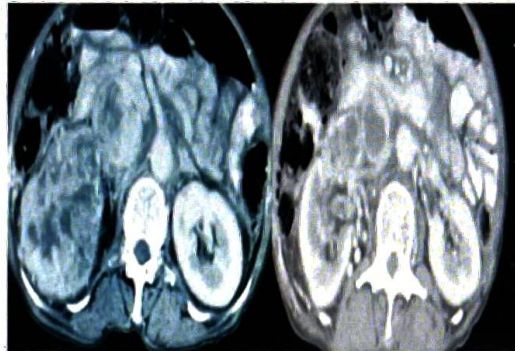
00:43:07



- Classic presentation : **Elderly patient with painless gross hematuria**.



- most common histopathologic subtype is **clear cell carcinoma**.
- TNM staging/**Robson's staging** system is used.
- Investigation of choice for RCC : **CE-CT**.
- **Renal vein/IVC invasion** is a peculiarity. It is not a contraindication for surgery.
- Investigation of choice for renal vein/IVC extension : **CE-MRI**.



Clinical scenario :

22 year old male complains of imbalance and visual loss. There is cerebellar solid cystic lesion, multiple pancreatic cysts and renal cell cancer.

kumarankitindia1



Diagnosis : **Von Hippel Lindau (VHL) syndrome**.

Mnemonic : **HIPPEL**.

**H**emangioblastoma of cerebellum (cyst with neural nodule).

Increased risk of **RCC**.

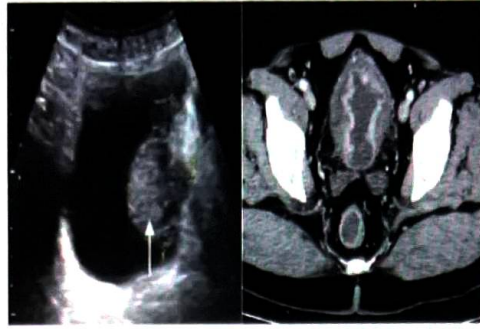
Risk of **P**heochromocytoma.

Risk of **P**ancreatic carcinoma, pancreatic cysts, pancreatic cystadenoma.

**E**ye lesions : Retinal hemangioblastoma, retinal detachment.

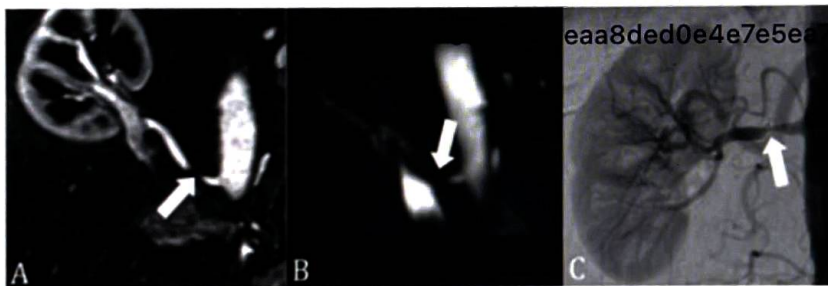
**L**iver/**p**ancreas/**s**pleen cysts.

**T**ransitional cell carcinoma :



- most common site : urinary bladder.
- Occurs in elderly, presents with painless hematuria.
- Smoking, cyclophosphamide therapy are risk factors.
- Soft tissue lesion projects into the bladder. On doppler, vascularity is seen.
- Can also present as diffuse enhancing wall thickening along the bladder wall/ureter.
- Antegrade pyelography : Goblet ring appearance or champagne glass appearance.

Renal artery stenosis/renovascular hypertension :



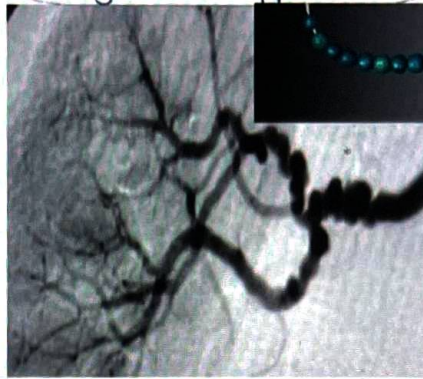
- Renin  $\rightarrow$  Angiotensin 2  $\rightarrow$  Aldosterone  $\rightarrow$  Salt and water retention  $\rightarrow$  Hypertension.
- 1<sup>st</sup>/screening investigation : Renal artery doppler.
- Investigation of choice : CT angio/MR angio.
- Gold standard investigation : Invasive catheter angiography.
- To detect functional significance of stenosis : Captopril-DTPA scan.

Fibromuscular dysplasia :

String of beads appearance : Alternate dilatation and stenosis along the renal artery.



String of Beads appearance



Question :

Identify the image and the diagnosis :

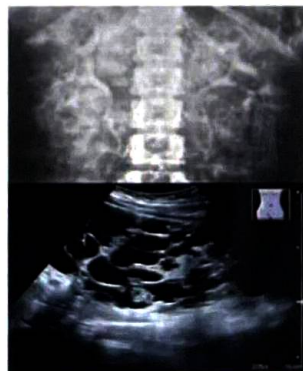


- A. CT-ARPKD.
- B. CT-ADPKD.
- C. MRI-ARPKD.
- D. MRI-ADPKD.

### Clinical scenario

00:55:14

Q. 50 year old male presents with deranged RFTs. Imaging shows the following. What is the diagnosis?

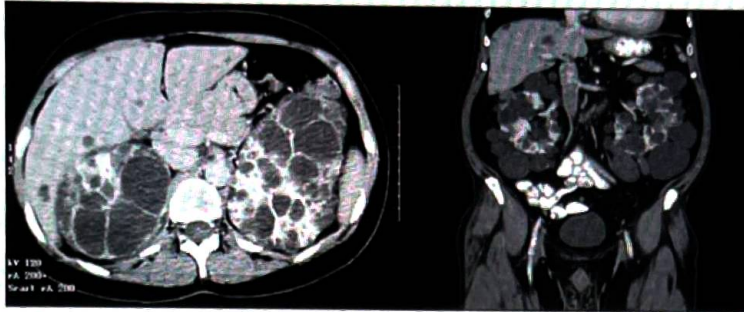


Diagnosis : Autosomal dominant polycystic kidney disease.



Swiss cheese appearance/spider leg appearance of calyces on IIV.

Q. 50 year old male presents with deranged RFTs. Imaging shows the following. What is the diagnosis?



Diagnosis : Autosomal Dominant Polycystic Kidney Disease (ADPKD).

Imaging shows renal macrocysts.

Autosomal Recessive Polycystic Kidney Disease (ARPKD) :



Incidentally detected on antenatal USG/neonatal USG :  
Kidneys are enlarged and appear echogenic/bright.  
Cysts are not seen on USG as they are microcysts.

multicystic dysplastic kidney :



Can present as abdominal lump in a neonate.  
On antenatal/neonatal USG, macrocysts are seen.



Clinical insights :

Acute renal colic :

Initial investigation : **X-ray KUB/USG.**

Best investigation : **NC-CT.**

Complications of obstructive uropathy :

- Acute pyelonephritis.
- Emphysematous pyelonephritis.
- Xanthogranulomatous pyelonephritis.

Investigation of choice for all of these conditions : **CE-CT.**

Renal TB clinical clincher : **Sterile pyuria.**

Investigation of choice for early diagnosis : **IVU.**

Overall investigation of choice : **CE-CT.**

Earliest finding on IVU : **moth eaten calyces.**

End-stage sequela of renal TB : **Putty kidney.** kumarankitindia1@gmail.com

Renal tumors :

Usually detected incidentally on **USG.**

Investigation of choice : **CE-CT.**

Fat density in tumor : **Renal angiomyolipoma.**

Central non-enhancing stellate scar : **Oncocytoma.**

Renal vein invasion : **RCC (Investigation of choice : CE-MRI).**

Renal cystic diseases :

Initial/best investigation : **USG.**

Adult with renal macrocysts and deranged RFTs : **ADPKD.**

Fetus/neonate with echogenic enlarged kidneys : **ARPKD.**

Fetus/neonate with renal macrocysts : **multicystic dysplastic kidney.**

# RENAL PAPILLARY NECROSIS

Renal anatomy :

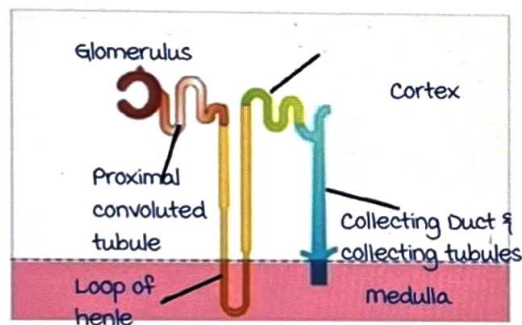
The kidney is a **bean** shaped structure.

The renal parenchyma can be divided into the **inner medulla** and **outer cortex**.



The nephron and its components include.

- Glomerulus.
- Proximal convoluted tubule.
- Loop of Henle.
- Distal convoluted tubule.
- Collecting tubule and duct.



majority of the structures lie in the cortex **except** for the **Loop of Henle** and the distal most part of medulla.

The collecting tubules converge together to form the collecting ducts.

Later they further converge to form a triangular configuration - these are known as renal pyramids.

The apex of the renal pyramid is called the **renal papilla**.





The renal papilla is cupped by a minor calyx which then drains into the major calyces.

The major calyx then drains into the renal pelvis and the urine will pass via the ureter into the bladder.

The tip of the renal pyramid (renal papilla) is susceptible to renal necrosis due to the following reasons :

- Peculiar longitudinal arrangement of tubules.
- Blood supply by vas recti.
- A surrounding hyperosmolar environment.

Even in a healthy individual, the physiological state of the renal papilla is **relatively hypoxic**.



Therefore, it is vulnerable to changes such as abnormal systemic circulation, or impaired microvasculature and lead to ischemic necrosis.

Once necrosed, it gets separated or sloughed off and passes into the ureter via the calyces.

### Predisposing Causes of renal papillary necrosis

00:02:26

Mnemonic : POSTCARDS

- Pyelonephritis.
- Obstruction due to calculi.
- Sick cell disease : due to the sickling that occludes the blood vessels leading to necrosis.
- TB.
- Cirrhosis.
- Analgesic abuse.
- Renal vein thrombosis can cause renal vein ischemia.
- Diabetes mellitus.
- Systemic vasculitis.

Pathology of renal ischemia :

The changes that occur in renal papillary necrosis have been described with the help of intravenous urography technique.

It is an x-ray based technique in which the contrast is injected intravenously and is filtered at the kidney.

The contrast material then fills the renal tubules and the calyces, making it possible to view them.

The minor calyx is filled with iodinated contrast, and it appears white.

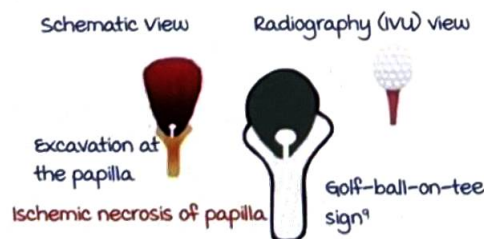
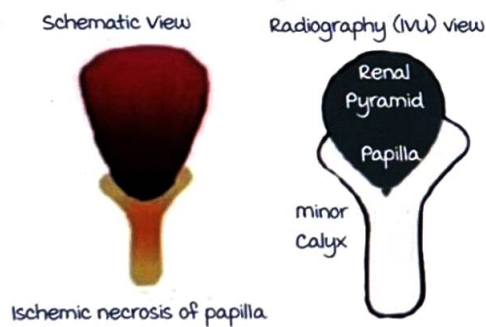
Whereas the pyramid is going to appear as a filling defect, hence will appear black or deep grey.

Initially when there is an ischemic insult at the tip of the papilla it leads to ischemic necrosis.

As a result of which, some amount of tissue will get sloughed off leaving behind a cavity.

This cavity then gets filled with contrast material excavating from the tip of the papilla giving a round globular ball like collection of contrast.

Since it gives the appearance of a ball sitting on a golf tee, it's called Golf-ball-on-a tee sign.





As it progresses, lateral extension of the necrosis occurs in the region of fornices called **forniceal extension of necrosis**. This then extends into the pyramid, creating a claw like appearance called **Lobster claw sign**.

Once the structure of the pyramid is affected the claws further advance to meet each other, causing the papilla to be separated from the rest of the renal pyramid.

Hence the part in the center will appear as a **filling defect** in the contrast around it.

This specific appearance is called **Signet-ring appearance**.

Once separated from the rest of the pyramid the papilla will then pass through the minor calyx into the ureter.

During its passage it can cause **obstruction** leading to **hydronephrosis**.

The shape of the calyx after the papilla has been sloughed off looks like a club, therefore called **clubbed calyx**.



Active space

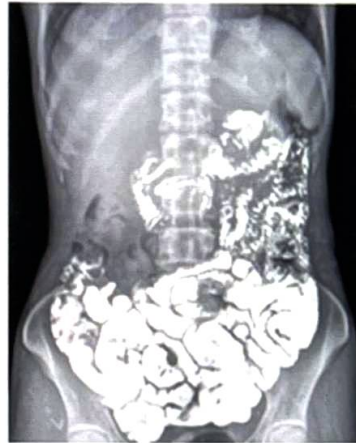
# GIT : CONVENTIONAL PROCEDURES

## MCQs

00:01:15

Q. A patient presented with recurrent abdominal pain. Identify the investigation in this image ?

- A. Barium meal.
- B. Barium swallow.
- C. Barium enema.
- D. Barium contrast radiography.



Answer : D. Barium meal follow through.

Bowel loops (central abdomen, small bowel) are opacified with contrast. This is called barium meal follow through.

Q. A 42 year old female presents with dysphagia more to liquid than solids. She has no history of weight loss. A barium swallow is done. What is the most likely diagnosis ?

- A. Esophageal stricture.
- B. Achalasia cardia.
- C. Esophageal cancer.
- D. Hiatus hernia.

Answer : B. Achalasia cardia.

Barium swallow s/o bird beak appearance : Achalasia cardia.



GE junction oblique

Q. Patient presented with neck swelling and regurgitation with gurgling sound when pressed over the neck. A barium swallow was performed and is revealed here. most likely diagnosis will be ?

Active space



- A. Esophageal stricture.
- B. Zenker's diverticulum.
- C. Esophageal web.
- D. Dysphagia lusoria



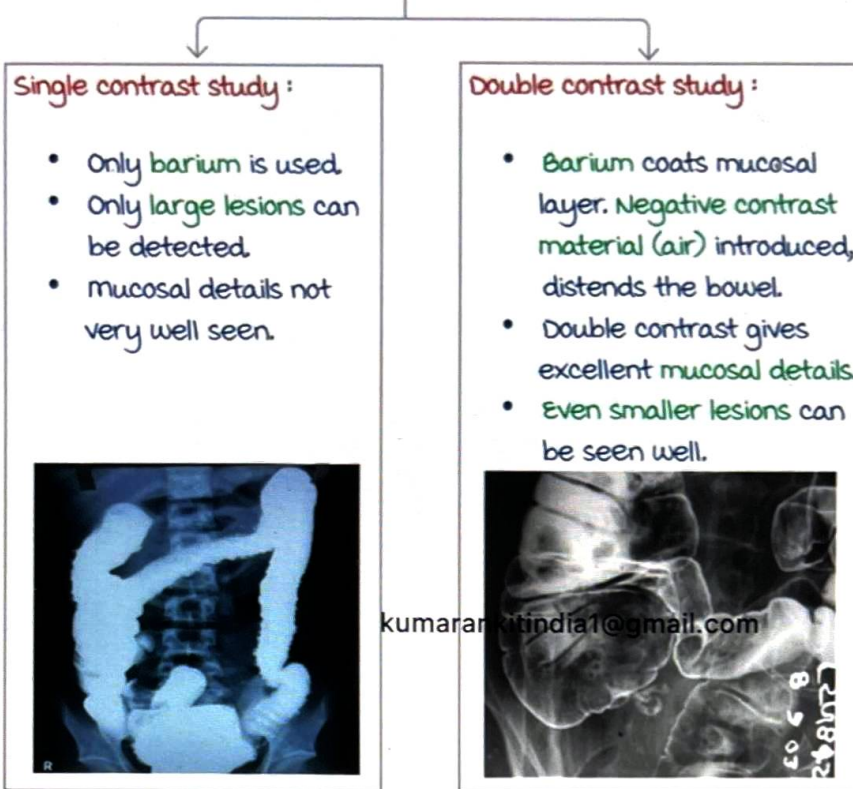
Answer : B. Zenker's diverticulum.

Barium swallow shows esophageal lumen + posteriorly directed diverticulum : Zenker's diverticulum.

Barium contrast studies :

Test	To evaluate	Conditions to be diagnosed
Barium swallow	Hypopharynx Esophagus. GE junction.	Achalasia. Cancer esophagus. Esophageal strictures. Esophageal webs.
Barium meal	Stomach. Proximal duodenum.	Peptic ulcers. Cancer stomach.
Barium follow-through	Small bowel.	malabsorption syndromes.
Barium enema	Large intestine.	Ca colon. Intussusception. Diverticulosis.
Barium distal loopogram	Distal loop.	Residual obstruction post colostomy.

## Barium enema



kumaran.tindia1@gmail.com

## Enterography :

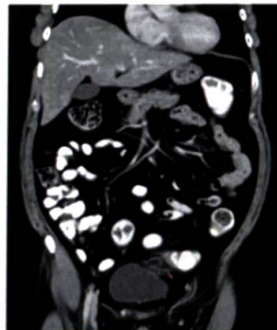
- Patient drinks contrast material → Esophagus → Stomach → Intestine → Bowel visualization.
- Depends on gastric emptying → Therefore, sub optimal.

## Enteroclysis :

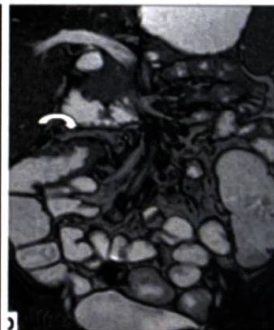
- Contrast introduced through nasoduodenal/ nasojejunal tube → Gastric emptying bypassed → Better and faster visualization of bowel.
- Invasive.



Conventional enteroclysis (X ray)



CT enteroclysis



MR enteroclysis

- Both enterography & enteroclysis can be done on X ray/ CT/MRI.



Contrast materials used :

- Negative contrast like fluid/mannitol.
- Positive contrast like iodinated contrast.
- On MR, it can be T1 weighted where lumen appears hypointense or in T2 weighted appears hyperintense.

**Barium spotters**

00:08:51

Iron deficiency anemia + Dysphagia + Esophageal web/cricopharyngeal web (thin 2-3 mm membrane of esophageal mucosa & submucosa, projecting into esophageal lumen → Transverse shelf like filling defect).



Ans : Plummer Vinson Syndrome/ Paterson Brown Kelly syndrome.

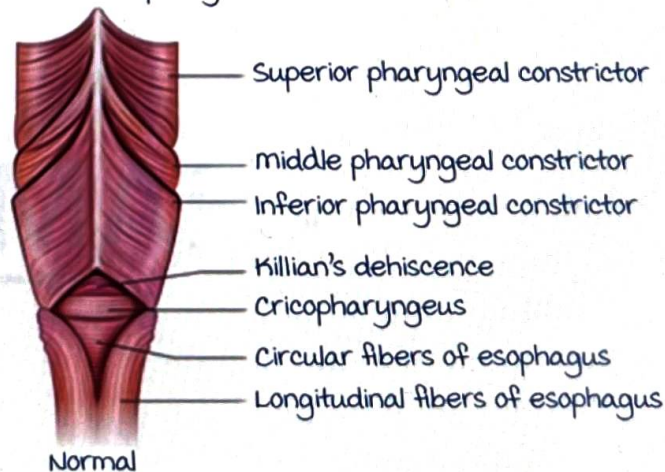
Predisposing factor to hypophyseal squamous cell esophageal carcinoma.

H/o Alkali consumption (Lye/ acid/alkali) → Damages the walls/mucosa-submucosa → Smooth elongated tapering of esophagus → Prolonged dysphagia.



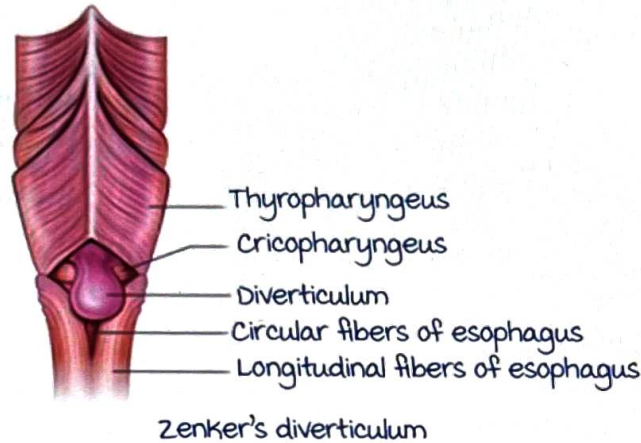
Ans : Esophageal Stricture.

Posterior view of pharynx



Active space

Below Pharyngeal constrictors → **Cricopharyngeal muscle.**  
 Weak area above cricopharyngeus : **Killian's dehiscence.**  
 When there is bulging of esophageal layers from the Killian's dehiscence, it leads to formation of a diverticulum called **Zenker's diverticulum.**



Zenker's diverticulum	Killian Jameison diverticulum
Bulges out of Killian's dehiscence. Above cricopharyngeus.	Bulges out of Killian's dehiscence. Below cricopharyngeus.
Common.	Rare.
Postero-lateral projection.	Antero-lateral projection (arises below cricopharyngeus).
False diverticulum.	
Retained food contents → Gurgling sound on palpation.	
Retained food contents → Aspiration (m/c Complication)	



Zenker diverticulum



Killian-Jamieson diverticulum



**Achalasia cardia :**

Failure of dilatation at the level of lower esophageal sphincter.

Dilated esophagus → Broad based shadow along the mediastinal contour.



Dilated esophagus

**Dysphagia**

00:15:28

- Progressive dysphagia for solids > liquids : CA esophagus.
- Progressive dysphagia for liquids > solids : Achalasia cardia.

Bird beak sign :  
Achalasiakumarankitindia@gmail.com  
Carcinoma esophagus**Carcinoma esophagus :**

60 year old male with weight loss + dysphagia for solids → Carcinoma esophagus.

Sudden abrupt narrowing of the esophagus + irregular mucosa s/o carcinoma esophagus

Rat tail appearance :  
Ca esophagus

**Rat tail appearance :** Sudden abrupt narrowing of the esophagus + irregular mucosa.

Investigations :

Overall IOC : Endoscopy guided biopsy.

Imaging IOC for staging : PET CT scan.

Imaging IOC for tumor & nodal assessment : Endoscopic USG.

H/o : Dysphagia + severe retrosternal pain (due to contractions in an uncoordinated manner).  
Corkscrew/Rosary bead / curling esophagus : seen in Diffuse esophageal spasm.



Diffuse esophageal spasm

A differential diagnosis for diffuse esophageal spasm is

Nut crackers Esophagus :

Dysphagia + severe retrosternal pain (due to contractions in an uncoordinated manner).

Barium swallow : Normal.

IOC : manometry.

Feline Esophagus/Esophageal shiver :

Horizontal lines seen are muscularis mucosae contracting → Folding of esophageal mucosal layer → Feline esophagus/esophageal shiver.

Associated with :

- Reflux esophagitis (related to hiatus hernia).
- Eosinophilic esophagitis.



Feline esophagus

Clinical scenario :

An opening along the anterior border of sternocleidomastoid muscle with watery discharge, after injecting contrast, it revealed a tract going upwards traversing between the carotid arteries and opened into the tonsillar fossa.

S/o of congenital remnant of a tract, typical of branchial cleft anomaly.



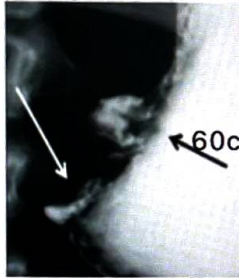



m/c presentation : Branchial cleft cyst.


m/c type : Type 2 fistula.

**Benign vs malignant gastric ulcer**

00:24:03

	Benign gastric ulcer	malignant gastric ulcer
Projection	Projects out of the lumen.	Tumor with central ulceration. Barium gets collected at the site of central ulceration. Projects inside the lumen.
Signs	<p><b>Hampton's line :</b> At the mouth of ulcer, mucosal edema → Black/lucent line at the mouth of the ulcer.</p> 	<p><b>Carman's meniscus</b> <b>Kirklin Complex</b></p> 
mucosal folds	Smooth. Reach upto the ulcer margin.	Irregular thick nodular folds. Do not reach the ulcer margin.
Shape of ulcer	Round and oval.	Irregular shape (necrotic).

**Carman's meniscus :** Convex rim towards gastric lumen formed by the accumulated barium at the central ulcerated area of the tumour.



**Kirklin sign/complex :** Halo around the Carman's meniscus.

**Clinical scenario :**

A known case of Scirrhus gastric cancer presents with recurrent vomiting.

Barium meal : Severely contracted stomach (narrowed lumen).

Lost mucosal markings due to submucosal infiltration of the scirrhus gastric cancer →

Leather bottle appearance → Linitus plasticum.



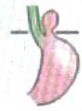
Linitus plasticum

Active space

**Hiatus Hernia :**

Gastroesophageal junction herniating up across the esophageal hiatus → Hiatus hernia.

- GE Junction > 2 cm above the diaphragmatic opening of esophagus → **Sliding hiatus Hernia.**



- GE junction remains infradiaphragmatic but the fundus of stomach projects up through a paraesophageal opening → **Rolling/paraesophageal hiatal hernia** (more dangerous).

IOC (initially) : Barium swallow.

IOC (present) : CT thorax with oral contrast.

**Congenital hypertrophic pyloric stenosis :**

- 8 weeks old baby.
- Projectile non bilious vomiting.
- **Olive shaped mass.**
- Recurrent vomitings.
- Imaging shows stomach overly distended with a narrowing at the pyloric sphincter.



the pyloric sphincter.

IOC : **USG** (as pylorus is superficial).

Pyloric muscle thickness > 4 mm, length of pyloric canal > 16-18 mm are considered for the diagnosis.  
kumarankitindia1@gmail.com

On a barium meal study :

1. **Shoulder sign** : Shouldering like narrowing into the pylorus.

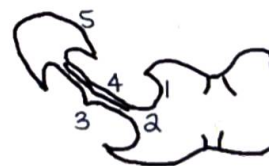
2. **Beak sign** : Opening at pylorus appears narrow like beak.

3. **String sign** : Opening at the pylorus extremely narrow like a string.

4. **Double tract sign** : 2 lines seen due to undermining of the mucosa.

5. **mushroom sign** : Hypertrophied pylorus projects into 1<sup>st</sup> part of duodenum like a mushroom.

**Caterpillar sign/appearance** : Stomach hyperperistalsis (to push contents beyond the stomach).





**Diverticuli – Diverticulosis :**

Barium enema : S/O colonic diverticuli  
(multiple outpouchings).

Patient may present with severe  
intermittent pain if they get infected.



Colonic diverticuli

multiple diverticuli (Saw tooth appearance).

IOC : Barium enema.



Diverticuli + Infection = Diverticulitis.

If peritonitis, barium cannot be given as it  
will create severe inflammatory response.

Here, IOC : Contrast enhanced CT scan.

**Cancer colon :**

Altered bowel habits + Increased  
frequency + Tenesmus + Signs of  
intermittent obstruction.

Barium enema : Apple core appearance  
(mass lesion, typically involving left  
sided large intestine).



Apple core sign : Ca  
colon/rectum

**Ulcerative colitis :**

Pain abdomen + loose stools +  
mucus in the stools.

Barium enema : No haustrations.

Lead pipe colon.



Ulcerative colitis

**Intussusception :**

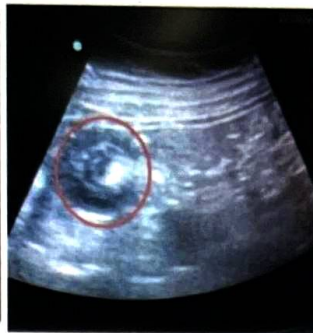
Child with pain abdomen + red colored stools (red currant  
jelly stools).

Bowel within bowel → Bowel wall markings highlighted by the  
contrast → Coiled spring appearance.

USG → Inner and outer bowel loop seen → Target/bull's eye/  
doughnut appearance.



Coiled spring appearance  
intussusception



Target/Bull's eye/doughnut  
appearance : Intussusception



Claw sign :  
Intussusception

**Treatment :**

Barium enema : **Hydrostatic reduction.**

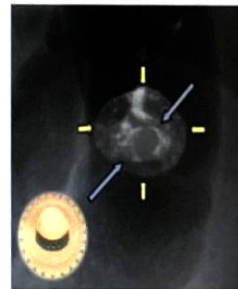
Contrast introduced → Pressure built → Pushes out the  
bowel → Contrast encircles the intussusceptum giving rise  
**Claw sign.**

**Pedunculated colonic polyp :**

H/o intermittent melena + occult stool  
blood.

Barium enema : **Antral/mexican hat sign.**

Contrast material that lines the stalk  
giving rise to inner circle, it also lines the  
head giving rise to outer circle.



mexican hat sign :  
Pedunculated colonic  
polyp

**Fistula-in-ano :**

Elderly patient presents with a perianal opening with purulent  
discharge.

He was treated with antibiotics and  
underwent a **conventional sinogram :**

Contrast tract has opened up into the  
bowel.

1. **Trans sphincteric :** Difficult to treat  
surgically.
  2. **Inter sphincteric :** Comparatively easier  
to treat.
- IOC : **MR Fistulogram.**



Fistula-in-ano

Active space



## Contrast studies done in GIT

00:39:04

Barium swallow : Esophagus.

Barium meal : Stomach & proximal duodenum.

Barium meal follow through : Small bowel.

Barium enema : Colon.

Contrast sinogram : Peri anal fistula.

### Contrast spotters :

Claw sign	Intussusception
Bird beak sign	Achalasia
Rat tail sign	Ca Esophagus
Hampton's line	Benign gastric ulcer
Carman's meniscus + Kirklin's complex	malignant gastric ulcer
Antral hat sign/ mexican hat sign	Colonic pedunculated polyp
Saw tooth appearance	Colonic diverticulosis
Corkscrew appearance	Diffuse esophageal spasm

## GIT IMAGING

Q. Patient presented to the emergency department with severe abdominal pain, an erect radiograph was done. Based on the findings, the management should be ?

- A. USG FAST.
- B. Gastric lavage.
- C. ICD insertion.
- D. Laparotomy.

Q. A patient presents with abdominal pain and distension. An X-ray was taken which showed dilated bowel loops as given in the image below. Identify the segment involved / marked by the arrow.



- A. Jejunum.
- B. Ileum.
- C. Duodenum.
- D. Transverse colon.

Q. A patient following a skid resulting in a motor traffic accident was brought to EMR 2 hours later. On examination he was stable with GCS 15/15, pupil +, tenderness and bruising over left lower chest wall with petechiae. Severe tenderness was elicited in the left hypochondriac region and BP : 90/50 mm of Hg. What is the best investigation used in the ER ?

- A. FAST.
- B. X ray.
- C. Diagnostic peritoneal lavage.
- D. CT.

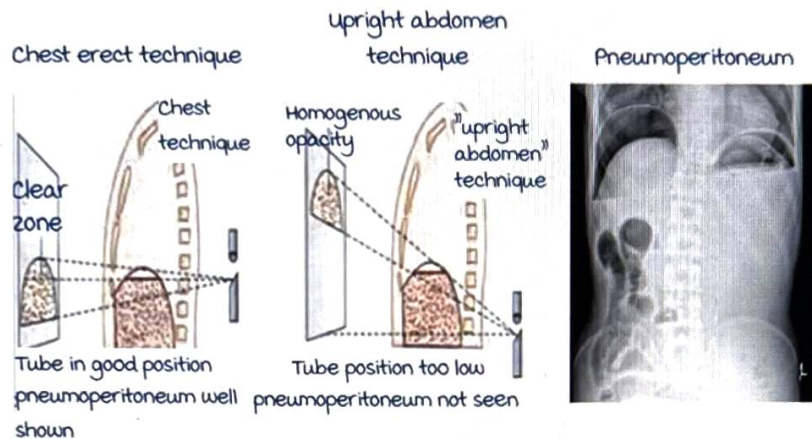


## Pneumoperitoneum

00:03:34

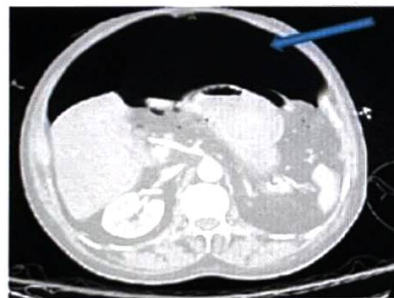
- **Easiest way** to diagnose pneumoperitoneum :  
Visualize areas under diaphragm (**Free air** under both domes of diaphragm).

60c6b3eeaa8ded0e4e7e5ea7  
Best radiograph to detect pneumoperitoneum : **X-ray erect chest.**



- most commonly done in hospital setup : **X-ray abdomen erect.**

Best investigation/Investigation of choice : **CT Scan.**  
(For USG, fluid is friend and air is the enemy).



Free air in the non-dependent part

Signs of pneumoperitoneum :

All signs are described on supine radiograph.

### 1. **Football sign :**

In supine position, air rises up and collects just below anterior abdominal wall creating a **large oval lucency**.

### 2. **Cupola sign :**

Free air also rises towards the diaphragm lining it and creates a **dome like appearance** of diaphragm.



3. **Falciform ligament sign :**

It is characterized by the outlining of falciform ligament with free abdominal gas.



4. **Liver/Gb edge sign :**

Visibility of sharp margins of liver/gall bladder due to collection of air.

5. **Rigler's double wall sign :**

Both bowel surfaces (mucosal as well as serosal) seen together as a sharp margin.

Air replaces the peritoneal fluid in pneumoperitoneum creating change in the density, allowing the outer margin of the bowel to be visible.

6. **Doge's cap sign :**

Triangular shape of air trapped within the Morrison's pouch (hepato renal pouch).



Q. most sensitive investigation for detection of pneumoperitoneum is ?

- A. USG.
- B. CT.
- C. X-ray chest lateral.
- D. X-ray chest PA view.

## Bowel Obstruction

kumarankitindia1@gmail.com 00:12:48

	Small bowel obstruction	Large bowel obstruction
Diameter (dilated)	> 3 to < 5 cm	> 5 cm (Cecum : > 9 cm)
Location	Central	Periphery
Number of loops	multiple	Few
Air fluid levels	multiple short levels	Few long levels
Bowel wall markings	Volvulae conniventis. Complete transverse mucosal folds	Haustrations. Incomplete transverse folds.
Gas in large bowel	Absent	Present





Small bowel obstruction    Large bowel obstruction

Air fluid levels :

It can also be seen in normal cases.

Abnormal when it is :

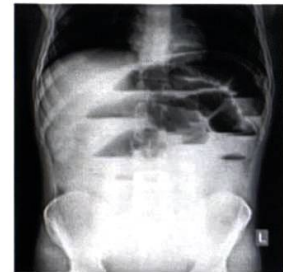
- > 2 in number.
- 2.5 cm in width.
- > 2 cm away in height when in the same bowel loop.



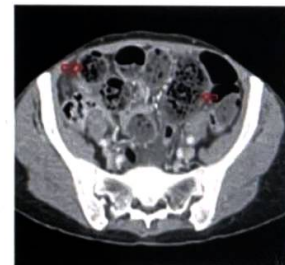
### Signs of intestinal obstruction

00:20:08

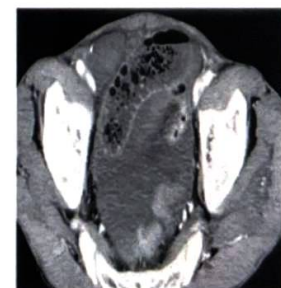
1. **Step ladder appearance :**  
multiple air fluid levels along the long axis of a bowel loop. Sign of small bowel obstruction.



2. **Small bowel feces sign :**  
Fecal contents in the small bowel loop (seen due to prolonged stasis content).



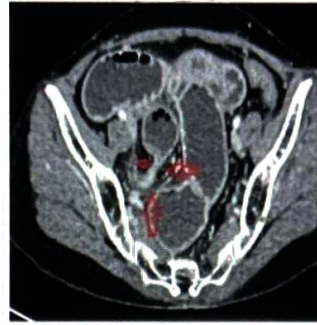
3. **Strings of beads sign :**  
Air bubble that rises up and get collected over the non-dependent part.



#### 4. Transition point on CT Scan :

most reliable finding.

It's the site of obstruction, proximal to which bowel will be dilated and distally bowels collapsed.



### X-ray abdomen spotters

00:23:42

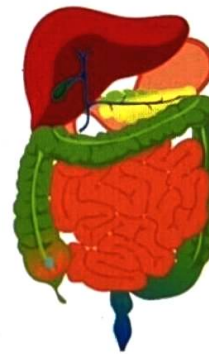
#### Pneumobilia :

- Air within the biliary tree.
- most common cause :  
Recent instrumentation of biliary tree (ERCP, Stent, Biliary anastomosis).



#### Gall stone ileus/Cholecysto duodenal fistula :

- Calculus in gall bladder/biliary tree passes into bowel either through biliary tree or directly to duodenum by the formation of fistula. It gets impacted at the terminal ileum and creates intestinal obstruction.
- Characterized by classical clinical triad :  
**Rigler's triad :**
  1. Pneumobilia.
  2. Small bowel obstruction.
  3. Density of right iliac fossa.

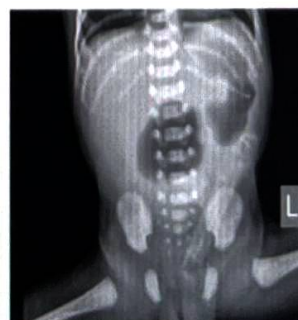


Q: On an abdominal radiograph, air in the rectum is seen in ?

- Normal person.
- Large bowel obstruction.
- Small bowel obstruction.
- Paralytic ileus.
- Gall stone ileus.

Clinical scenario :

- Neonate presents at birth with bilious vomiting.



Active space



- An atretic segment involving the 2<sup>nd</sup> portion of duodenum.
- **Double bubble appearance** seen in **duodenal atresia**.  
(Single bubble appearance in pyloric stenosis, a triple bubble appearance described in jejunal atresia).

Clinical scenario :

- Elderly female, known case of psychiatric illness.
- massive gaseous distension of abdomen & absolute constipation.



Ans : **Sigmoid Volvulus** :

- **Coffee bean sign** / bent tyre tube sign/Omega sign.
- Apex of the loop : under the **left dome** of diaphragm.
- Liver overlap sign.
- Left flank overlap sign.
- **Frimann Dahl sign** : Three dense lines representing the sigmoid walls converging to the site of obstruction.

## **Congenital Diaphragmatic Hernia (CDH)**

00:31:50

**Newborn** with respiratory distress.  
Left dome of diaphragm : Not seen.  
Instead, bowel loops extend into left thoracic cavity → mediastinal shift towards opposite side.

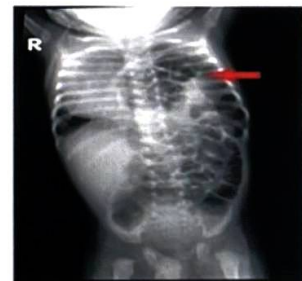
Think of it as a defect in diaphragm.

Ans : **CDH.**

most important prognostic predictor : Degree of

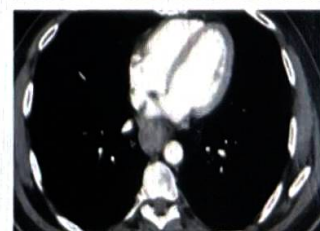
**Pulmonary hypoplasia.**

**Bochdalek type (mc)** : Left side.



Clinical scenario :

- 65 year male.
- **Dysphagia solids** > Liquids.
- weight loss.



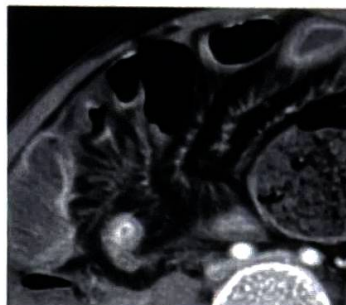
S/o of **esophageal cancer**.

Staging modality of choice : **PET CT scan**.

Clinical scenario :

- 38 year male.
- Recurrent diarrhoea.
- Weight loss.

CT Showing **Comb sign** :



Hypervascularity along mesentery with linear vessels going towards bowel loops : S/o of **Crohn's disease**.

- **Crohn's disease** is also called regional enteritis.
- most common site of involvement : Terminal ileum.
- **Cobble stone appearance** of bowel mucosa.
- **String sign of cantor**.
- Best investigation : **CECT Scan**.

Signs seen on CT :

- **Fat halo sign** (inflamed fat along bowel loops).
- **Creeping fat sign** (fibrofatty proliferation along the bowel loop).

Clinical scenario :

- 38 year male.
- Recurrent diarrhoea.
- Weight loss.

Imaging showing **Lead pipe colon** (loss of haustrations) :



S/o **ulcerative colitis**.

Predominantly starts with the involvement of rectum following proximal extension of the inflammatory process.

- Double contrast barium enema shows : **Granular appearance** of mucosa.
- **Button hole/collar stud ulcers**.
- Pseudopolyp like appearance.
- **Toxic megacolon** : Progressive dilatation of transverse colon.

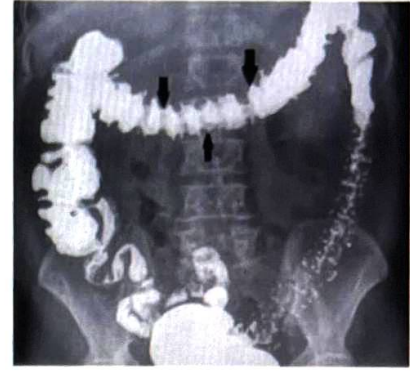
60c6b3eaaa8ded0e4e7e5ea7

Active space



Ischemic Colitis : Clinical scenario :

- 65 year male.
- Acute pain in abdomen.
- Blood in stools.
- Imaging showing thumb printing sign : Large bowel wall thickening caused by edema s/o of ischemic colitis.
- most common vessel involved : Superior mesenteric artery.
- Investigation of choice(IOC) : CT Angiography.
- Gold standard : Invasive catheter angiography.
- Shock bowel : Complete absence of enhancement of bowel wall on contrast injection.
- Pneumatosis intestinalis : Air within bowel wall lumen.

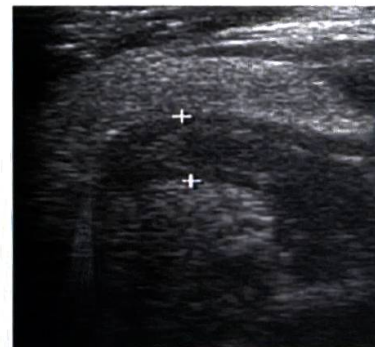


## Acute appendicitis

00:40:19

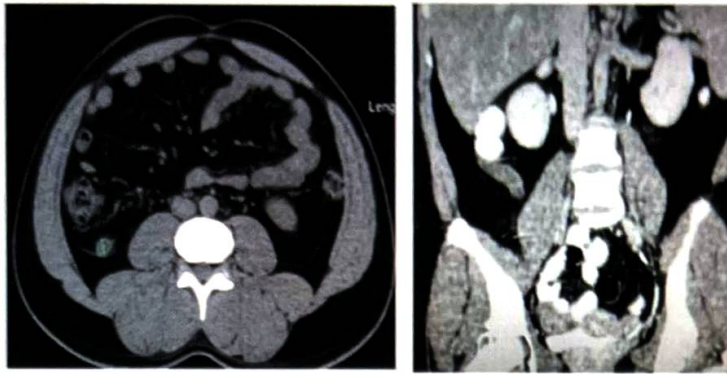
Presents with : Severe right iliac fossa pain, vomiting & fever, tenderness in right iliac fossa at mcBurney's point.  
 IOC in children : USG (to avoid high radiation exposure).  
 IOC in adults : CECT.

- On USG : Blind ended tubular structure in right iliac fossa with diameter of appendix  $>7-8$  mm. Presence of appendicolith increases the chance of perforation.



Signs on CT :

- Cecal bar sign : Layer of edematous cecal base lying between appendix & cecum.
- Arrowhead sign : Cecal contrast material creates a sign indicating towards the appendix.

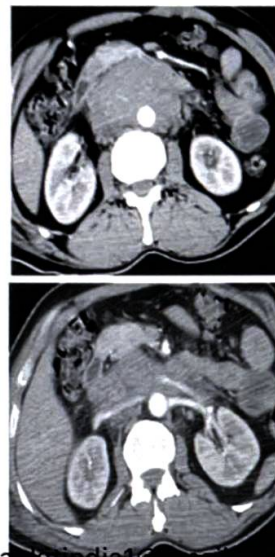


**Abdominal lymphoma :**

Gives rise to multiple enlarged confluent lymphnodal masses. Shows low level enhancement on contrast.

**vessel embedded sign :** The abdominal blood vessels (here : Aorta) are completely embedded/encased.

**Sandwich/hamburger sign :** mesenteric vessels get embedded within the lymph nodal mass.

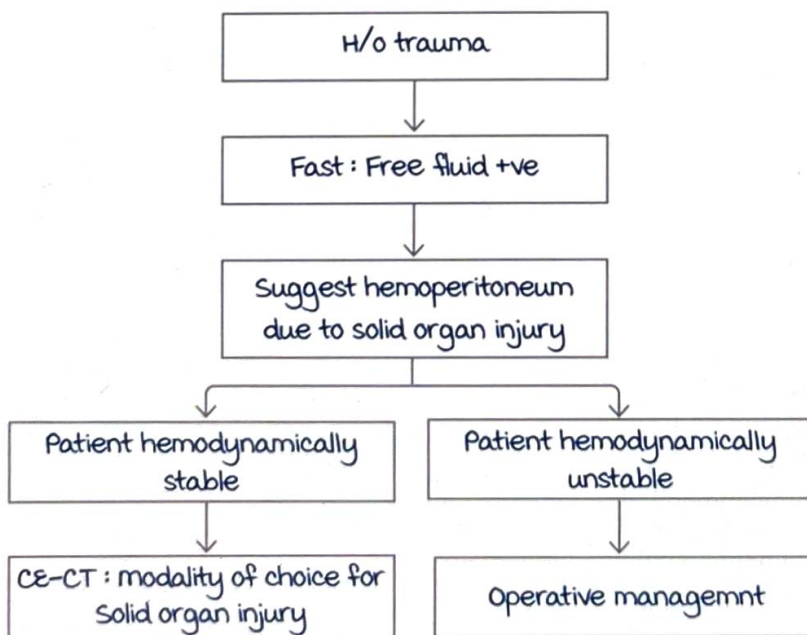


kumaran.india1@gmail.com

**FAST**

00:43:35

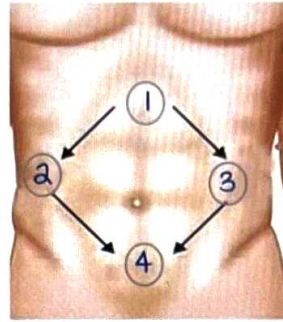
FAST : Focused Assessment with Sonography for Trauma



Active space



Standard FAST protocol :



1 : Subxiphoid view (1<sup>st</sup> view obtained).

2 : Longitudinal right upper quadrant view.

Best/most sensitive view for hemoperitoneum : Helps to see **Morrison's pouch**, considered to be one of the deepest & most dependent part of abdominal cavity in supine position.

3 : Longitudinal left upper quadrant view.

4 : Supra pubic view.

kumarankitindia1@gmail.com

**e-FAST protocol** : Extended FAST by involving the **thorax**.

- Assessed in upper non dependant part to rule out pneumothorax.
- Assessed in lower dependant part to rule out hemothorax.

**BOAST** : Bed Side Organ Assessment with Sonography in Trauma.

Q. USG /e-FAST is least useful in ?

- Retroperitoneal hematoma.
- Pneumothorax.
- Renal injury.
- Pericardial effusion.

Clinical insights :

1. Pneumoperitoneum :

- Best X-ray : Erect Chest X-ray.
- IOC : CT scan.

2. Intestinal obstruction :

- 1st investigation : Abdomen erect + Supine X-ray.
- IOC Children : USG.
- IOC Adults : CE-CT Scan.
- m/c cause : Adhesions.

Intestinal obstruction specifics :

Child presents with vomiting		
Age	New born at birth	6-12 weeks after birth
Type of vomiting	Bilious	Non bilious
Condition	Duodenal atresia	Pyloric stenosis
Relation to D2 segment	Obstruction distal to D2	Obstruction proximal to D2

60c6b3eaaa8ded0e4e7e5ea7

Active space

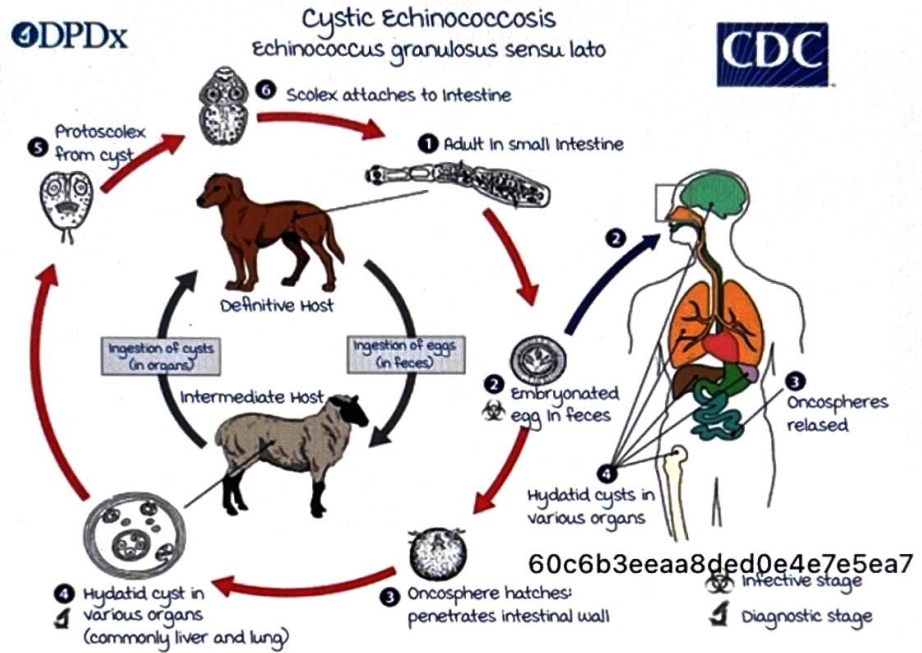


# HYDATID CYST

Caused by larva of *Echinococcus granulosus* / *multilocularis*.

Hydatid cyst imaging :

Oncospheres enters bowel → Blood drained by portal vein and reaches the liver.

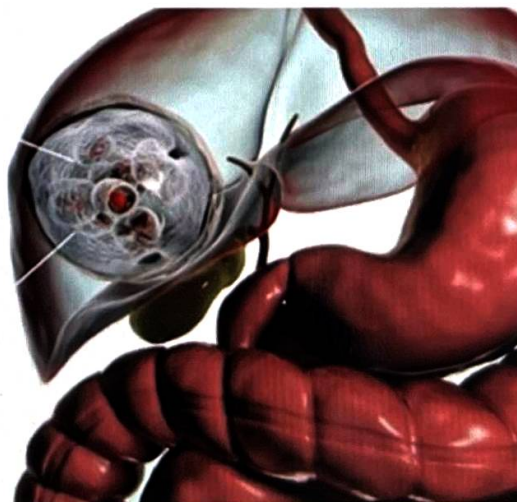


most common organ involved :

Liver (right lobe > left lobe) : 75%.

Hepatic vein → IVC → Right heart → Lung.

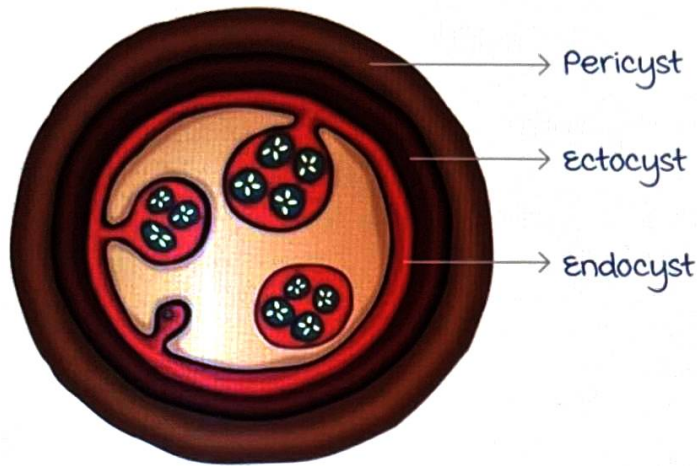
2<sup>nd</sup> most involved organ : Lung.



Active space

# Named signs in hydatid cyst

00:01:18



Hydatid structure :

3 layers of wall :

- True walls
- Pericyst : modified host cell forming a dense and fibrous protector zone.
  - Ectocyst : It is an **laminated acellular membrane** that allows passage of nutrients.
  - Endocyst : It is the innermost layer of cyst wall. **metabolically active layer.** Also called germinal layer. **Produce scolices or daughter cells within large mother cyst**

Stages of the cyst :

Simple cyst :



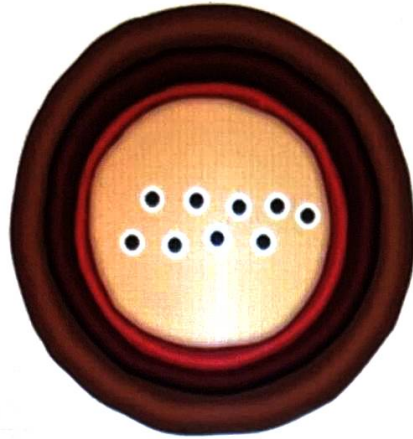
Begins as a simple cyst



Simple cyst

Active space

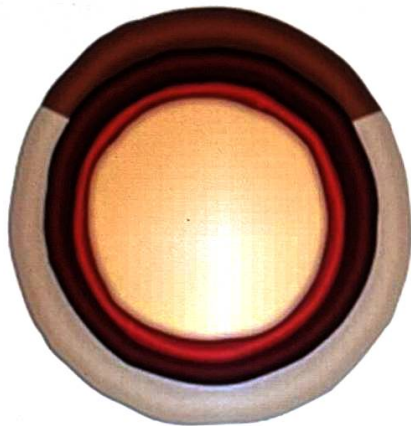




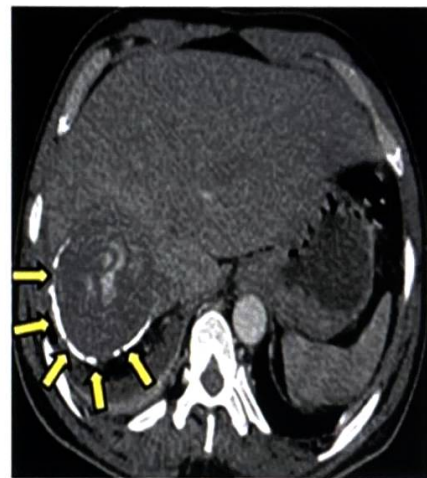
mobile echogenic foci due to Hydatid Sand Looks Like a Snow-Storm



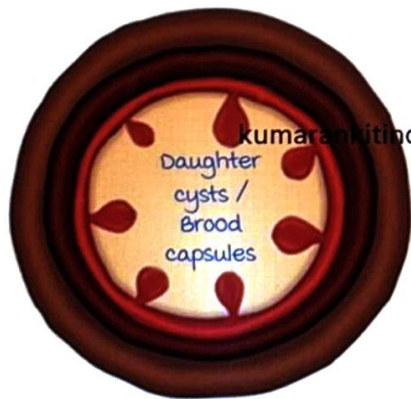
Snow-storm sign



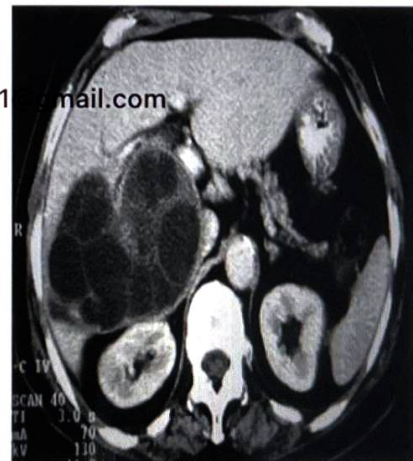
Peripheral curvilinear calcification is a highly peculiar feature



Peripheral curvilinear calcification



Daughter cysts / Brood capsules



multiple daughter cyst

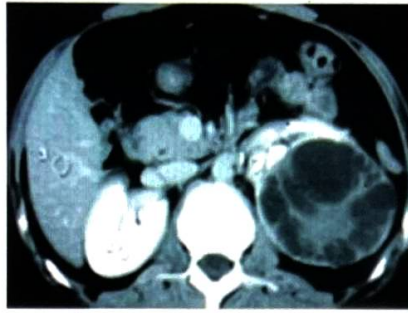


Daughter cysts are produced within the mother cyst

Active space



Daughter cysts separated by  
hydatid matrix



Wheel spoke sign : Hyperdense  
and speculated.

Hydatid sand forms :

It is mobile.

mobile sand settles into the dependent part giving  
**Snow storm appearance.**

**Peripheral Curvilinear Calcification** (Highly peculiar feature)

When Hydatid cyst present for long duration of time.

Endocyst divides and germinates forming **Daughter Cyst**  
(DC).

60c6b3eaaa8ded0e4e7e5ea7

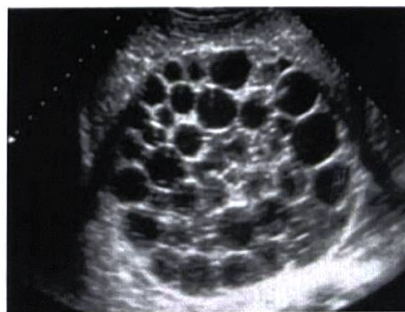
DC converge to one another, thick material between them  
to form **wheel-spoke like appearance.**

Endocyst divides multiple times such that entire mother cyst  
filled up with daughter cyst giving **honeycomb appearance.**

Endocyst degenerates and separates from wall floating  
within cyst giving **floating membrane sign.**



Looks like a  
Honeycomb



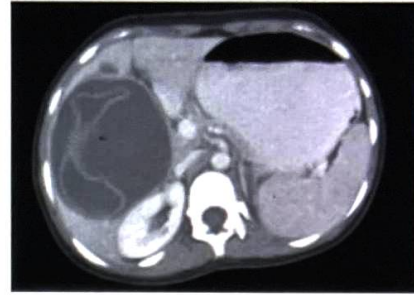
Honeycomb sign

Active space





Floating membranes within the cyst

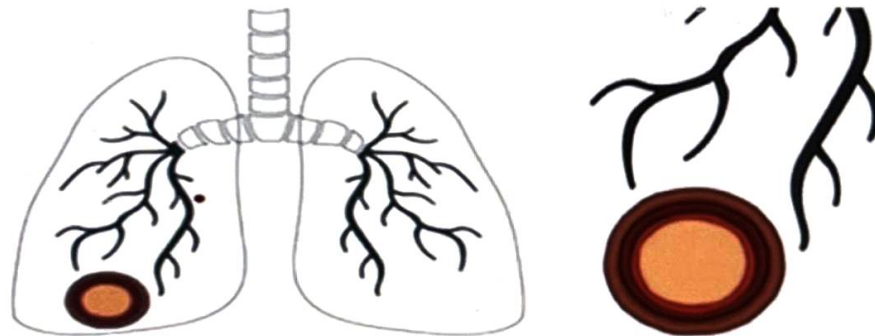


Floating membrane sign

**Hydatid cyst in lung**

00:05:33

Pericyst ruptures as it enlarges and the hydatid cyst communicates with bronchus.



Air enters into cyst wall and collects as crescent of air inside pericyst. Sometimes, air gets collected in the dependant part → **inverse crescent sign**.

Sometimes air bubble occurs in cyst giving **air bubble sign**. Endocyst ruptures and air enters into cyst cavity forming a air fluid levels :

- 60c6b8e4e7e5ea7 } **Combo appearance/sign.**
- In endocyst

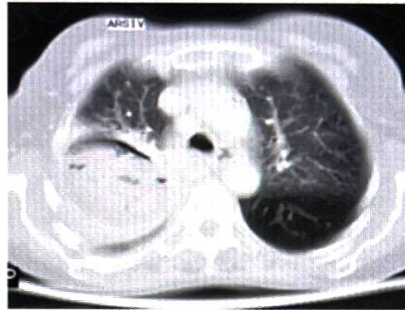
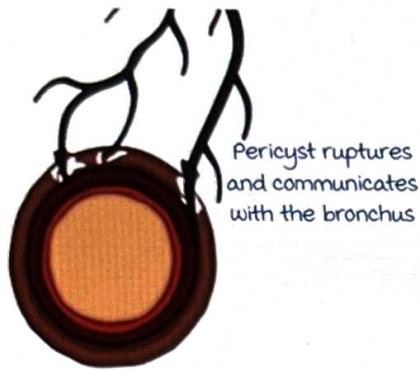
Fluid and contents of cyst expectorated out. As fluid depletes membranes degenerate forming whirls giving **whirls/serpent sign**.

Few membranes float forming flower like appearance giving **water lily sign/camalote sign**.

Active space

Eventually all membrane and debris clumped as a mass at bottom of cyst giving rising sun sign/ mass within a cavity sign.

All contents expectorated out giving empty cyst sign.



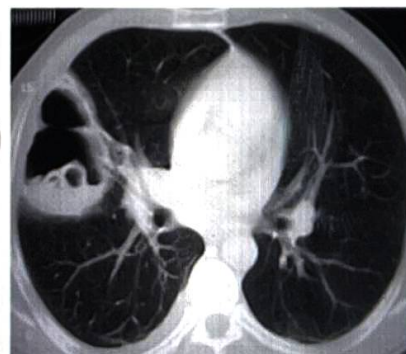
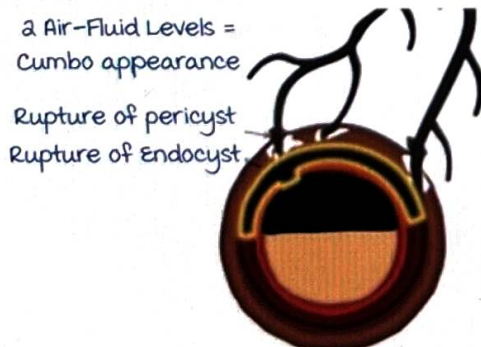
Air crescent sign



Inverse air crescent sign



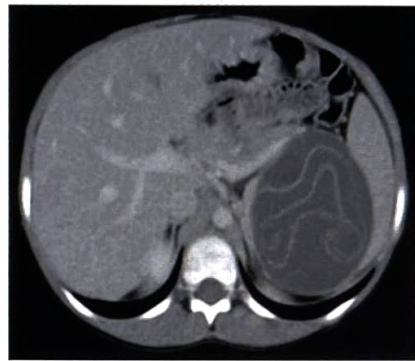
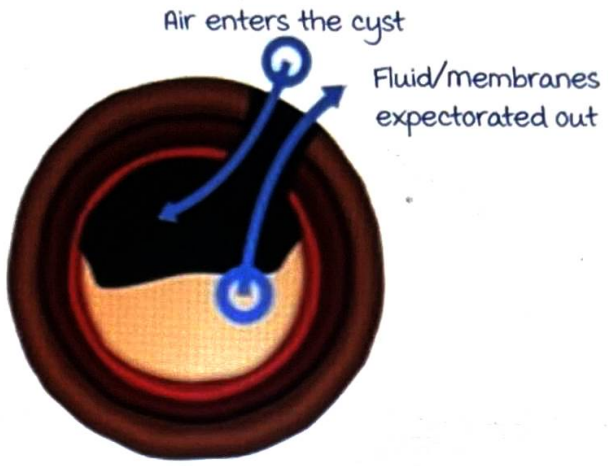
Air bubble sign



Cumbo sign.

Active space

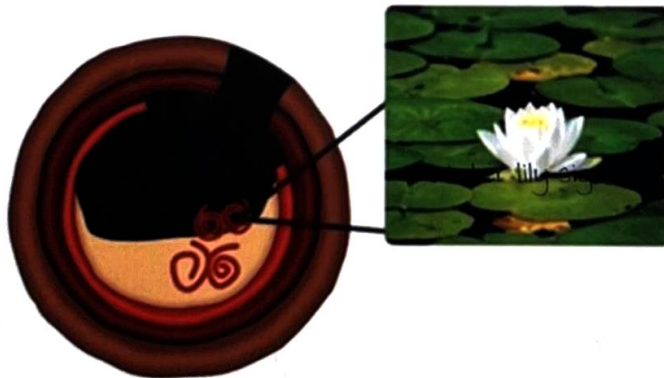




Cyst contents gradually expectorated out

Whirl / serpent sign

60c6b3eaaa8ded0e4e7e5ea7



Few of the membranes float on the surface : Water lily sign

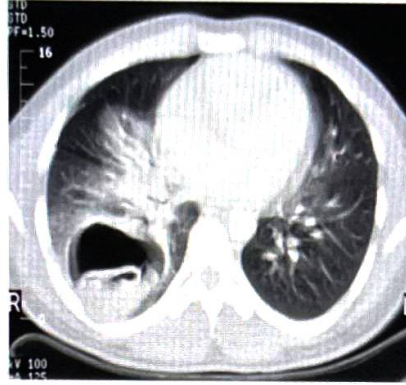


Floating water lily/ Camalote sign

Active space



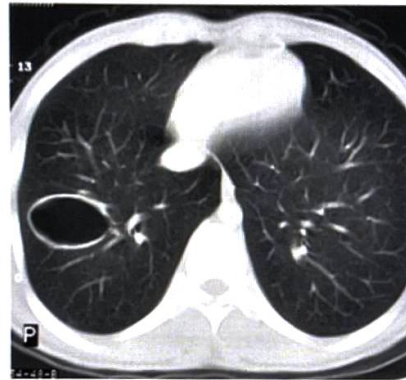
Rising Sun/ mass within cavity appearance



Rising sun / mass within a cavity



Empty cyst appearance



Empty cyst sign

60c6b3eaa8ded0e4e7e5ea7

Active space



# HEPATOBIILIARY AND PANCREATIC IMAGING

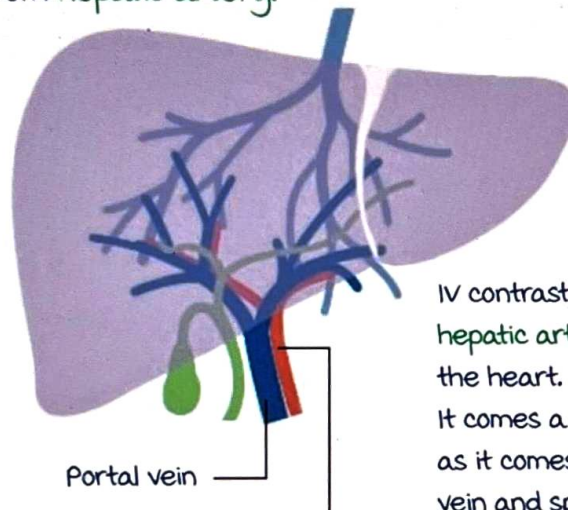
## Multiphasic contrast CT

00:02:10

60c6b3eaa8ded0e4e7e5ea7

The multiple phases are related to the blood supply of the liver.

major supply is by the portal vein, and smaller contribution from hepatic artery.



Portal vein

Hepatic artery through the respective arteries.

IV contrast, would come first to hepatic artery, via circulation from the heart.

It comes a little later in portal vein, as it comes to superior mesenteric vein and splenic vein, after it flows

### Arterial phase :

30 s after dye injection.  
Enhances conditions supplied by hepatic artery.

- HCC.
- Hemangioma.
- Hypervascular metastasis from aggressive tumors.

Liver does not enhance because it is supplied by portal vein.

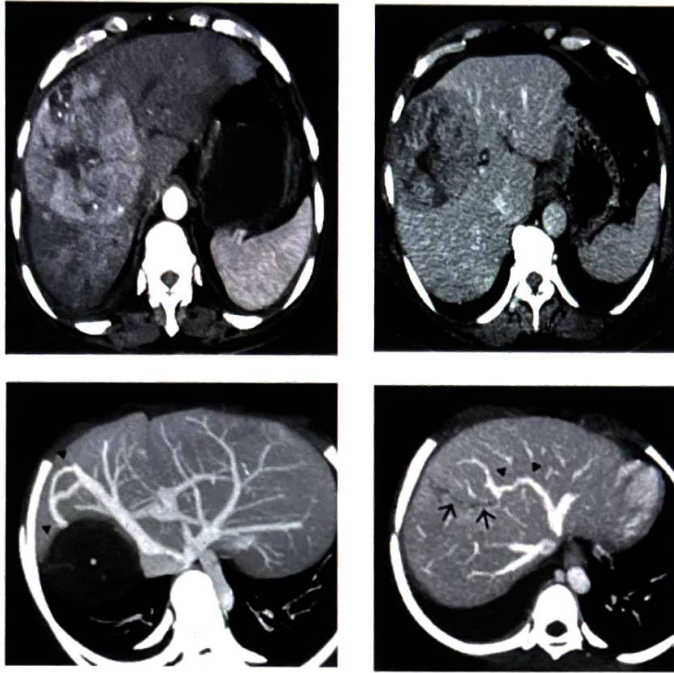
### Parenchymal phase :

60 s after dye injection.  
Normal liver parenchyma shows enhancement.  
HCC will appear washed out.

It is also known as portal venous phase.

### Hepatovenous/delayed phase :

3-5min after dye injection.  
Abnormalities in IVC and hepatic vein like Budd Chiari syndrome can be diagnosed.



IOC :

- Focal liver lesions.
- To differentiate between primary HCC and liver metastasis.

Q : multiphasic hepatic imaging includes all except?

- A. Arterial phase.
- B. Hepatic parenchyma phase.
- C. Delayed phase.
- D. Capillary phase.

Ans : D.

### Focal liver lesions with clinical scenarios

00:07:38

Liver abscess :

A 35-year-old male presented with fever spikes and elevated WBC counts.

O/E : Pain in right hypochondrium with jaundice.

USG : Complex cystic lesion with thick hypoechoic echoes.

First investigation.

Follow up to look for liquefaction of abscess.

CECT (IOC) : Peripheral ring of enhancement (due to inflammation).

Active space





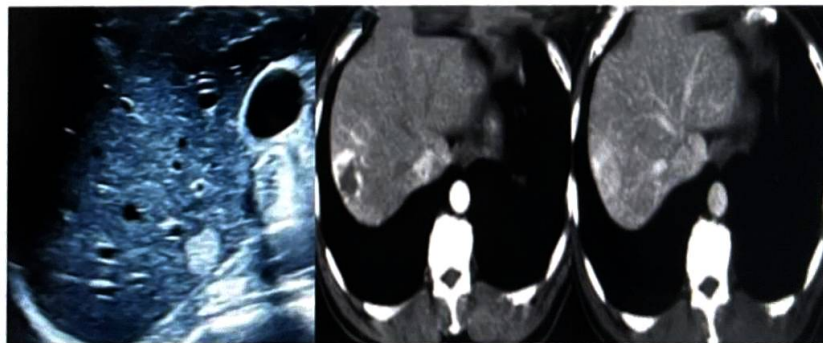
Pyogenic liver abscess :

- Similar clinical presentation as that above.
- CECT : **Cluster sign.**

Liver abscess (likely pyogenic)



Hemangioma :



USG : Focal hyperechoic lesion.

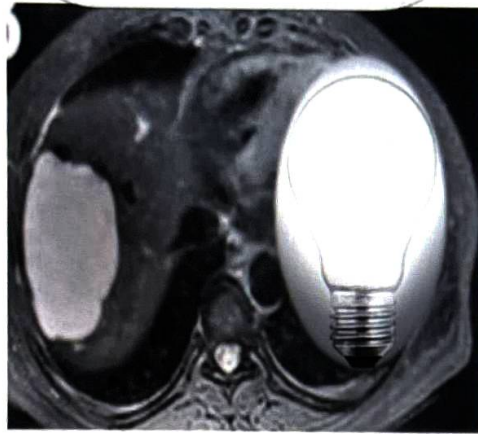
multiphasic CECT : Arterial phase. Peripheral early enhancement.

multiphasic CECT : Delayed phase. **Blood pool enhancement.**

kumarankitindia1@gmail.com

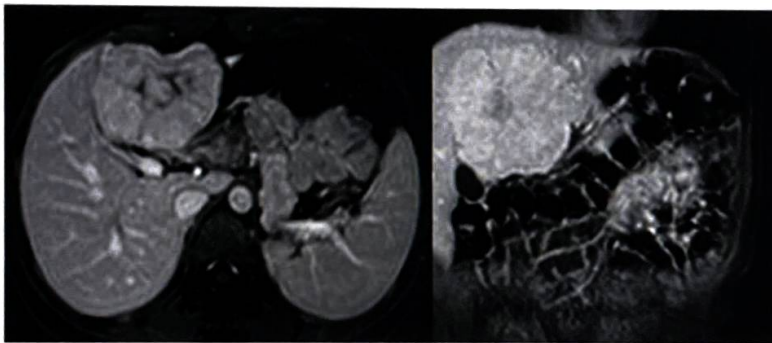
- Incidentally detected lesion.
- most common benign lesion of liver parenchyma.
- CECT : **Bright dot sign.**
- T2 weighted MRI : **Light bulb appearance.**

Active space



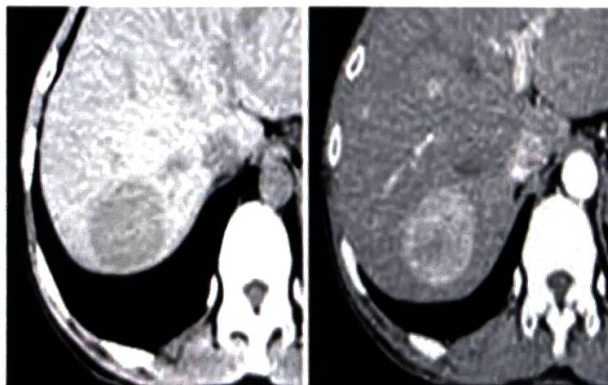
### Focal Nodular Hyperplasia (FNH) :

- Incidentally detected lesion.
- **SPIO MRI** (Super Paramagnetic Iron Oxide MRI) shows **60% signal loss**.
- **Tc - 99m labelled Sulphur colloid scan** shows uptake.
- Rich in **Kupffer cells**.



### Hepatic adenoma :

- Young female, on **OCPs**.
- Incidental detection.
- Can show **intratumoral hemorrhage**.





## Hepatocellular carcinoma

00:15:11

Focal liver lesion in a **cirrhotic liver** (unless proven otherwise), mostly seen in elderly male.

Risk factors :

- Chronic alcoholic with liver parenchymal disease.
- Hepatitis B positive.

O/E : Jaundice.

**Elevated alpha-feto protein levels** (tumor marker for HCC).



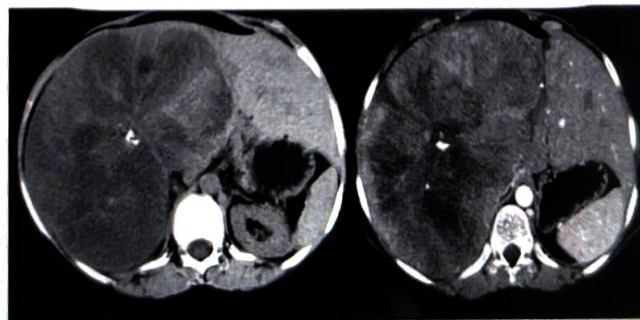
most common primary malignant tumor of liver.

Tendency to invade into portal vein or hepatic vein : **Tumor thrombus** (may enhance).

Angiography : **Streaks and threads appearance**.

Fibro-lamellar HCC :

- Younger patients.
- No known illnesses.
- multiphasic CT : Large arterially enhancing liver mass with a **central calcified stellate scar**.
- **Normal alpha-feto protein**.
- **Elevated Neutrophin**.
- **Better prognosis**.

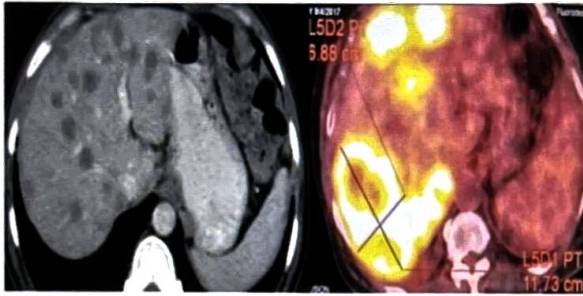


Non-contrast CT with scar.

multiphasic CECT : Arterially enhancing lesion with scar.

### Liver metastasis :

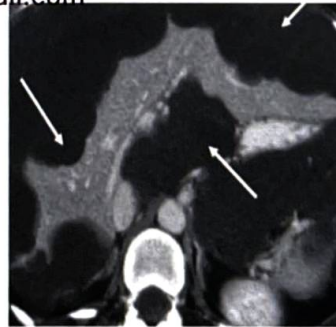
- most common type : **Hypovascular** (enhance less compared to normal liver parenchyma).
- Elderly patient.
- History of cancer (m/c carcinoma colon).
- Anorexia, generalised weakness.
- O/E : Jaundice.
- USG : **Bull's eye/target appearance.**



Hypoechoic lesion      PET scan : High metabolic uptake of FDG (hot spots)

### Pseudomyxoma peritonei :

- History of mucinous tumors (m/c : **Appendiceal mucinous tumor**).
- Thick gelatinous mucinous ascites in the peritoneal cavity.  
kumarankitindia1@gmail.com
- **Liver parenchyma eaten away.**
- **Edges scalloped.**
- Poor prognosis.
- Rx : Surgical debulking.



### Arterial enhancing metastasis

00:21:11

usually arise from aggressive primary tumors like :

- RCC.
- Thyroid malignancies.
- Neuroendocrine tumors like carcinoids.
- Choriocarcinoma.
- melanoma.

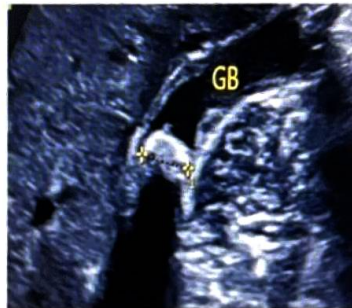
Active space





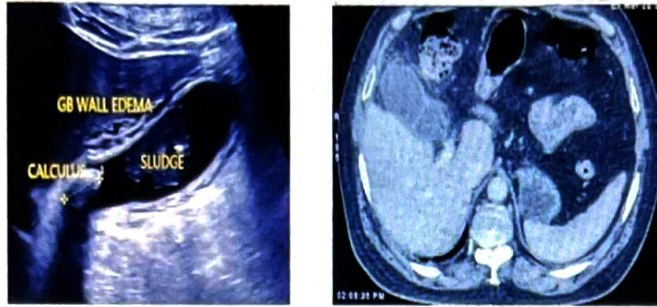
### Cholelithiasis :

- Females in 40s.
- Presents with **mild intermittent** right hypochondriac quadrant (RHQ) pain.
- USG : Hyperechoic area with dense shadow behind it, in the gall bladder.
- IOC : **USG** because the biliary stones have poor calcium content and would not be picked up in CT or X ray.
- most common type : **mixed stones**.
- **mercedes Benz appearance**.



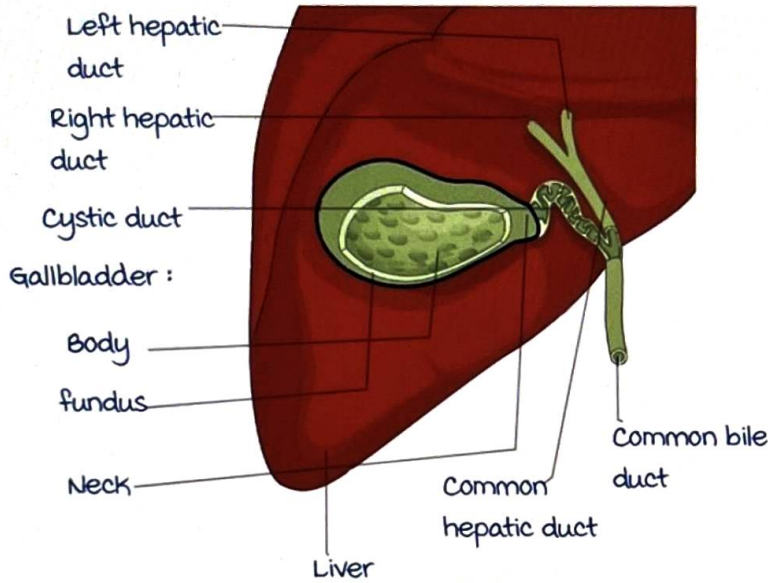
### Cholecystitis :

- Bile in gall bladder will become turbid, seen as echoes.
- Gall bladder wall thickens.
- CT : **Fat stranding** around the gall bladder.
- Very severe pain.
- **murphy sign positive** :  
Palpate the right hypochondriac area, ask the patient to take a deep breath, and observe for change in facial expression. **Catch in breath due to severe pain**.
- **Sonographic murphy's sign positive** : Pain on applying the probe.



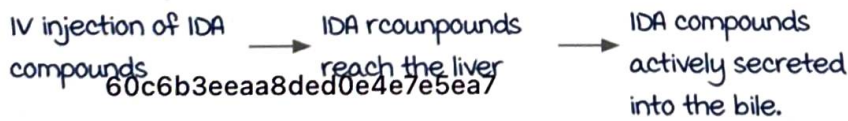
HIDA scan

00:25:24



Uses Imino-di-acetic compounds (IDA).

For hepatic imaging : HIDA.



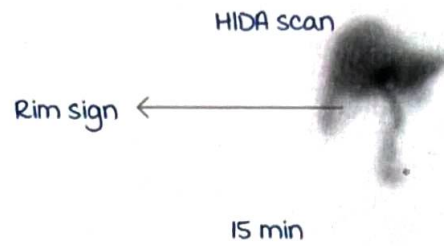
Within few minutes, the entire biliary tree is enhanced.

Non visualization of gall bladder in HIDA : Acute cholecystitis.

- Gall bladder stone that is impacted at the neck, causing stasis of the bile.
- The impacted stone prevents the IDA compounds from moving into the gall bladder.
- Increased uptake of IDA compounds because of hyperemia, along the liver parenchyma near the gall bladder : Rim sign.

Active space





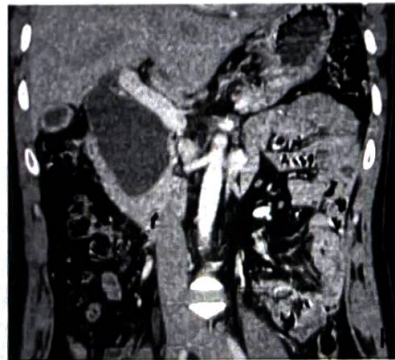
### Porcelain gall bladder :

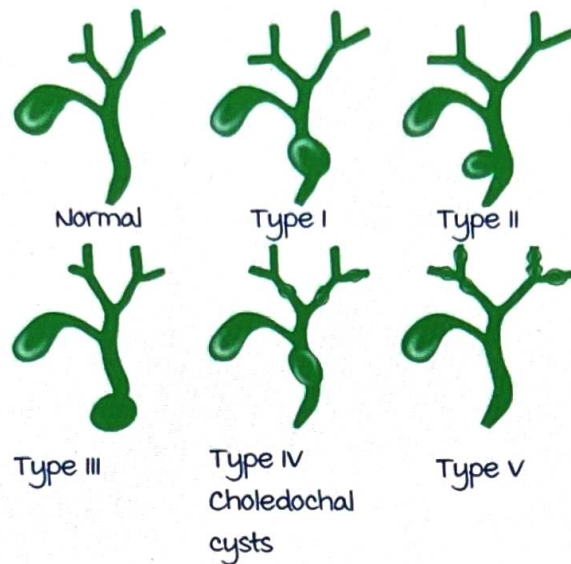
- Incidentally detected lesion.
- Asymptomatic.
- Gall bladder wall is calcified.
- Can be associated with adenocarcinoma of gall bladder (long term).



### Choledochal cyst :

- Triad of abdominal pain, jaundice and abdominal mass.
- Fusiform dilatation of the common bile duct.
- Congenital malformation.
- IOC : MRCP.
- Gold standard investigation : ERCP (invasive).





Classification of choledochal cyst : **Todani classification.**

Type I : Fusiform dilation of extrahepatic CBD.

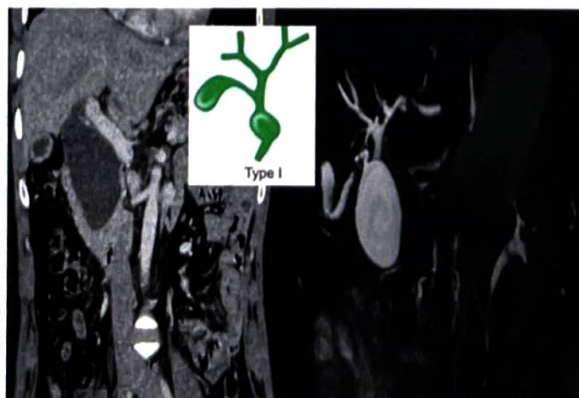
Type II : Diverticulum of CBD

Type III : Choledochocele : Cystic dilatation at the opening of the CBD.

Type IV A : Dilatation of intrahepatic and extra hepatic.

Type IV B : Only extra hepatic dilatation.

Type V : **Caroli's disease** : Only intrahepatic biliary radicle dilatations.

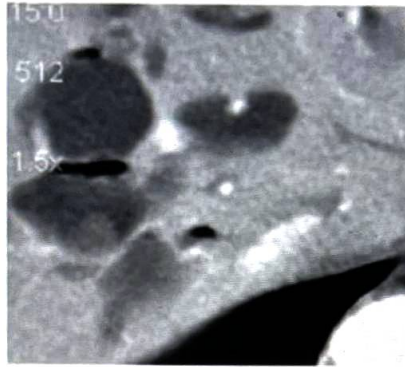


Choledochal cyst type I



Caroli disease :

**Central dot sign** : Dilated intrahepatic biliary radicle, with portal vein radicle within it.



T-tube cholangiography :

- Biliary imaging modality.
- usually done in **post-operative**.
- Stem lies outside.
- One end in proximal and the other in distal end of the biliary tree.
- Rule out leak of contrast, before removing.


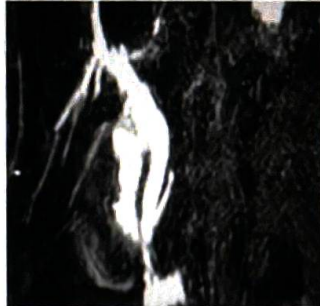
60c6b3eaa8ded0e4e7e5ea7



## Pancreas imaging

00:34:16

Ultrasound is not a good modality for evaluation.  
 Air in the bowel, in front of pancreas hinders visualization.  
**CECT** is the IOC.

ERCP	MRCP
<ul style="list-style-type: none"> <li>• Endoscopic Retrograde Cholangiopancreatography</li> <li>• Invasive procedure.</li> <li>• Diagnostic and therapeutic.</li> <li>• Gold standard for visualization of biliary tree.</li> </ul>	<ul style="list-style-type: none"> <li>• MR Retrograde Cholangiopancreatography.</li> <li>• Non-invasive procedure.</li> <li>• Fairly accurate.</li> <li>• Multiplanar.</li> <li>• Only diagnostic.</li> <li>• IOC for diagnosis.</li> </ul>
	

Acute pancreatitis :

Chronic alcoholic.

Presents with epigastric pain with radiation to back.

O/E : Guarding at epigastrium.

Elevated serum **amylase and lipase**.

CT :

- Enlarged bulky pancreas.
- Pancreatic margins are **fuzzy, irregular**.
- Fluid collection along the pancreatic surface.
- Peri pancreatic mesentery showing **fat stranding**.

X-ray :

- **Gas less colon**
- **Colon cut off sign** (due to spread of inflammation along the phrenicocolic ligament via transverse mesocolon → sudden cut off of the colon at that particular point at splenic flexure).
- **Sentinel loop sign** (due to dilatation of bowel loop located close to pancreas).





Severity of pancreas :

- **Balthazar grading system** : Has prognostic implications
  - **CT severity index** : Balthazar grading system with, presence or absence of pancreatic necrosis.
- It is considered to be better than Balthazar grading.  
Better correlation with overall morbidity and mortality.

Pancreatic pseudocyst :

Inflammatory fluid collection in the pancreas.

**4-6 weeks** after an episode of acute pancreatitis.

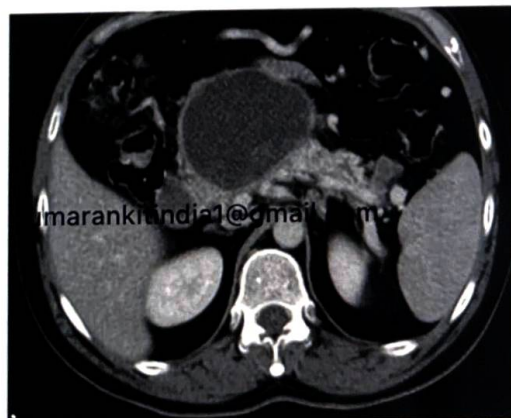
Presents with :

Abdominal fullness.

Vomiting.

mild pain in epigastrium.

**CECT** : Fluid density lesion in pancreas, with wall showing some degree of enhancement.



Chronic calcific pancreatitis :

History of multiple admissions for acute pancreatitis.

Presents with abdominal discomfort.

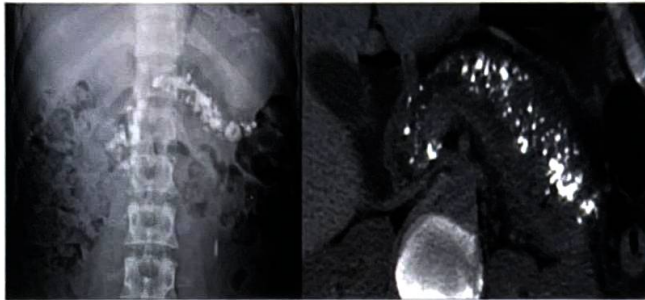
**Diffuse calcification** seen along the pancreatic parenchyma.

Calcification :

Intraductal calculi.

Pancreatic parenchymal calcifications.

IOC : mRCP with secretin stimulation > CECT.



## Pancreatic Cancer

00:41:36

- Elderly male.
- Incidentally detected mass in pancreas.
- With/without jaundice.
- Contrast studies : Lesion enhances lesser than the normal pancreatic parenchyma. [kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)
- IOC : PET CT.
- Barium study : Widening of the C shaped loop of duodenum : Reverse 3 sign of Frostberg.



CECT



Contrast enhanced MRI

Double duct sign :  
Cancer at ampulla.  
Common bile duct & pancreatic duct are dilated at the same time.



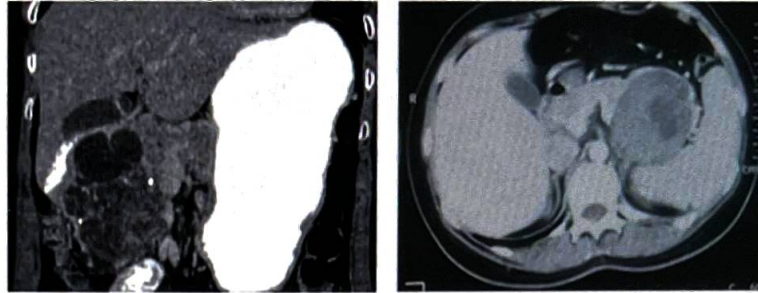
Double duct sign

Active space



Cystic pancreatic cancers :

Serous cystadenoma	mucinous cystadenoma
Elderly. microcysts. Honey comb/swiss cheese appearance.	middle aged macrocysts.



IOC
<p>USG :</p> <ul style="list-style-type: none"> <li>• Gall bladder calculi.</li> <li>• Cholecystitis.</li> </ul> <p>Multiphasic CECT :</p> <ul style="list-style-type: none"> <li>• Focal liver lesions.</li> <li>• HCC vs metastases.</li> </ul> <p>PET CT :</p> <ul style="list-style-type: none"> <li>• Liver metastases in unknown primary.</li> </ul>

Gold standard for imaging of biliary tree : ERCP.  
 Best non-invasive modality for imaging of biliary tree : MRCP.

most common	Condition
Benign liver tumor	Hemangioma
2 <sup>nd</sup> MC benign liver tumor	FNH
malignant tumor of liver	metastasis
Primary liver malignancy	HCC
Primary liver tumor in children	Hepatoblastoma

Active space

Q : A 35 year old female patient presented with fever, severe pain in epigastrium and right hypochondriac region. A HIDA scan was done with non-visualization of gall bladder as shown. most likely diagnosis ?

- A. Acute pancreatitis.
- B. Acute cholecystitis.
- C. Biliary stricture.
- D. Acute gastritis.

Ans : B.

HIDA scan



Q : This technique may be best used for all of the following, except ?

- A. Periapillary mass.
- B. unexplained jaundice.
- C. Recurrent pancreatitis.
- D. Acute pancreatitis without choledocholithiasis.

Ans : D.



ERCP



# RADIONUCLIDE IMAGING BASICS

## Radionuclide scan basics

00:00:10

- Step 1 : Patient lies on the radionuclide scanner table
- Step 2 : Specific radionuclide is injected intravenously into patient's body after deliberate consideration e.g., in order to visualize the thyroid gland it is better to inject a radionuclide laced with iodine, so we use radioactive isotope I-123 of iodine to scan thyroid gland.
- Step 3 : Radionuclide is uniformly distributed throughout patient's body.
- Step 4 : Radionuclide gets concentrated in its organ of affinity e.g., almost the entire I-123 (95-99%) will get localized selectively into thyroid gland.
- Step 5 : The radioactive isotope emits radiation from that organ in all directions, in this case the thyroid gland.
- Step 6 : This information from the organ is detected, processed and used for image reconstruction and interpretation.

Types of radionuclide scans :

Depending on how we utilize the information radiated by the organ they can be as follows.

- Planar scintigraphy : Radiation is detected using single gamma camera in only one plane, used in olden days when there were technical difficulties.  
Due to its limitation to one plane, there is very poor anatomical resolution, poor spatial resolution and poor sensitivity.
- SPECT/Single Photon Emission Computed Tomography : Gamma cameras are placed everywhere around patient's body to detect radiation from every direction. This entire set of information that is used for

image reconstruction thus giving us a high-resolution image with better anatomical resolution, better spatial resolution and better sensitivity for lesion detection.

- PET.

## Technetium/Tc-99m

00:06:30

Technetium = Artificial ; 99m = metastable isotope.

Tc has an atomic number of 43.

most common isotope used in nuclear medicine.

Very sticky radionuclide as it attaches itself to any other atom, molecule, cell or particle e.g.,

- If we tag Tc-99m with iodine, the Tc isotope radiates gamma rays effectively forming radioactive iodine and can be used in thyroid imaging.
- It can be attached to RBC's making them radioactive RBC's helping detect any site of bleed,
- It can also be attached to neutrophils, these radioactive neutrophils can be used to detect any infectious foci in the body.

Synthesis and transport :

It is synthesized from molybdenum-99, which has a very long half-life and so can be transported to the hospital.

Where it is put into Tc generators, to generate Tc-99m, the isotope used in all radionuclide scans.

$t_{1/2}$  Tc-99m = 6 hours (optimum half-life for diagnostic purposes).

It disintegrates to the normal isotope of Technetium, Tc-99.

$t_{1/2}$  Tc-99 = 2 lakh years, emitting very low energy electrons.

∴ Overall residual radiation exposure to the body is very low.

And it ultimately disintegrates to Ruthenium 99.

Q. False regarding Tc99m is?

- Half-life is 6 hours.
- Emits beta and alpha rays.
- most commonly used radionuclide in diagnostic imaging.
- Generator originated nuclide.
- Produced from molybdenum.

Answer : Emits beta and alpha rays ; It emits gamma rays.

Active space



## PET SCAN

Externally looks very similar to a CT/MRI machine but internally its functioning is different.

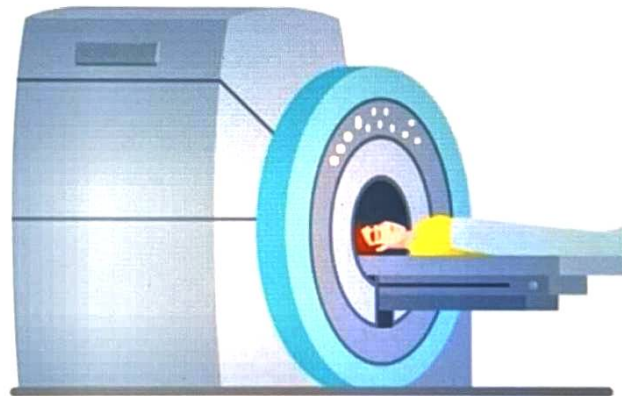
Patient lies on the table & slides inside.

**Positron emission tomography** is a cross-sectional imaging modality.

Radionuclide used in PET scan emits **positrons** (hence the name).

Application: **Cancer imaging** (most important).

- Diagnosis of the primary tumor.
- For staging of tumor.
- Assess distant metastasis.
- Assess response to treatment.
- Recurrence detection.

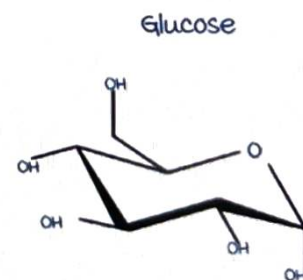
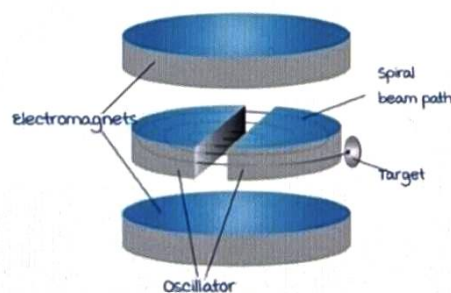


### 18-FDG

00:01:42

Radionuclide: **18-Fluoro deoxy glucose (18 FDG)**.

Specifically synthesized inside a cyclotron.



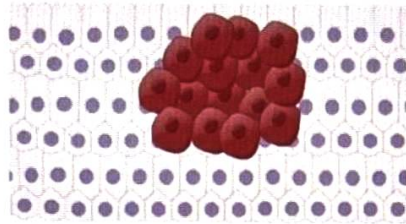
**18 F** replaces 1 hydroxyl group of the glucose forming **18 FDG**.

It is a **radioactive form of glucose**.

Half life of  $^{18}\text{F}$  FDG is around 110 minutes.

Neoplasm or a cancer is defined as an abnormal mass of tissue.

most common radionuclide used : As in tumor the **growth exceeds** that of normal tissues & it is **uncoordinated** with that of normal tissues.



Changes that occur inside a cancer cell : Cell cycle checkpoints are inactivated.

Cancer cells replicate rapidly.

Cell replication is an active process, hence require energy.

ATP : Energy currency.

Cancer cell generates its own ATP and utilised for cell division.

This is the mechanism for the use of FDG.

Cancer cell is a **glucose hungry cell**.



In normal cell :

Does not have to divide rapidly.

Low baseline glucose requirement .

**Only GLUT-2** transporters are present.

In cancer cell :

Rapid cell division occurs.

Glucose taken up into the cell using multiple GLUT transporters (GLUT 1, 2, 3, 4, 5).

**multiple GLUT transporters are expressed in the cell (over expressed).**

**GLUT type 1** is mostly overexpressed on cell surface.

most of glucose in the blood stream is taken up into the cancer cell.

FDG is similar to glucose.

60c6b3eaa8ded0e4e7e5ea7

Active space

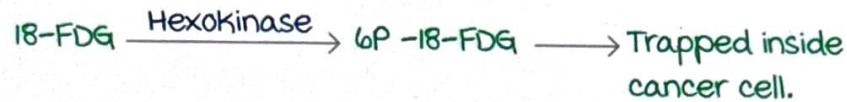


Injected 18-FDG in the blood stream is also taken up by cancer cell.

Glucose undergoes glycolysis with enzyme hexokinase. Hexokinase is also overexpressed.

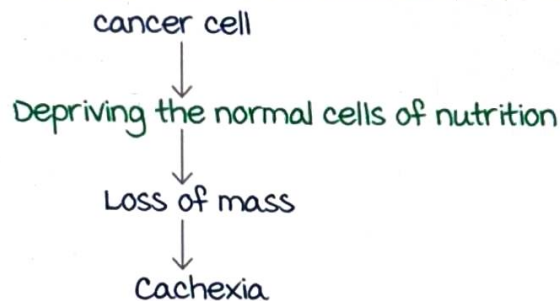


18-FDG also gets phosphorylated :



This is also one of the mechanisms of cachexia in cancer patient :

The glucose/nutrition in the bloodstream is taken up by this

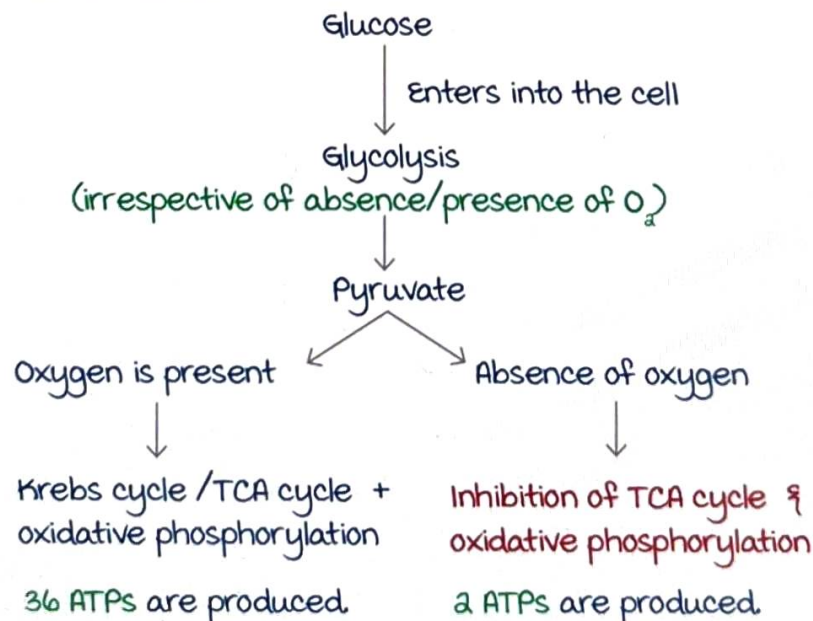


## Warburg effect

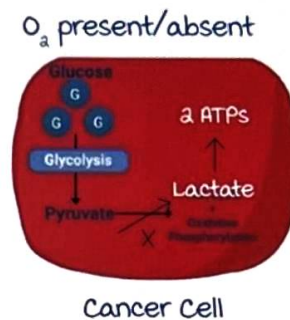
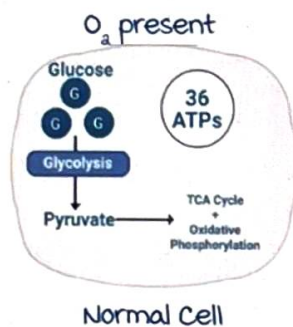
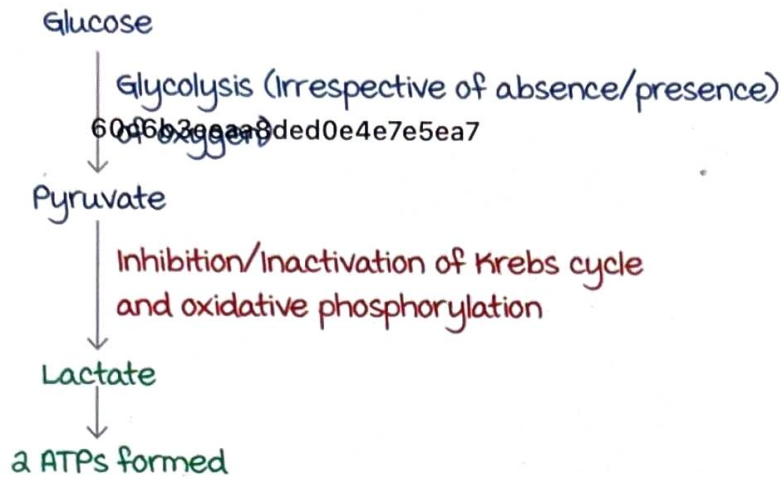
00:07:45

Established by a physiologist by the name of Otto Warburg. He was also awarded the nobel prize in physiology for his invention .

In a normal cell :



In a cancer cell :



Aerobic glycolysis :

Inefficient mechanism of utilization of glucose : Only 2ATPs produced (inspite of presence of oxygen).

The metabolites of pyruvate and lactate in a cancer cell are shunted towards production of intermediates (required for cell replication).

Therefore cancer cell has a distinct survival advantage.

MCQ :

In a PET scan , the detectors in the machine detect which of the following coming from the lesion in the patients body ?

- A. Positrons.
- B. Electrons.
- C. X rays.

D. Gamma energy photons (coming from the lesion in the patients body due to the annihilation reaction).



## Annihilation reaction

00:13:55

Trapped  $^{18}\text{F}$  FDG emits positrons.

Positron ( $\beta^+$ ) identical to electron ( $\beta^-$ ) except for the opposite charges.

Annihilation reaction :

Positron & electron move randomly

Collide with each other

Annihilation/destruction of matter mass

matter converted into energy

511 Kev gamma energy photons

2 photons are emitted & in exact opposite direction ( $180^\circ$ ) called as co-incidence imaging.



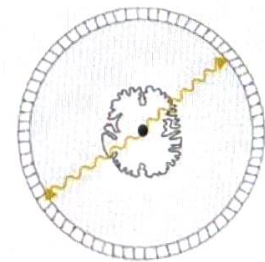
## Coincidence imaging

00:15:38

Specific for PET scan.

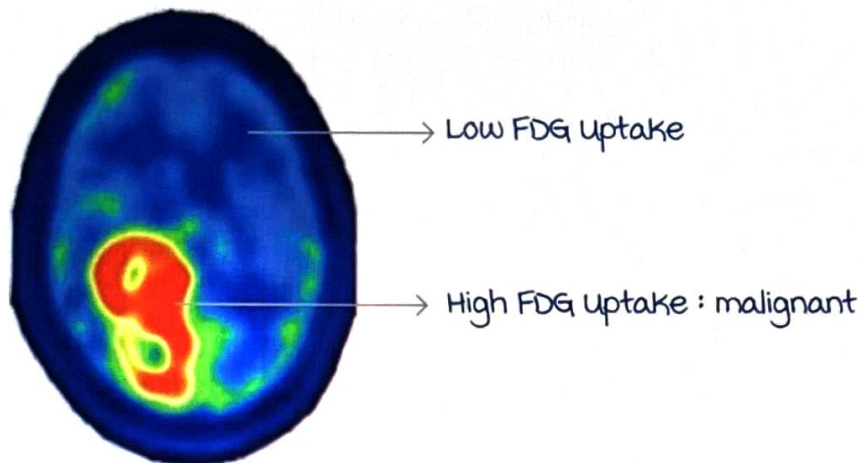
Example :

In a PET scan of a brain and there is a tumor within the brain. At the site of tumor FDG taken up & positrons are emitted.



Ring of detectors

Gamma ray photons which are emitted at 180 degrees opposite reaches detectors. machine reads the signal from these 2 detectors (located 180 degree opposite to each other). As the signal is arising from a same point, they coincide perfectly w.r.t timing and configuration. machine considers it to be true signal. Other signals are ignored if not coinciding.



PET Images are colour maps.

Dark Areas : Low FDG uptake : Low metabolism.

Bright Areas : High FDG uptake : High metabolism (malignant).

PET scan images are a functional map/metabolic map of tissue.

Other major applications : (Other than malignancies)

- Epilepsy imaging.
- Surgical treatment.
- myocardial viability (are alive or not before bypass grafting).
- Alzheimer's disease.
- Parkinson's disease.
- In dementia.

## PITFALLS OF PET SCAN

00:19:56

**False negative :**

Inspite of tumor present, shows no tumor/negative.

Active space



## Causes :

- Size of tumor < 1 cm.  
Due to low output of gamma rays coming out from the tumor, machine may not be able to detect.
- Low grade malignancy :  
Due to slow rate proliferation : Low glucose requirement.

## Examples :

Typical carcinoid tumor.

Bronchoalveolar carcinoma.

Lung metastasis from a mucinous  
extrapulmonary tumor.

After chemotherapy but later recurrence.

- Hyperglycemic state (diabetes) :  
Due to competitive inhibition of FDG by the excess glucose in blood.  
FDG competes for GLUT.

## False positive :

No tumor but PET scan will be positive.

- High glucose requirement :  
In cells with high metabolism like brown adipose tissue.
- Rapid turnover :  
Infection/granulomatous conditions like,  
Sarcoidosis.  
Tuberculosis.  
Cryptococcosis.  
Pneumocystis Infection.  
Abscesses especially in the periphery (donut appearance).
- Radiation fibrosis due to secondary inflammation.
- Others :  
Pneumoconiosis with massive fibrosis.  
Sclerosing hemangioma of lung.  
Brown adipose tissue.

MCQs :

18 FDG stands for :

- A. 18-Fluoro deoxyglucose.
- B. 18-Fluorodioxo glucose.
- C. 18-Fluorodeoxy galactose.
- D. 18-Fluorodioxo galactose.
- E. 18-Fluorodeoxy glycogen.

Q2 : All are true regarding FDG pet scan except :

- A. Produces a image of the functional process of the body.
- B. Produces better anatomic details than MRI.
- C. Radiation exposure is higher than CT abdomen.
- D. malignant cells show high uptake due to increased metabolism.
- E. used to detect tumorr recurrence in patients who had undergone surgery for brain tumour.

60c6b3eaaa8ded0e4e7e5ea7

Q3 : Which of the following would be overall the best image in modality for cancer image in

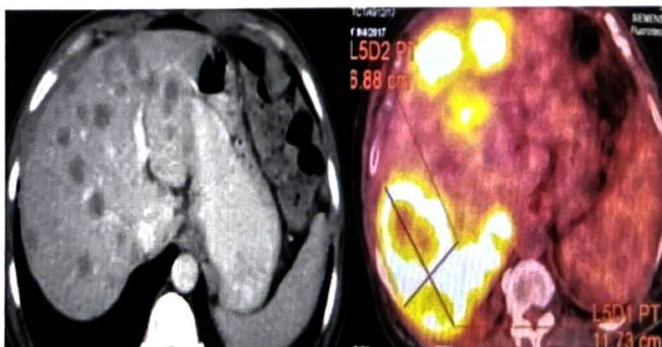
- A. CT.
- B. MRI.
- C. PET.
- D. PET-CT.

Hybrid/fusion imaging modality :

Fusion of anatomic and functional modality.

PET-CT/PET-MRI.

In liver, combining to PET scan (superimposed) : Colormap suggestive of high uptake of FDG implying malignancy.



Active space



## SYSTEMIC RADIONUCLIDE IMAGING : PART - 1

Clinical quiz :

Q. A patient has recently suffered a MI and has been diagnosed to have Ischemic cardiomyopathy. Angiography reveals multiple vessel disease. Prior to CABG, the cardiologist wants to assess the myocardial viability. Best test to be done is ?

- 60c6b3eeaa8ded0e4e7e5ea7
- A. Thallium scan.
  - B. 18-FDG PET scan.
  - C. 99m Tc Stannous pyrophosphate scan.
  - D. MUGA scan.

Ans : B

Q. A 35 year old female patient presented with fever, severe pain in the epigastrium and right hypochondriac region. A HIDA scan was done with non-visualization of GB as shown here. most likely diagnosis is ?

- A. Acute pancreatitis
- B. Acute cholecystitis
- C. Biliary stricture
- D. Acute gastritis.

Ans : B



HIDA scan

### Infection/Inflammation

00:05:48

Gallium-67 scan :

$T_{1/2}$  : 78 hours.

used in PUO : Hidden focus of infection.

Gallium is a component of inflammatory mediators.

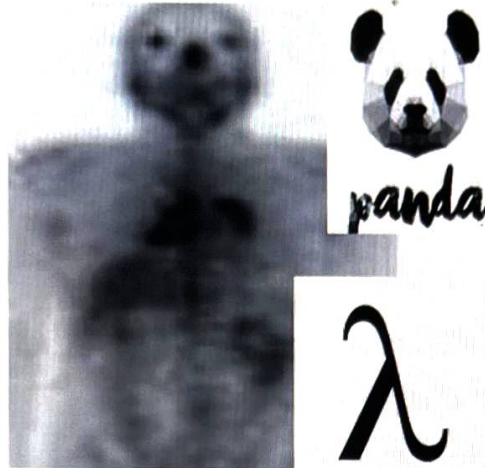
Radioactive gallium will get concentrated at site of inflammation thereby showing hidden focus of infection/ inflammation.

High sensitivity.

Low specificity: Positive Gallium scan in Sarcoidosis / Lymphoma.

Gallium 67 scan in sarcoidosis:

**Panda sign** : The uptake of Gallium in the lacrimal glands and Parotid glands superimposed on normal intake in the nasopharynx.



**Lambda sign** : Uptake of gallium in B/L hilar lymph nodes and right paratracheal lymph nodes.

**Leucocyte Tagging** : Tc99m labelled WBCs (neutrophils) used. These neutrophils, after activation and chemotaxis, get concentrated at site of infection.

**Specific.**  
**Sensitive.**

## Cardiac imaging

00:11:13

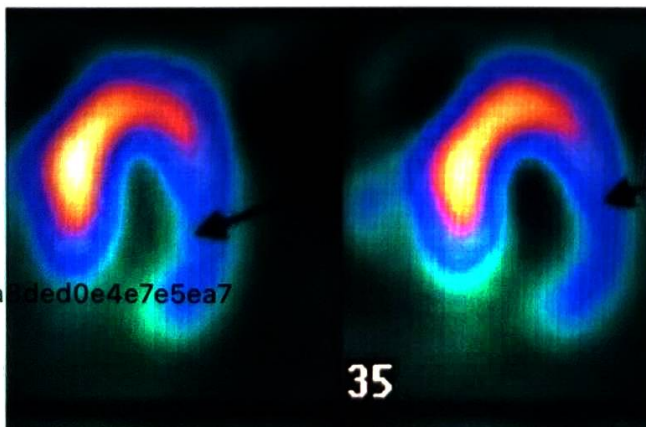
Perfusion (capillary blood flow) imaging :

Thallium - 201 scan used.

Thallium behaves exactly like potassium.  $K^+$  is mainly present in the intra cellular compartment.

Normal area of heart will have normal perfusion : Hot spot.

Area of myocardial infarct will have no perfusion : Cold spot.



60c6b3eeaa1ded0e4e7e5ea7

Perfusion Imaging

Active space



Infarct avid Imaging :

Tc99m : **Stannous Pyrophosphate** used.

Infarct appears as a hot spot.

**Radionuclide Ventriculography (RNV) :**

Tc99m labelled RBCs used.

**Quantitative cardiac function** calculated.

End diastolic volume (EDV) and End Systolic volume (ESV) measured.

$EDV - ESV = \text{Stroke volume (SV)}$ .

$SV \times HR = \text{Cardiac output (CO)}$ .

**MUGA scan :** multiple gated acquisition scan. Type of RNV.

myocardial viability assessment :

**18-FDG PET scan** used.

In a normal heart, Free fatty acids are used as energy substrate. Therefore no uptake of 18-FDG : Cold spot

In an Ischaemic heart, **glucose used as energy substrate.**

18-FDG (fluorodeoxy glucose) uptake seen : Hot spot.

Q. True regarding perfusion cardiac scintigraphy is ? kumarankitindia1@gmail.com

- A. Invasive technique.
- B. Can detect myocardial viability after MI.
- C. Gamma camera is used.
- D. Abnormal areas appear as hot spots.
- E. Thallium is the most commonly used radionuclide.

Ans : B, C and E.

## GIT imaging

00:19:35

**GI bleeding evaluation :**

Foregut : Coeliac trunk.

Midgut : Superior mesenteric artery.

Hindgut : Inferior mesenteric artery.

Catheter angiography: Contrast injected in superior mesenteric artery (SMA), if comes out into bowel : **GI bleeding.**

Drawback :

Low sensitivity, invasive, can detect only active bleeding.

Threshold dose (ml/min) :

- Flush aortogram:  $>5\text{ml}/\text{min}$
- Selective Angiogram:  $>0.5\text{ml}/\text{min}$

Radionuclide studies :

High sensitivity.

Threshold dose:  $0.05-0.1\text{ml}/\text{min}$ .

$^{99\text{m}}\text{Tc}$ -Sulfur Colloid	$^{99\text{m}}\text{Tc}$ -RBCs	$^{99\text{m}}\text{Tc}$ -pertechnetate
Active GI bleed.	Intermittent bleed in bowel (every 1 hr) can be detected.	meckel's diverticulum bleed (Ectopic gastric mucosa)

Miscellaneous:

Diarrhea/IBD/Abdominal sepsis	Ectopic Splenic Tissue
$\text{Tc}^{99\text{m}}$ -WBCs	$\text{Tc}$ -RBCs (heat damaged RBCs)

Q. IOC for accessory spleen localization is?

- USG
- CT
- MRI
- Radionuclide imaging.

Ans: D using  $\text{Tc}$  labelled heat damaged RBCs.

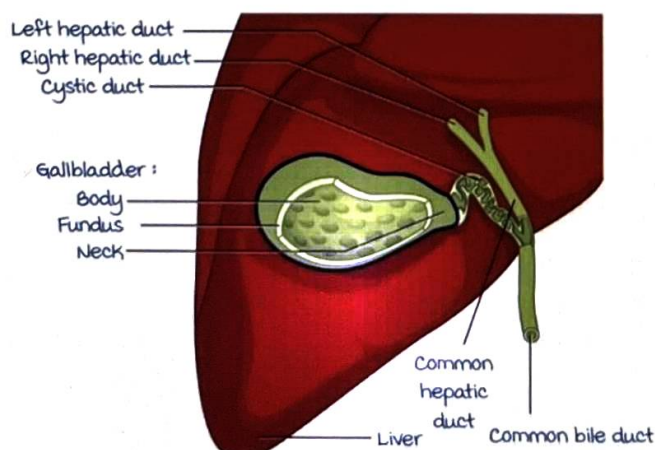
## Hepato-Biliary Imaging

00:26:38

**HIDA scan** : IDA compounds (Imino diacetic acid compounds) used for hepatic imaging.

IDA compounds IV  $\rightarrow$  Hepatocytes  $\rightarrow$  Secreted in bile.

Non visualization of GB in HIDA scan : Acute cholecystitis.



Active space





HIDA scan in acute cholecystitis

Q. Non-visualization of Gall bladder on HIDA scan is suggestive of?

A. GB perforation

B. Cholecystitis

C. Biliary atresia

D. Biliary leak

60c6b3eeaa8ded0e4e7e5ea7

Ans: B

**Rim sign**: Increased uptake of IDA compounds in liver parenchyma adjacent to GB because of reactive hyperemia.



Rim sign in acute cholecystitis

HIDA scan applications :

- Acute cholecystitis.
- Biliary atresia
- Biliary dyskinesia/stricture
- Bile leak.

Hepatic hemangioma imaging :

Hemangioma made of blood vessels.

Pool of RBCs seen.

Tc-RBCs used.

## Skeletal Imaging

00:32:05

Tc99m-MDP (methyl diphosphonate) bone scan.

MDP has strong hydroxyapatite affinity at osteogenic sites.

Uses:

- Osteomyelitis.
- Avascular necrosis.
- Tumors.
- Stress fractures.

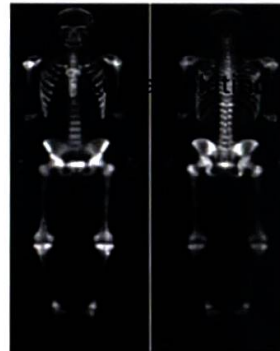
Tc99m-MDP triphasic bone scan :

Phase	Cellulitis	Osteomyelitis
I- Angiographic (30s - 1 min)	Increased uptake	Increased uptake
II- Blood pool phase (5min)	Increased uptake	Increased uptake
III- Delayed phase (2-4hrs)	No uptake	Increased uptake

Delayed phase helps in differentiating cellulitis and osteomyelitis.

Tc99m-MDP superscan :

High uptake of MDP compound in bones.  
Seen in Renal failure, metabolic bone disorders, Hyperparathyroidism, Paget's disease, metastasis involving bone.



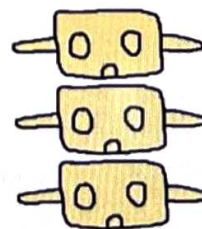
1@gmail.com

Super scan

mickey mouse sign :

Paget's disease.

The vertebral body and two pedicles show high uptake focally.



mickey mouse sign

Lymphatic imaging :

Tc99m- Nanocolloid particles used.

Nanocolloid particles exit capillaries → lymph → lymphatics.

Active space



## Neck Imaging

00:36:58

Thyroid gland imaging:

$Tc^{99m}$ -pertechnetate	$I^{123}$ -Na-Iodide
Trapped by thyroid follicular cells	Organified by thyroid follicular cells. most commonly used.

Thyrotoxicosis	Thyroid nodules/Ectopic thyroid tissue
$I^{123}$ -Na-Iodide	Pertechnetate scan

Thyroid nodule imaging :

1. Cold nodule :

- most common.
- Hypofunctional, does not take up Iodine compound.
- High risk of malignancy (20%).

2. Warm nodule : Euthyroid.

3. Hot nodule :

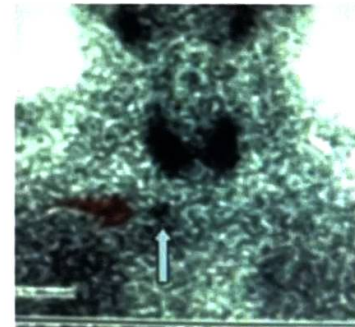
- Hyperfunctional.
- Least malignant.

60c6b3eaa8ded0e4e7e5ea7

Parathyroid Imaging :

- Tc- Tetrafosmin scan.
- Tc-Sestamibi scan : most common.

Taken up by cells rich in mitochondria (Parathyroid adenomas).



Parathyroid imaging

Q. IOC for localization of Parathyroid gland is ?

- USG
- CT
- MRI
- MIBI scan.

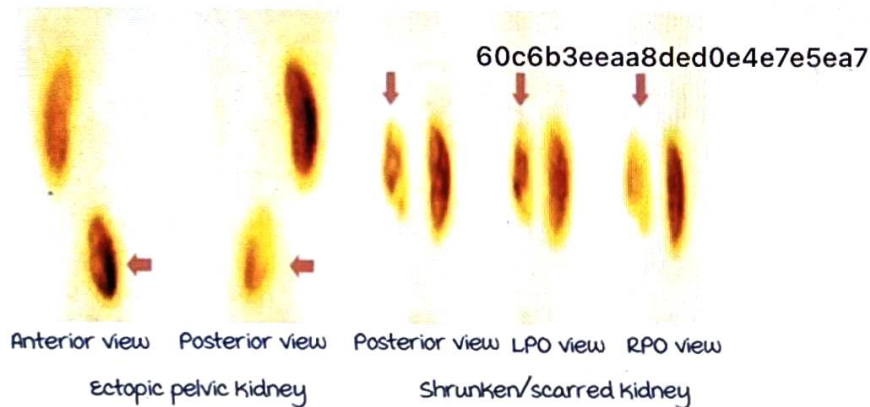
Ans: D.

# SYSTEMIC RADIONUCLIDE IMAGING : PART - 2

## Renal imaging

00:00:09

- For structural/anatomical evaluation :  $Tc^{99m}$  - DMSA (Dimercapto succinic acid) eg : Absent/ectopic kidney.
- DMSA is concentrated in the Proximal convoluted tubules located in the renal cortex in around 2-4 hours.
- Investigation of choice to detect renal cortical scars in a known case of vesicoureteric reflex (VUR) : DMSA scan.  
VUR → reflex of urine from bladder into ureter → dilatation of ureter → pyelonephritis → cortical scar.



- For functional evaluation (GFR) :  $Tc^{99m}$ -DTPA (Diethylene triamine penta acetic acid).
- DTPA is excreted exclusively by glomerular filtration from the kidneys.
- Only indication of DTPA scan : To estimate the GFR.
- For functional evaluation/dynamic renal scintigraphy :  $Tc^{99m}$ -MAG3 (mercapto acetyl triglycine).
- To estimate effective renal plasma flow (ERPF) and renal clearance. Preferred to  $Tc^{99m}$ -DTPA, nowadays.
- MAG3 has more efficient extraction and better correlation with ERPF (excreted via tubular transport).
- MAG3 is the most commonly used renal radionuclide.
- For the diagnosis of renal artery stenosis → renovascular hypertension : Captopril +  $Tc^{99m}$ -DTPA.
- Shows the functional significance of the stenosis.

Active space



Pathology of hypertension in RAS :

- **Renal artery stenosis** → less blood under less pressure in afferent arteriole → decrease in GFR → sensed by macula densa cells → secretes renin → activates angiotensin 2 and aldosterone (salt and water retention) → hypertension.

Response :

- Angiotensin-2 → constriction of afferent arterioles → increase in the GFR.
- Captopril (ACE inhibitor) → dilatation of the efferent arteriole → significant decrease in the GFR → acute renal failure → contraindicated in B/L renal artery stenosis.

**Application :**

Step 1 : DTPA scan is done to estimate the baseline GFR of the patient.

Step 2 : A small dose of Captopril is administered and repeat DTPA scan is done to estimate the new GFR.

The new GFR will be less compared to the baseline GFR in patients with renal artery stenosis/renovascular hypertension.

**One-liners** in renal artery stenosis :

60c6b3eaa8ded0e4e7e5ea7

- 1<sup>st</sup>/screening investigation : USG + Renal doppler imaging.
- Investigation of choice : CT angiography/MRI angiography (equally good). In practice, CTA > MRI angiography.
- **Gold standard** investigation : Invasive angiography.
- Investigation that detects the functional significance of stenosis : Captopril + Tc99m-DTPA.

Q. IOC for detection of renal cortical scars in a known case of VUR is ?

- A. USG.
- B. CT
- C. MRI.
- D. DMSA scan.

Q. Compound used to measure GFR is/are ?

- A. Inulin.
- B. Creatinine.

- C. MUGA.
- D. Tc99-DTPA.
- E. Tc99-MAG3.

## Lung imaging

00:15:26

- ventilation-perfusion scan (to detect V/Q mismatch).
- ventilation is the air reaching the alveoli of the lungs which is measured by :
  - Tc labelled aerosol → **Technegas**.
  - Radioactive Xenon**.
- Perfusion is the capillary level blood flow which is measured by [kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)
  - Tc- **MAA** (macro aggregated albumin).
  - m/c indication to do a VP scan → **Pulmonary thromboembolism** (in olden days).
  - with normal ventilation & perfusion, V:Q ratio is 1.
- **matched defect** : Both ventilation and perfusion are absent in a particular area of lung.
  - Seen in **airway obstruction** (Absent ventilation in obstructed airway → blood supply gets blocked (autoregulation) → blood shunted to areas of normal ventilation) and **lung parenchymal disease**.

**mismatched defect** is seen in pulmonary thromboembolism. Thrombus in lower limb veins → dislodges into IVC → Right atrium → Right ventricle → Pulmonary artery (blocked). Blood flow/perfusion to a particular area of the lung is blocked whereas the ventilation at that site is maintained in the early phases.

**Triple match** : Seen in pulmonary infarct due to pulmonary thromboembolism.

- Perfusion is absent.
- Ventilation also gets affected in the later stages due to pulmonary ischemia/infarction.
- CXR Shows opacity in that area.

**Solitary pulmonary nodule (SPN)** :



- Single nodule of size  $< 3\text{cm}$  within the lung.
- Usually incidentally detected.
- **18-FDG PET scan**  $\rightarrow$  To assess if the nodule is malignant based on **Warburg effect**.
- PET scan plays a role in the **lung cancer evaluation** for primary diagnosis, staging, response to treatment, to assess recurrence & distant metastasis.

### CNS imaging

00:22:53

- For stroke imaging/perfusion imaging : **Tc99-HMPAO** (Hexa methyl propylene amine).
- HMPAO is a **lipophilic** compound which can easily cross the BBB.
- The brain uptake of HMPAO is proportional to the cerebral blood flow (seen as a cold spot in infarcted areas).

Specific CNS applications :

- CSF rhinorrhoea/hydrocephalus : Intrathecal administration of Tc-DTPA by lumbar puncture in head low position.
- Dementia/encephalitis : HMPAO SPECT scan.
- Epilepsy :
  - A. Ictal scan (during seizures) : HMPAO scan (as the perfusion increases at the site of epileptogenic focus).
  - B. Interictal scan (in between the seizures) : 18-FDG.

### Miscellaneous applications

00:26:07

- **MIBG** (meta Iodo Benzyl Guanidine) scan.
- Guanidine analogue-specific for **catecholamine producing tumors/neuroendocrine tumors (NET)**.
- Labelled with **I-131**.
- Stored in the vesicles of the sympathomedullary system.
- Any tumor secreting catecholamines, shows high uptake of MIBG.

Applications of the scan :

- Adrenal pheochromocytomas.
- Extradrenal pheochromocytomas/paragangliomas.
- Neuroblastomas.
- Carcinoid tumors.
- medullary thyroid cancer.
- Ganglioneuroma/ganglioneuroblastoma.

## Neuroendocrine tumour imaging

00:28:00

- Ga68- DOTA-peptide PET/CT.
- Ga68- DOTATATE PET/CT.
- Ga68- DOTATOC PET/CT.
- Ga68- DOTANOC PET/CT.
- In111-Pentetrotide SPECT.

NETs express somatostatin receptors. Hence, SSTR affinity agents are specific for NETs.

- DOTA compounds are somatostatin receptor affinity agent which are specifically used for the detection of NETs.
- Pentetreotide is a somatostatin receptor analogue like octreotide.
- Investigation of choice for adrenal pheochromocytoma → MRI.
- Investigation of choice for extra-adrenal pheochromocytoma → DOTA PET scan.

Q. A patient recently suffered a MI and has been diagnosed to have ischemic cardiomyopathy. Angiography reveals multiple vessel disease. Prior to CABG, the cardiologist wants to assess the myocardial viability. Best test to be done is ?

- Thallium scan.
- 18-FDG PET scan.**
- 99m-Tc-Stannous pyrophosphate scan.
- MUGA scan.

Explanation : **Glucose** is used for metabolism by an ischemic myocardium.

Q. A 35 year old female patient presented with fever, severe pain in the epigastrium and right hypochondriac region. A HIDA scan was done with non-visualization of GB as shown here. most likely diagnosis is ?

- Acute pancreatitis
- Acute cholecystitis**
- Biliary stricture
- Acute gastritis

HIDA SCAN



15 MIN

Active space



# RADIOTHERAPY : PART - 1

## Introduction

00:00:07

**Henri Becquerel** : Discovered the property of radioactivity in 1896.  
Becquerel : SI unit.

**marie and Pierre curie** : Coined the term radioactivity.  
Curie : Conventional unit.

Radioactivity :

The act of emitting radiation spontaneously from an inherently unstable nuclei.

Radiation decay/ disintegration :

The **unstable nucleus** emits radiation and eventually disintegrates into smaller non-radioactive nuclei that doesnot emit radiation.

## Types of Radioactive decay

00:05:02

1. Alpha decay :

Unstable radioactive nucleus : Emits **alpha particles**.

Alpha particle = 2 protons (Atomic no.) &

2 neutrons (Atomic mass number =  $2+2=4$ ).

Atomic mass no : Decreases by 4.

Atomic no : Decreases by 2.

It is similar to a helium nucleus.

2. Beta decay :

Unstable nucleus due to **excess neutrons**.

This nucleus converts to proton, electron and neutrino.

Emits **electron** and retains proton.

Atomic number : Increases by 1.

Atomic mass No. : Unchanged.

A/K/A isobaric decay.

Neutrino : Insignificant.

## 3. Gamma decay :

unstable nucleus : Emits **only gamma rays** and no particle emitted [proton, electron].

Atomic mass No. and Atomic number : **unchanged**.

Radiation components

00:11:25

	Alpha	Beta	X ray (mc used)	Gamma
Ionising/ damaging power	maximum (tissue damage)	Slightly less	Further less	Least
Penetrating power	Least	High	Higher	Maximum

Law of Radioactive decay

00:17:04

$$\frac{dN}{dt} = -\lambda N$$

$dN/dt$  is called **velocity of disintegration**, which is  $\propto N$

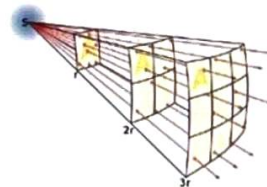
$N$  - number of nuclei

$dN$  - difference in number

$dt$  - difference in time

$\lambda$  - disintegration constant - determines half-life

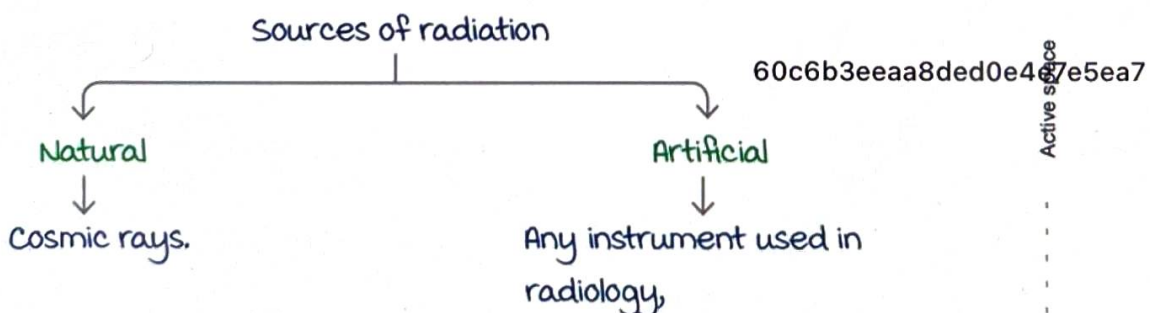
$[T_{1/2}]$



Inverse square law : **Intensity** =  $\frac{I}{d^2}$

Sources of Radiation Exposure

00:20:07





Ground/atmospheric related. radiotherapy & nuclear medicine.

Internal sources.

Background radiation :

Radiation occurring constantly from natural sources.

Maximum in Kerala in India.

## Mechanism of Radiation

00:22:32

Two types : Direct and indirect.

Indirect method : MC method.

The radiation interacts with the water molecules in a particular tissue



Causes ionisation by production of hydroxyl free radicals.



Further interaction with oxygen forms superoxide free radicals.



Causes dsDNA breaks and leads to cell death.

Direct method :

The radiation directly acts on the DNA and causes dsDNA break.



Called double stranded DNA breaks [dsDNA].



Cannot be repaired and leads to cell death.

1<sup>st</sup> step of radiation induced damage : Ionization (free radical generation).

mechanism of cell death : Genetic damage (dsDNA breaks).

Sensitivity to radiation of a cell :

Radiosensitivity of a cell varies with the phase of cell cycle it is in

maximum radiosensitivity of a cell : Cells in G<sub>2</sub>-M junction/

**m phase**, when the cell is entering division/ actively dividing.

**minimum radiosensitivity** of a cell : Cells in **S phase** (since all synthetic enzymes are active during this phase & any damage to the DNA is quickly corrected.

**Disadvantages** of administering a single large dose :

1. massive cell death of both tumor cells and normal cells.
2. metabolic overload from by products of cell death leading to toxicities & maybe even death.
3. Different cells in a tissue will be at different phases of cell cycle .  
(Some cells in G<sub>2</sub>-m junction / m phase & some cells in S/G<sub>1</sub>/G<sub>2</sub> phase).  
Therefore, some cells get destructed and some survive.

### Fractionated Radiotherapy

00:29:18

Fractionated radiotherapy is used due to the disadvantages of administering a single large dose.

Fractionated radiotherapy :

A single large dose is **split into many fractions** and is given fraction by fraction (one after another).

**Advantages** of fractionated radiotherapy :

1. No massive cell death. So, minimum toxicity.
2. Increases the efficacy of treatment as it facilitates the cells to progress to G<sub>2</sub>-m junction/ m phase which has the maximum radiosensitivity : Reassortment.

### Fractionated Radiotherapy Components

00:34:04

5 Rs.

1. Radiosensitivity :

Determines whether the **modality** will be effective or not.



### SFA [surviving fraction 2]:

- Quantitative measurement parameter of radiosensitivity.
- Surviving fraction of tumor cells after exposure to a radiation dose.
- Important prognostic factor for local control of cancers.
- High SFA indicates high resistance : Low radiosensitivity.
- Low SFA indicates low resistance : High radiosensitivity.

### 2. Repair/Recovery :

- Fraction radiotherapy allows normal cells to repair in between the fractions.

### 3. Repopulation :

- Tumor cells can repopulate, if incompletely damaged.
- Normal cells can repopulate, better than cancer cells between fractions.

### 4. Reoxygenation :

- In a tumor : Peripheral cells are well oxygenated & central cells hypoxic.
- 1 fraction : Destroys oxygenated cells in periphery.
- Central cells : Better oxygenated
- Subsequent fractions lead to destruction of the next adjacent group of peripheral cells.
- Thus, treatment efficacy improved.

### 5. Reassortment :

- First fraction : Destroys cells in G<sub>2</sub>M junction/m phase.
- Second fraction : Few more cells moved to G<sub>2</sub>M junction/m phase are destroyed.
- Increases treatment efficacy.

60c6b3eeaa8ded0e4e7e5ea7

## Types of Fractionated Radiotherapy

00:40:00

Conventional Fractionation :

MC used strategy.

1 fraction per day [2 Gy] for 5 days/week & weekend holiday.

Weekend : To metabolize & excrete the built up of byproducts of cell death.

To allow re assortment & re oxygenation of cells.

used in seminoma, prostatic cancer, lymphoma.

Hyper Fractionation :

> 1 fraction per day/ thrice a day [1- 1.2 Gy BD/TDS].

used in cerebral gliomas, small cell lung cancer, head & neck tumors.

Hypo Fractionation :

< 5 fractions per week or higher dose for 15 days.

used as palliative treatment, for melanomas, soft tissue sarcomas.

CHART (Continuous Hyper-fractionated Accelerated Radiotherapy) :

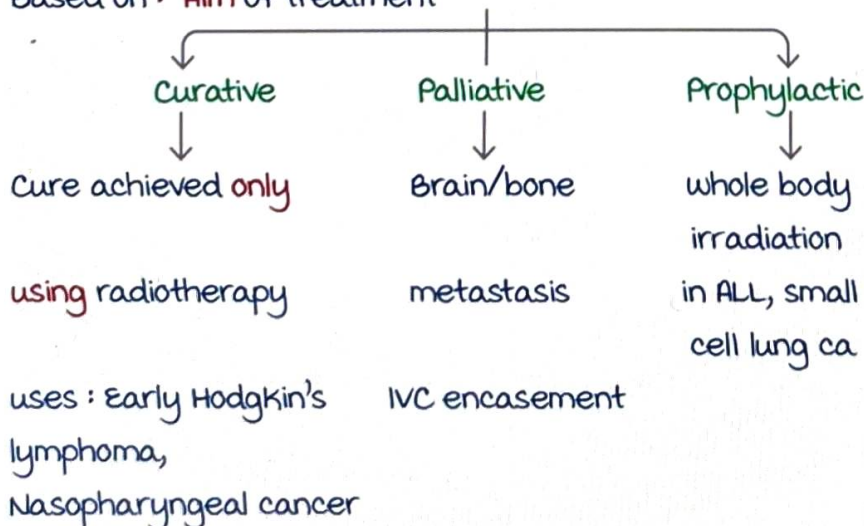
1-2 Gy BD or TDS for all 7 days for 4 - 6 weeks.

used for adenocarcinoma of the lung.

## Radiotherapy Types

00:44:45

Based on : Aim of treatment



Active space



Based on : **Time** of treatment.

Neo adjuvant  
Radio-Rx

Radio-Rx used first  
[Preoperatively]

To downstage the  
tumor & decrease  
size.

more effective surgical results.

Adjuvant Radio-Rx

used after surgery  
[Postoperatively]

Colon ca,  
Lung, Breast  
Pancreatic ca.

Chemo-radio

Chemotherapy &  
radiotherapy  
are given  
together.

## Radiotherapy Types : Based on Modes of Delivery

00:48:11

External beam radiotherapy/ **teletherapy** : **MC** type.

Radiation source is at a certain distance from the body

The source creates a radiation beam

enters the body and hits the tumor.

**Teletherapy types** : Depending on the intensity of radiation beam

Kilo voltage  
radiotherapy [Rx]

40-500kV

Contact/ superficial  
Deep orthovoltage  
therapy.

super voltage Rx

500-1000kV

deeper tumors.

mega voltage Rx

1 mega volts or higher

60c6b3eaa8ded0e4e7e5ea7

Teletherapy equipments :

Co-60 (Cobalt -60) machines :

MC radioisotope used.

Artificial radioisotope. (Natural isotope is Co -59).

T<sub>1/2</sub> : 5.2 years.

Procedure :

The radioisotope is kept inside the Co-60 machine



Emits radiation beam, which enters the body & radiotherapy administered.

Disadvantages :

Risk of radiation exposure to handlers.

Personal shielding required.

LINACS (linear accelerators) :

They are modified heavy duty x-ray tube.

Electrons are accelerated greater than in x-ray tubes.



Hits the heavy metal target.



Very high energy x-rays are produced used for radiotherapy.

Output : High energy x-rays & electrons.

Advantage :

No radioactive isotope used.

Easy to operate.

Radiation beam shape/ intensity can be modulated.

Disadvantage : Exposure & permanent damage to normal tissues cannot be avoided.

## Brachytherapy

00:56:57

Radiation source is placed on/ inside the body.

Advantage : minimal /no exposure to normal body tissues.

Active space



### Interstitial brachytherapy :

Radiation source is placed within the tumour tissue itself.

Used in prostate cancer.

Challenges in radiotherapy of prostate cancer :

Prostate gland is located deep within the pelvis.

Urinary bladder & rectum : In close proximity & highly radiosensitive.

First step : Under imaging guidance, **empty shells** are placed manually in prostate gland one by one.

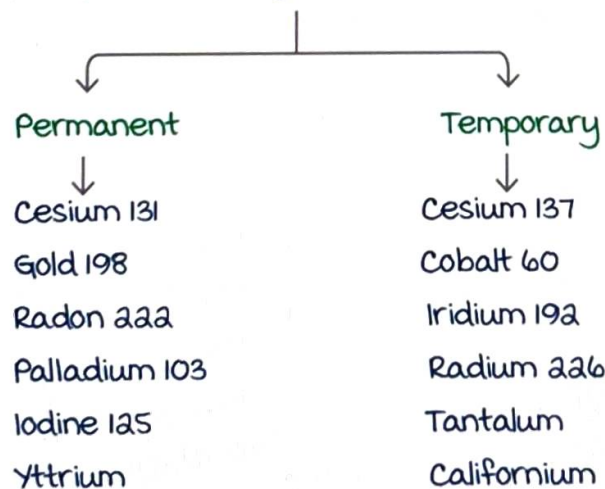
Second step :

**Remote after loading** : Computerised robotic automated equipment using which **radiation beads/sources** are implanted into the empty shells/ target organ in an automated manner.

These radiation beads then start emitting radiation and hence the prostate is irradiated from within the gland.

**Advantage** : Radiation emitted from the beads has very limited penetrating power & hence, normal cells are not affected.

**Isotopes** used may be



Short half-life : **Permanent implants** as they disintegrate in a short time.

Long half-life : **Temporary implants** that are retracted after sometime as there is risk of prolonged radiation exposure..

High density brachytherapy :

Type of temporary interstitial brachytherapy.

Used for CA Prostate/ CA Breast.

## Intracavitary & Mold Brachytherapy

01:03:01

Intracavitary Brachytherapy : Radiation source is placed in a naturally occurring body cavity.

Eg., In cervical cancer, teletherapy cannot be used as the cervix has the bladder anteriorly and rectum posteriorly.

Radiation exposure can lead to vesico - vaginal/ recto - vaginal fistulas.

A radioactive bead is placed in cervical canal using an applicator.



Irradiates the tumor from inside but has poor penetrating power.

Surrounding organs are not exposed.

mould Brachytherapy :

Superficial tumors: Penile cancer, cancer at nail bed/ finger.

A mould/cap of radioactive material is placed directly on the tumor. minimal exposure to normal tissues.

Interstitial brachytherapy

Intra cavitary brachytherapy

mould brachytherapy

Biggest advantage :  
minimal/ no  
exposure to normal  
body tissues.

## Systemic Radiotherapy

01:05:56

Radioactive material through IV : Localises only to the target organ.

Eg :  $I^{131}$  : Papillary Thyroid Ca.

$P^{32}$  : Polycythaemia Rubra Vera.

Samarium 152 / Strontium 89 in painful bone metastasis.



MCQ :

Q. True about Alpha particle ?

- A. Similar to Helium atom.
- B. Has high penetrating power.
- C. Can be stopped by a thin paper.
- D. Similar to neutrons.
- E. Similar to protons.

Q. Which of the following rays are used in teletherapy ?

- A. Gamma rays.
- B. X rays.
- C. Alpha.
- D. Protons.
- E. Electron beam.

Q. Particulate radiation is/ are ?

- A. Photon.
- B. Proton.
- C. X ray.
- D. Electron. [kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)

E. Negative pi mesons.

Photons & x rays are forms of energy.

Q. Features of high density brachytherapy are all except?

- A. Source of radiation placed inside the body for a short time.
- B. Indicated for prostate and breast cancer.
- C. Healthy tissue nearby gets a small dose of radiation.
- D. Radioactive seeds are permanently placed inside or near the tumor.
- E. IMRT : Delivers precise dose to a malignant tumor or specific areas within the tumor.

## RADIOTHERAPY : PART - 2

### Specialised applications of radiotherapy

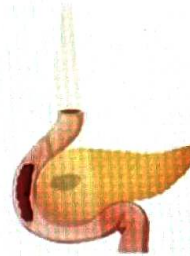
00:00:15

60c6b3eaaa8ded0e4e7e5ea7

Intra-operative radiotherapy :

Radiotherapy is administered during the surgery.

For example, in pancreatic CA surgery, the excision of the tumor is followed by irradiation of the tumor bed by the help of an **electron beam**.



Used in :

- Pancreatic cancer
- Gastric cancer.
- Colorectal cancer.
- Head and neck cancer.

The most commonly used radiation component :

- Electron beam (stationary megavoltage electron beam).
- X-rays (occasionally used).

This is followed up in the post-operative period by teletherapy.

### Stereotactic/image guided radiotherapy

00:01:30

Stereotactic means **accurate localisation**.

most common application of this is in the treatment of **brain tumors**.

For example, for a tumor which is located deep within the parenchyma of the brain which is to be treated with radiotherapy (total calculated dose = 100 units).

If the tumor is irradiated using a single beam of 100 units, there is a risk of



Active space



injury to the normal brain tissue that lies proximal and distal to the tumor along the path of the radiation beam.

This leads to the death of normal neurons and causing permanent neurological deficits.

Therefore, radiotherapy to the brain tumor cannot be administered using a single high intensity beam.

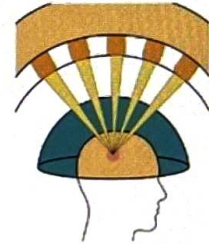
Stereotactic radiotherapy for treating brain tumors :

1. Prior to radiotherapy, 3D CT/MRI is done for the accurate localization of the tumor along the x, y and z axis.

2. Specific frames called **Leksell frames** are used to achieve perfect immobilization of the head (to fix the reference points).

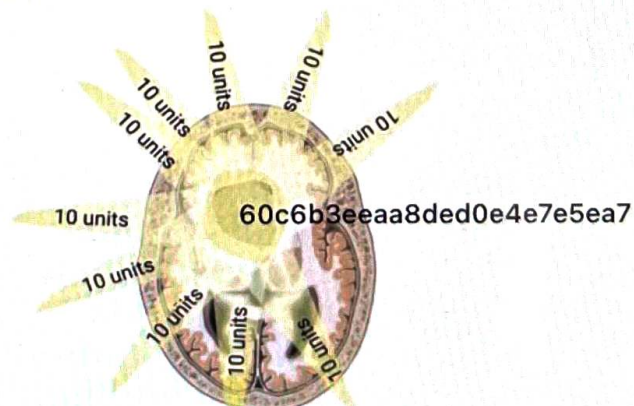


3. Specialized radiation focussing helmets, have multiple apertures which help focus/converge multiple radiation beams on to the tumor.



4. Using localisation information, stereotactic radiotherapy strategy is planned in such way that instead of using a single beam of 100 units, multiple beams from multiple directions are used to focus all of them on to the tumor.

5. This is achieved by targeted delivery of a large dose (100 units) to the tumor, where there is exposure of the surrounding normal brain parenchyma to a relatively smaller doses.



In stereotactic radiotherapy, no permanent damage to the normal brain tissue. Hence no permanent neurodeficits occur. Patient gets a distinct survival advantage.

**Mr. Lars Leksell** : Inventor of stereotactic radiotherapy.

Terms :

**Stereotactic radiotherapy** : Fractionation strategy is used to administer radiation.

**Stereotactic radiosurgery** : A single large dose is administered in one session.

Applications :

- Solitary brain tumors/metastasis.
- Arterio-ventricular malformations.
- Trigeminal neuralgia.
- Acoustic schwannoma.
- Pituitary adenoma.

**Gamma knife radiosurgery** :

Similar to stereotactic radiosurgery.

Used for **brain tumors**.

Uses **Co-60** producing high intensity gamma rays.

**Cyber knife radiosurgery** :

Used elsewhere in the body (**other than brain tumors**).

Uses **LINACS (X-rays)**.

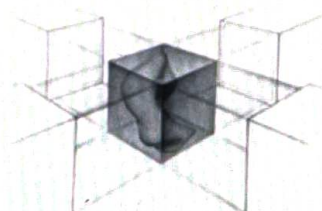
kumarankitindia1@gmail.com

### 3D Conformal radiotherapy

00:08:46

A tumor does not have a rigid shape, instead it has an irregular shape.

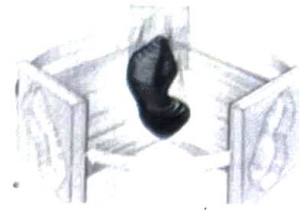
Thus administration of a rigid shaped beam may result in excessive exposure to the normal surrounding tissues.



Active space



**Multileaf collimators** are used to modify the size and shape of the radiation beam to exactly match it to the **tumor configuration** (so exposure to the normal surrounding tissues is minimized).



## Intensity modulated radiotherapy/IMRT

00:09:48

most important application is in the treatment of **prostate cancer**.

It cannot be used in tumors that move with respiration like lung cancers.

Form of **high precision** radiotherapy which can deliver extremely controlled doses to the malignant tumors.

For example, in the treatment of CA prostate :

multiple beams are directed from different directions, each beam is further divided into smaller beamlets.

Smaller beamlets are of varying intensity/strength (depending on the tumor size and shape).

The best combination of beamlets intensity is modulated by a computer software.

Thus a very precise dose delivery is achieved, avoiding exposure to the adjacent normal tissues .

Applications of IMRT :

- Prostrate cancer.
- Head and neck cancers (close to many vital structures).

Disadvantages :

- **Time consuming** due to planning and delivery.
- If the **tumor moves during respiration** there is failure of accurate delivery and hence it **cannot be used in lung cancer**.



## Boron neutron capture therapy/BNCT

00:12:10

used specifically for **brain tumors**.

A **boron compound** (Boronphenylalanine/BPA) is given intravenously, which is selectively taken up by brain cancer cells.

Patient is then irradiated with a **neutron beam**.

This boron compound when exposed to a neutron beam disintegrates into lithium (**stable**) and emits **alpha particles** and thus irradiating the tumor cell from within.

60c6b3eeaa8ded0e4e7e5ea7

Because alpha particles have minimum penetrating power, surrounding normal neurons are not exposed.

## Volumetric modulated arc therapy/VMAT

00:13:25

It is an advanced type of IMRT.

A **single radiation source rotates around the tumour** with real time rapid dynamic intensity modulation of the radiation beam (based on the tumor size and shape).

**Precise dose delivery** to the tumor is thus made possible .

## Stereotactic ablative radiotherapy/SABRT

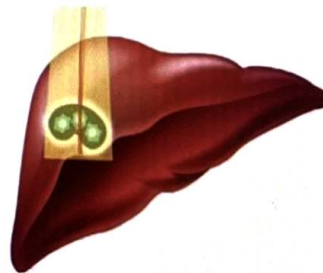
00:14:35

High intensity focussed radiation beam is administered to a tumor in a very short time.

The tumor is thus **ablated entirely**.

This can achieve a longer disease free & symptom free intervals.

used when surgery is not feasible.



Surface guided radiotherapy :

Permanent radiotherapy tattoos are made to act as skin markers to irradiate the tumor.

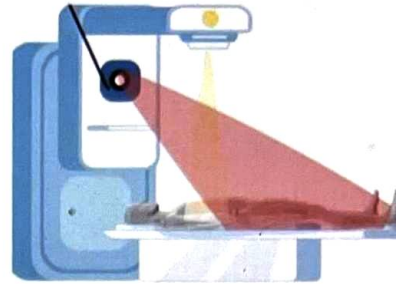
This can be avoided by SGRT.



Active space



It uses a sophisticated **3D camera technology** to accurately target the treatment radiation beam.



Done by continuously and accurately scanning the patient's position using the patient's body surface as the reference.

### Cranio-spinal irradiation

00:17:20

Therapeutic measure :

used in **already diagnosed spinal spread of tumors** like in **medulloblastoma** (cake icing-like droppings along the spinal canal : Zuckerguss)/**glioblastoma multiforme (GBM)** deposits.

Prophylactic strategy (for aggressive tumors) :

- medulloblastoma.
- Glioblastoma multiforme.
- Germinoma.
- Acute lymphoblastic leukemia (ALL).
- Small cell lung carcinoma.
- Non Hodgkin's lymphoma (NHL).

### Emergency radiotherapy

00:18:37

used in emergency situations like :

- SVC encasement/compression.
- Acute metastatic spinal cord compression.
- Pericardial tamponade.
- Severe hypercalcemia. kumarankitindia1@gmail.com
- Tumor lysis syndrome.
- Brain metastasis causing raised intracranial tension.

### Bragg's peak

00:19:59

Bragg's peak is seen in case of heavy charged particles like  **$\alpha$  particles/protons**.

The **radiation dose** which is deposited in the body tissue is

inversely proportional to the velocity of radiation.

The velocity of the radiation is maximum when it enters the body (dose deposited is less).

As the radiation goes deeper into the tissues, its velocity decreases (dose deposited increases).

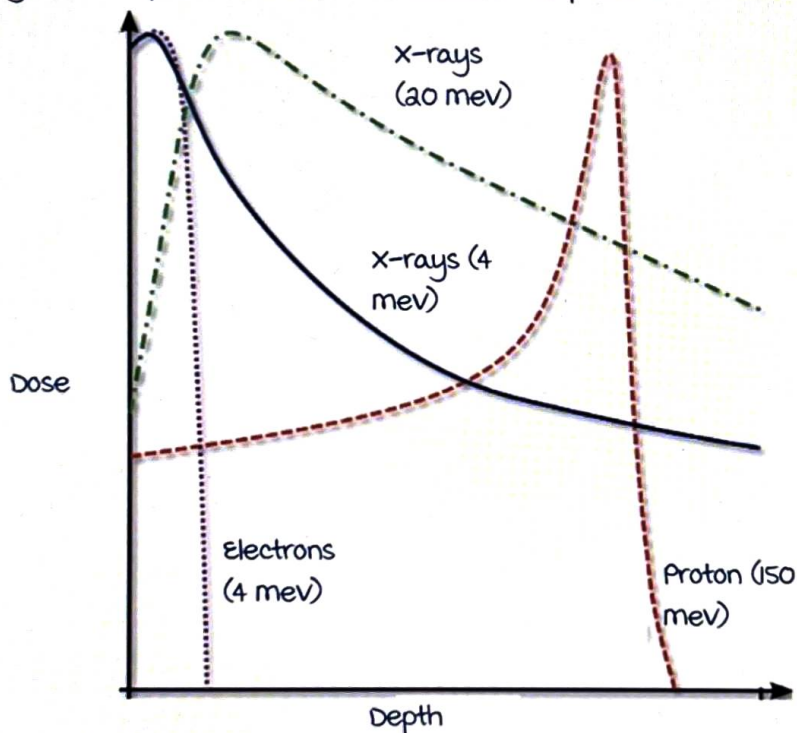
As the depth from the skin surface increases, the velocity of the radiation gradually falls down and the dose deposited gradually increases.

A point where **velocity is minimum**, the dose deposited is maximum (**Bragg's peak**).

60c6b3eeaa8ded0e4e7e5ea7

This is used clinically for the precise and maximum dose delivery at the site of the tumor.

Beyond the peak there is no radiation exposure.



About Bragg peak effect, all are true except ?

- Precise dose delivery possible.
- Dose at one point is more than 4 times at previous point.
- Applies to electromagnetic radiation.
- may be used for intracranial AVMS.

### Chemical modifiers

0:24:29

Agents which are used in conjunction with the radiotherapy to either help in :



- The enhancement of the radiotherapy on the cancer cells (**radiosensitizers**) or
- To protect the normal tissues from the effects of radiotherapy (**radioprotectors**).

**Radiosensitizers** : Any chemical that causes fixation/ prolongation of the life of free radicals (damage to the cells).

**Hypoxic cell sensitizers** : They enhance the tissue response by mimicking the effect of oxygen.

- Nitroimidazoles : **metronidazole, misonidazole.**
- **Hyperbaric oxygen** therapy.
- **Anticancerous drugs** like Cisplatin, Actinomycin D, 5-Fluorouracil, Hydroxyurea, Bleomycin.

**Non hypoxic cell sensitizers** : mechanism is not known.

**Halogenated pyrimidines** : **BuDR/IuDR.**

**Radioprotectors** : They scavenge/inhibit the free radicals.

- Thiophosphate compounds with sulphhydryl groups like <sup>60c6b3eeaa8ded0e4e7e5ea7</sup> Cystine/Cysteinamine.
- Amifostine.
- Granulocyte-monocyte Colony stimulating factor I (GM-CSF I).
- Zinc oxide.
- melatonin.
- Pentoxifylline.
- Chlorhexidine (to prevent stomatitis).
- Potassium iodide (to protect thyroid from radioactive iodine).

**Highly radiosensitive tumors (mnemonic : WELMS) :**

- **W**ilm's tumor.
- **E**wing's.
- **L**ymphoma.
- **M**ultiple myeloma.
- **S**eminoma/dysgerminoma.



Highly radioresistant tumors (mnemonic : Hot PROM) :

- HCC.
- Pancreatic cancer.
- RCC.
- Osteosarcoma.
- melanoma.

most radiosensitive phase of cell cycle : G<sub>2</sub>M junction/  
M phase.

most radioresistant phase of cell cycle : S phase.

MC radiation component used in RT : X-rays.

MC component used in intra-operative RT : Electron beam.

MC output from LINAC machines : High energy X-rays.

most radiosensitive tissue : Bone marrow/gonads.

Least radiosensitive tissue : CNS.

most radiosensitive blood cell : Lymphocyte.

Least radiosensitive blood cell : Platelet.

most radioresistant organ : Vagina.

1<sup>st</sup> Radio-isotope used in radiotherapy : Radium 226.

MC radio-isotope used in EBRT/teletherapy : Co-60 (half life  
of 5.2 years).

kumarankitindia1@gmail.com

MC application of IMRT : CA prostate.

Highest ionizing power : Alpha (least penetrating power).

Least ionizing power : Gamma (maximum penetrating power).

MC mechanism of cell death in RT : ds DNA breaks (1<sup>st</sup> step of  
tissue damage is ionization → leading to ds DNA breaks).

MC side effect of radiotherapy : Skin erythema.

MC thyroid cancer that develops after head and neck  
irradiation : Papillary thyroid cancer.



MC thyroid cancer that develops in a case of long standing  
goiter irradiation : Follicular thyroid cancer.



# OBSTETRICS AND GYNAECOLOGY IMAGING

## Clinical questions

00:00:08

Questions	Imaging
<p>Q. A patient was being investigated for <b>recurrent miscarriage</b>. Can you identify this investigation done in this patient? (NEET PG 2021 pattern).</p> <p>A. Saline infusion sonosalpingography.            B. <b>Hysterosalpingography</b>            C. CT Salpingography.            D. MR salpingography.</p>	
<p>Q. A 32 year old patient come for antenatal USG with positive UPT. This <b>double bleb sign</b> seen in early pregnancy is due to?            (INI-CET Nov 2021 pattern).</p> <p>A. Heterotopic pregnancy.            B. <b>The amnion and yolk sac.</b>            C. Two uterine gestational sacs            D. Amnion &amp; chorion.</p>	

Q. A 32 year old female with **repeated history of first trimester miscarriage**, underwent HSG, look at the image and identify the diagnosis?

(NEET 2018 pattern/FMGE Aug 2020 pattern).

- A. Septate uterus.
- B. **Unicornuate uterus.**
- C. Bicornuate uterus.
- D. Arcuate uterus.



Mullerian duct anomalies :

Various techniques used :

3D ultrasonography (USG).

MRI.

Laparoscopy along with hysteroscopy.

Investigation of choice : **MRI ≥ 3D USG** (but vice versa in

Obs-Syn-textbooks)

**Gold standard : Laparoscopy + Hysteroscopy.**

Best time to do hysterosalpingography :

Between **6<sup>th</sup> - 10<sup>th</sup> day** of menstrual cycle.

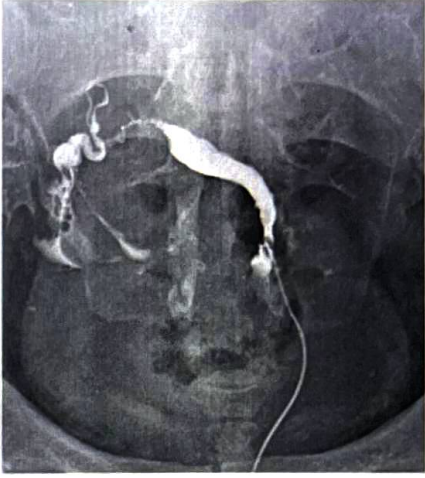

This method involves cannulation of the cervix. So, better avoided during menstruation and after 10<sup>th</sup> day, in case the patient has short cycles and conception has occurred between 11<sup>th</sup> - 14<sup>th</sup> day.

The contrast will damage the conceptus.



## Hysterosalpingography spotters

00:06:49

Condition	Imaging
<p>Unicornuate uterus :</p> <p>Shape of uterus : Deviated to one side and only one uterine horn &amp; fallopian tube seen with free peritoneal spill of contrast on that side.</p>	
<p>Bicornuate uterus :</p> <p>Two widely separate uterine horns.</p>	

kumarankitindia1@gmail.com

Active space

Arcuate uterus :

Normal variant.

The upper fundus of the uterus is concave facing upwards.

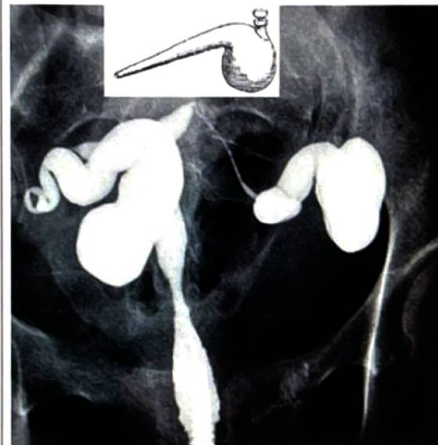
Normally, the fundus of the uterus is convex upwards.



Hydrosalpinx :

Retort shaped fallopian tubes.

Fallopian tubes filled with fluid/contrast due to block.



Tubal block :

Normal shaped uterus but contrast present only on one side fallopian tube.

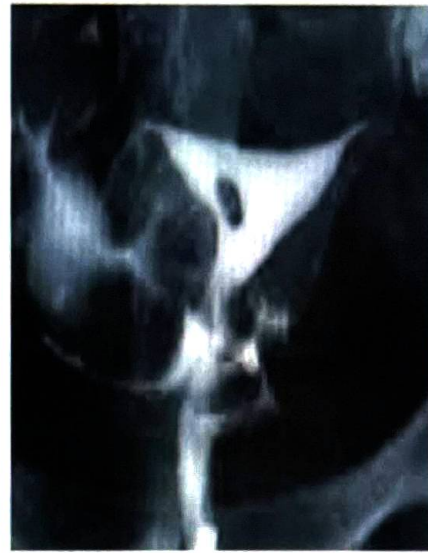
Occluded fallopian tube in cornual region.





uterine **synechia/**  
**adhesion :**

Filling defect due to  
adhesion within the uterus  
between the anterior and  
posterior endometrial lining.  
60c6b3eeaa8ded0e4e7e5ea7



Obstetrics Imaging :

### Best parameters for dating on USG

00:11:24

Trimester	Best parameter.
1 <sup>st</sup> (up to 13 weeks + 6 days)	CRL (Crown Rump Length in millimeters)
2 <sup>nd</sup>	BPD (Biparietal Diameter) or HC (Head Circumference)
3 <sup>rd</sup>	FL (Femur Length)

Dating Parameters :

Overall best	Parameters
Overall best time for dating	1 <sup>st</sup> trimester
Overall best parameter for dating throughout pregnancy	CRL (Crown Rump Length)
Overall best parameter for fetal weight. (To assess IUGR, macrosomia)	Abdominal circumference

Active space

## Antenatal scans :

Question	When?
Check scan	4 - 6 weeks
Dating/Viability scan	6 - 8 weeks (as embryo is seen & CRL can be measured).
NT scan (Nuchal Translucency)	11 weeks 0 days - 13 weeks + 6 days/ only when CRL : 45 - 84 mm
Anomaly scan/ TIFFA (Targeted Imaging For Fetal Anomaly)	18 - 20 weeks
Fetal echocardiography scan	22 - 24 weeks
Interval growth scan ± doppler	28 - 32 weeks & 37 weeks



## Quiz :

Question	Answer
<p>Q. Arrange the following scans in their correct sequence during pregnancy. (AIIMS may 2019 - sequential arrangement type)</p> <p>A. NT scan</p> <p>B. Structural anomaly scan</p> <p>C. Dating scan</p> <p>D. Fetal echocardiography</p>	<p>Answer : C → A → B → D.</p> <p>Dating scan.</p> <p>NT scan.</p> <p>Structural anomaly scan.</p> <p>Fetal echocardiography.</p>



## Early Pregnancy signs

00:17:28

Duration of pregnancy	Radiological signs
<p>Around 4-5 weeks :</p> <p>Thickened (&gt;10mm) echogenic endometrium seen.</p> <p>Focal echogenic zone seen at the site of implantation : Nonspecific.</p> <p>Corpus luteum also seen.</p>	
<p>Around 4 - 5 weeks :</p> <p>Intra decidual sac sign : Gestational sac.</p> <p>The slightly bright rim/wall of the echogenic sac is called <b>Chorionic rim</b>.</p> <p>On Transvaginal USG (TVS) at 4 weeks 0 days - 4 weeks 3 days.</p> <p>On Transabdominal USG (TAS) at 5 weeks.</p>	

Active space

4 - 5 weeks :

**Double decidual sac sign :**

Two echogenic rims around the gestational sac.

Inner rim : Decidua capsularis + Chorion leave.

Outer rim : Decidua parietalis.

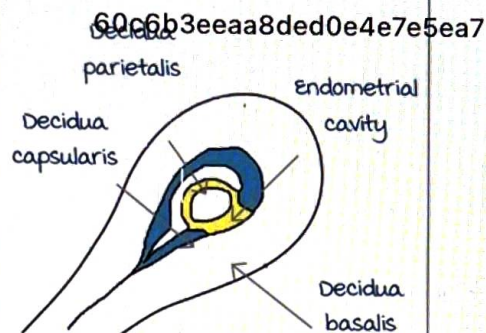
One of the most **definitive signs** of intra uterine pregnancy.

Helps **distinguish between** intra uterine & an ectopic pregnancy.

Since ectopic pregnancy can develop an intra uterine pseudo gestational sac.

**Pseudo gestational sac :**

Fluid collection in the uterus due to increased HCG that can be misinterpreted as intrauterine gestational sac.





5 - 6 weeks :

Yolk sac : 1<sup>st</sup> structure seen inside gestational sac.  
Thin walled cystic structure.

TVS : 5w 0d  
TAS : 5w 5d.

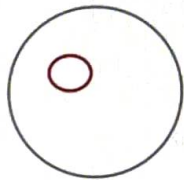
Yolk sac : Amnionicity of the pregnancy.

Gestational sac : Chorionicity of pregnancy.

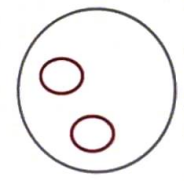
Single yolk sac : monoamniotic pregnancy.  
2 yolk sacs : Diamniotic monochorionic twin gestation.



Gestational sac with yolk sac.



Single gestation : Gestational sac with 1 yolk sac



monoamniotic diamniotic gestation : Gestational sac with 2 yolk sacs

5 - 6 weeks :

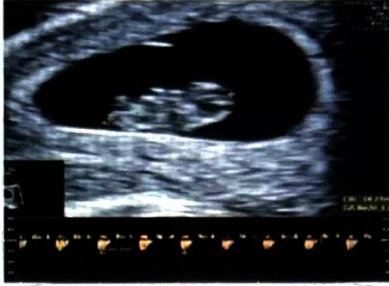
Double bleb sign : Amnion + Yolk sac.

The tiny structure at the junction of the 2 sacs could be the fetal pole/embryo.




kumarankitindia1@gmail.com

Active space

<p>6 weeks :</p> <p>Embryo seen clearly.</p> <p>Crown Rump Length (CRL) can be measured.</p> <p>Cardiac activity can be measured.</p> <p>Fetal Heart Rate must always be <math>&gt; 100/\text{min}</math> when embryo size is 5 - 7 mm.</p>	 <p>Fetal Pole with cardiac activity.</p>
---	---

### Nuchal Translucency scan

00:25:18

Duration	Imaging
<p>NT Scan :</p> <p>At CRL : 45 - 84 mm.</p> <p>At 11 w 0d - 13 w 6d.</p> <p>NT : The thickness behind the nape of the baby.</p> <p>Screening test for aneuploidies like Down's Syndrome, Trisomy 13 &amp; 18 :</p> <p>NT increased.</p> <p>kumarankitindia1@gmail.com</p>	

Active space



Summary of early pregnancy signs :

Feature	Duration	
	TVS	TAS
Visualization of gestational sac	4w0d - 4w3d	5w0d
Visualization of yolk sac	5 weeks	5.5 weeks
Visualization of cardiac activity	5 - 6 weeks	6 weeks.

Signs of early pregnancy failure :

Features	
mean sac diameter (MSD)	16 - 25 mm : No yolk sac/embryo seen indicates failure of pregnancy.
CRL	5 - 7 mm : Embryo seen but with no cardiac activity. Pregnancy failed.

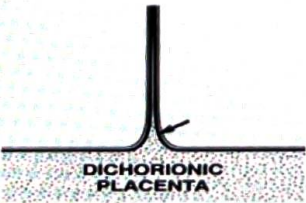

Question.	Answer.
<p>Q. Best time to detect Chorionicity &amp; Amnionicity of pregnancy is? (NEET 2018 pattern)</p> <p>A. First trimester            B. Second trimester            C. Third trimester            D. Peripartum</p>	<p>Answer : A.            No. of sac : Chorionicity.            No. of yolk sac : Amnionicity</p>

<p>Q. 1<sup>st</sup> Trimester USG is /are used for? (PGI Nov 2019 pattern)</p> <p>A. Confirmation of pregnancy. B. Gestational age. C. Screening of aneuploidy. D. Diagnosis of placenta previa. E. To check for fetal presentation.</p>	<p>Answer: A, B, C.</p> <p>Diagnosis of placenta (can be seen only after 15 weeks) &amp; to check for fetal presentation (remains variable for up to 32 - 34 weeks)</p>
---	---

60c6b3eaa8ded0e4e7e5ea7

**Obstetric imaging spotters : Twin pregnancy**

00:30:07

Twin Pregnancy	Imaging
<p>Lambda Sign/twin peak sign :</p> <p>Placenta extends between the sacs and forms a lambda appearance.</p> <p>Indicates dichorionic twin pregnancy.</p> 	

Active space



**T Sign :**

membranes insert into the chorionic villi at right angles without extension of the placenta between membranes.

Indicates **monochorionic twin** pregnancy.



### Obstetric Imaging spotters : Anomalies.

kumarankitindia1@gmail.com

Anomaly	Imaging
<p><b>Anencephaly :</b></p> <p>Absence of brain &amp; head.</p> <p>Earliest anomaly to be diagnosed with USG at 10 - 11 weeks.</p> <p>Has <b>Frog's eye appearance/mickey mouse sign.</b></p> <p>Cranial neural tube defect.</p>	

## Arnold Chiari malformation type 2:

Lemon sign:

Cranium compressed in the frontal area: Lemon shaped head.

Dilated ventricles:

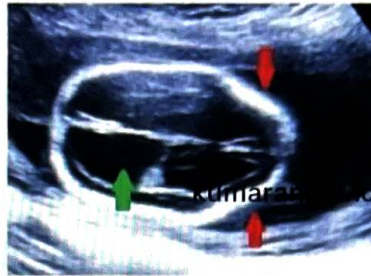
Hydrocephalus.

Banana appearance:

Small posterior fossa with cerebellum wrapped around the brain stem.

Indicates a neural tube defect along the sacrum.

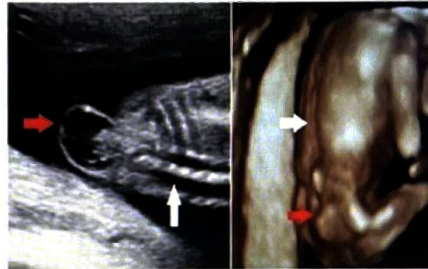
Lumbar meningocele.



Lemon sign




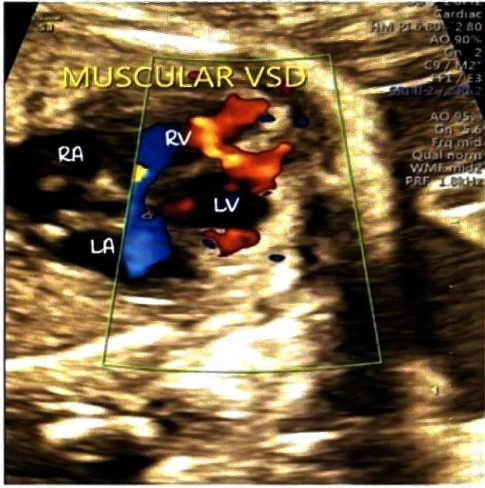

Banana appearance




Neural tube defect: meningocele



## Obstetric imaging spotters : Heart defects

Defect	Imaging
<p>muscular ventricular septal defect (VSD) :</p> <p>Blood flows through the interventricular septum.</p> <p>MC location of VSD : membranous/peri membranous VSD.</p>	<p>VSD :</p>  
<p>Hypoplastic left heart syndrome :</p> <p>The left side of the heart is not developed.</p> <p>Has very poor outcome.</p>	

## Obstetric imaging spotter : Abdominal defects.

Defect	Imaging.
<p>Duodenal atresia :</p> <p>Double bubble sign :</p> <p>Stomach &amp; duodenum in antenatal USG.</p> <p>Neonate presents with bilious vomiting immediately after feeding (birth) with double bubble sign in USG : Duodenal atresia.</p>	

kumarankitindia1@gmail.com

Active space



## BREAST IMAGING

mammography has significantly reduced the mortality due to breast cancer by early detection especially in patients with BRCA mutation, 1st degree relative with CA breast.

### Mammography

00:03:42

Breast tissue contains fat and fibroglandular tissue.

Simple X ray cannot distinguish between both, since both tissues have similar radiographic density.

To differentiate between these tissue components :

Increase the contrast of the image by decreasing kVp or increasing mAs (mAs  $\propto$  contrast, kVp  $1/\propto$  contrast).

1. Decreasing kVp (20 - 30 kVp)
  - will increase contrast.
  - Decreases penetration.
2. Increase spatial resolution : To detect microcalcifications. Tiny focal spots (target area on anode) of  $\leq 1$  mm are used.
3. Decrease geometric distortion (tissue variability) : Compress breasts between compression paddles to attain uniformity.



Factuals about mammography :

- uses characteristic spectrum radiation (low kVp).  
Less common method of X ray production.
- Anode : **molybdenum** (X ray : Tungsten rhenium alloy).
- Filter : molybdenum Rhodium combination  
(X ray : Beryllium).

- mammographic screening leads to 15 - 20 % reduction in breast cancer mortality.
- Radiation exposure is very small (3.7 - 4.7 mGy).  
Adverse effects of radiation are not seen.

Breast imaging for breast cancer :

IOC for screening : mammography.

Overall best imaging/IOC : Dynamic contrast enhanced MRI.

## American society of breast surgeons recommendations for breast cancer

### screening - 2019

00:11:58

1. Formal clinical risk assessment at 25 years.
2. Women with higher than average risk :
  - Hereditary susceptibility from pathogenic mutation carrier status (BRCA 1/2 mutation).
  - Prior chest wall irradiation in age 10-30 years  
Screen from 25 years with annual MRI study since mammography cannot penetrate dense breast tissue. After 30 years, switch to mammography since the breast tissue density decreases.
  - Predicted lifetime risk >20% by any model.
  - Strong family history : First degree relative with a history of carcinoma breast (annual mammography from 35 years onwards).
3. Women with average risk :
  - Non dense breasts : mammography at 40 years.
  - Increased breast density : USG + MRI.

Status	Age	Investigation Of Choice
Women with mutation carrier status/prior chest wall irradiation at 10-30 years of age	25 years	Annual MRI
	30 years	mammography
Women with strong family history/predicted lifetime risk >20 %	35 years	mammography
Women with average risk	40 years	mammography. Supplement with USG + MRI if the breast tissue is dense.

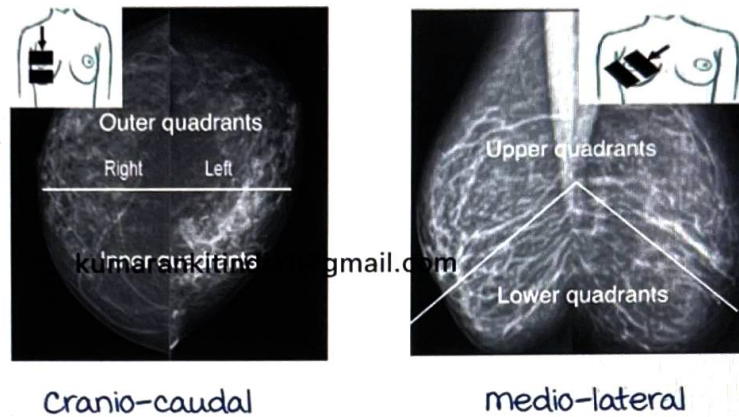
Active space



## Mammography views

00:17:35

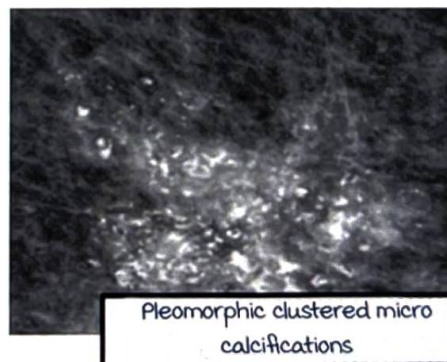
- Cranio-caudal view :  
Breast tissue is compressed in between compression paddles. X ray beam travels from cranium to caudal region (vertically down).
- medio-lateral oblique view : X ray beam travels from superomedial to inferolateral region.



- medio-lateral is identified by presence of **pectoralis major**.  
**Nipple line** drawn from tip of pectoralis major muscle to nipples divides the view into 2 quadrants :  
 Above nipple line : Upper quadrant.  
 Below nipple line : Lower quadrant.

Benign vs malignant lesions :

- Based on mammography calcifications :  
micro calcifications : **malignancy** (Pleomorphic = variable)



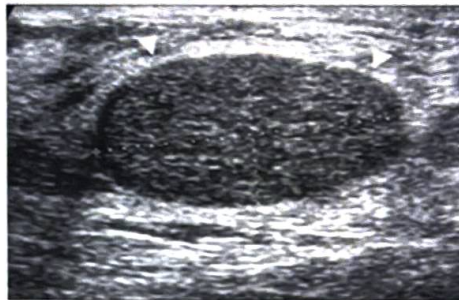
macro calcifications : **Benign.**



Popcorn calcification : Fibroadenoma.

Based on shape & margin of a lesion :

- Benign : Oval shape. Eg : fibroadenoma.



Oval shape (wider than taller) with smooth well defined margins

- malignant : Irregular.  
multiple lobulations and spiculations can be seen.



60c6b3e9aa8ded0e4e7e5ea7

Irregular shape (taller than wider) with irregular margins.

	Breast lesion	
	Benign	malignant
Shape	Oval	Irregular
margins	Smooth	Irregular
Spiculations/ lobulations	Absent	Present
Calcifications	macrocalcification	microcalcification



Architectural distortion (invasion)	Absent	Present
Echogenic halo	Absent	Present

**BI-RADS**

00:25:25

Breast Imaging Reporting and Data System : 7 categories.

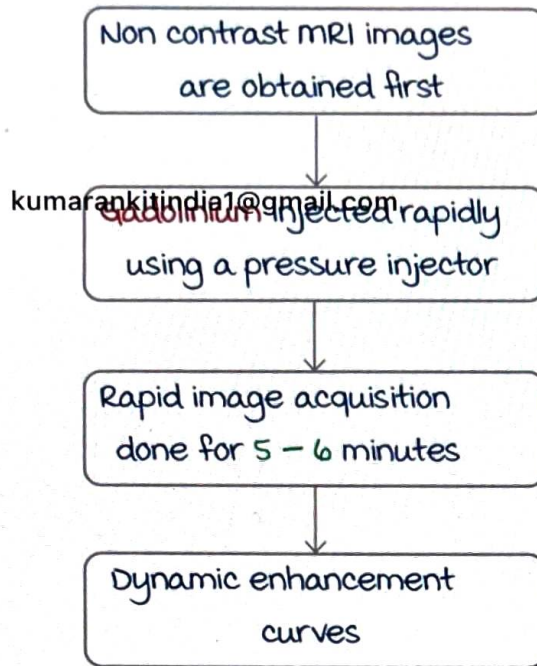
Category		management	Likelihood of cancer (%)
0	Incomplete evaluation	Complete evaluation with USG/MRI/previous reports	-
1	Negative	Normal routine screening	No/ 0%
2	Benign (classic fibroadenoma)	Continue with routine screening	No/ 0%
3	Probably benign	Short interval follow up (every 6 months)	<2%
4	Suspicious : 3 types 4a, 4b, 4c	FNAC/biopsy (tissue level diagnosis)	4a : 2-10%
			4b : 10-50%
			4c : 50-95%
5	Highly suggestive of malignancy	FNAC/biopsy	>95%
6	Biopsy proven malignancy	Surgical intervention	100%

Depending on atypical features, 4 is subclassified to 4a,4b,4c.

Q : BIRADS guidelines can be applied to which of the following modality ?

- A. mammography.
- B. USG.
- C. MRI.
- D. All of the above.

## Dynamic contrast enhanced breast MRI :



## Types of dynamic MRI enhancement curves :

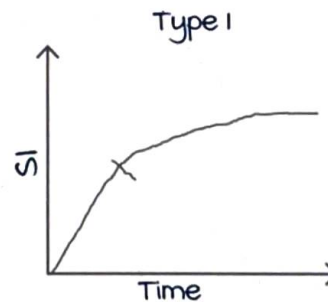
X axis : Signal intensity.

Y axis : Time.

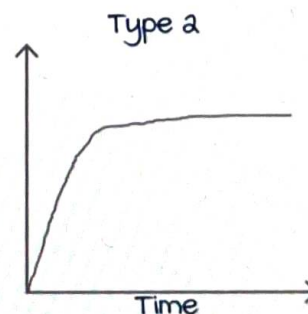
0 - 2 minutes : Region of initial upslope.

Beyond 2 minutes : Delayed uptake.

- Type 1 curve :  
Upslope : **slow**.  
Delayed : Continues to rise.  
Suggestive of **benign breast lesions**.

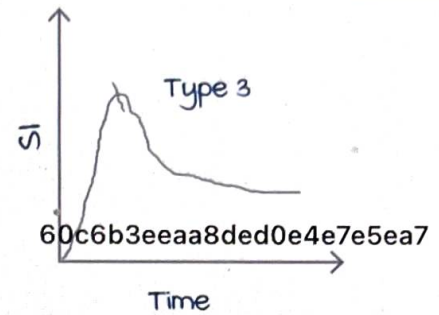


- Type 2 curve :  
Upslope : **Rapid**.  
Delayed : Plateau.  
Results are **indeterminate**.





- Type 3 curve :  
Upslope : **Rapid**.  
Delayed : **Decline**.  
Suggestive of **malignant**  
breast lesions.



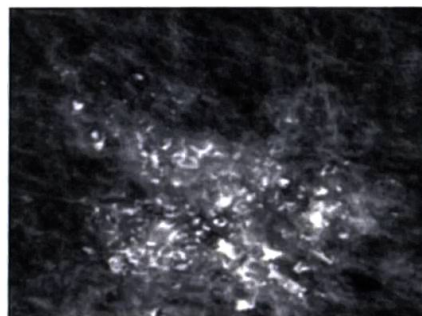
## Mammography spotters

00:35:08

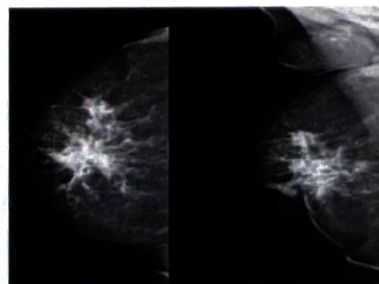
1. Breast-within-breast appearance :  
Seen in **hamartoma/fibroadenolipoma**.



2. Pleomorphic clustered microcalcifications :  
Seen in **ductal carcinoma in situ (malignancy)**.



3. Spiculations : High density spiculated lesion with  
pleomorphic calcification.  
Suggestive of **carcinoma**.  
**multiple spicules** extending into breast tissue.



#### 4. Intra capsular breast implant rupture :

The membranes of ruptured implants have shrunk and fallen down onto the implant itself, because the capsule of implant is intact.

Well contained rupture.

Likened to an italian pasta : Linguine sign.



Implant rupture on T2 breast MRI

Recent advancement in breast imaging :

Digital breast tomosynthesis :

- Volumetric reconstruction of breast tissue.
- Multiple slice images obtained (not overlapping).
- High sensitivity for small breast lesions.
- Similar radiation exposure.

### Breast elastography

00:40:25

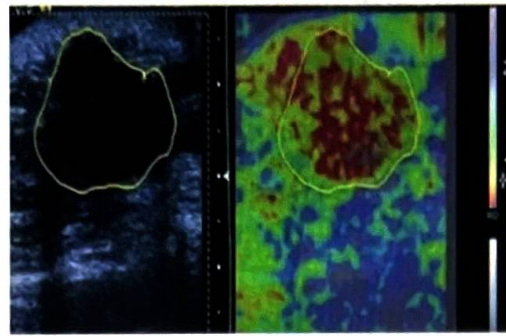
- USG + color map of breast tissue.
- Estimates hardness/elasticity of tissues.
- Elasticity is graded using a color scale.
- Benign (cyst) lesion : more elastic as it can be compressed.
- malignant : Less elastic (hard/scirrhous).
- Can be used in breast/liver/thyroid lesions.
- Strain elastography : Applying physical pressure to the breast using probe to assess the distortion in the breast architecture.

kumarankitindia1@gmail.com

- Shear wave elastography : Pressure applied by emitting certain waves.

Active space





Breast elastography

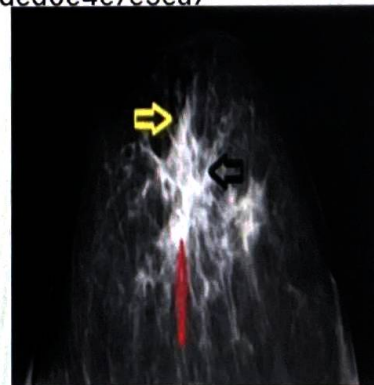
MCQs :

Q : A 32 year old patient comes to OPD for routine breast examination and screening. Her breast examination is normal. However, there is a strong family history of breast cancer with her mother and elder sister both having breast cancer. In view of the recent guidelines, at what age should her screening by mammography begin ?

- A. Immediately at 32 years.
- B. At 35 years.
- C. At 40 years.
- D. At 45 years.

Q : A 55 year old post menopausal woman on hormone replacement therapy presents with heaviness in both breasts. A screening mammogram reveals a high density, spiculated mass lesion with cluster of pleomorphic microcalcifications and ipsilateral enlarged axillary lymph nodes. The mammography image is shown here. This mass most likely represents ?

- 60c6b3eaa8ded0e4e7e5ea7
- A. Cystosarcoma phylloides.
  - B. Lymphoma.
  - C. Fibroadenoma.
  - D. Carcinoma breast.



Q: A lactating woman presents with a painful breast. Which of the following investigation would you do next?

A. X-ray chest.

B. USG breast.

C. mammography.

D. MRI breast. 60c6b3eaa8ded0e4e7e5ea7

Explanation: Stasis of milk while feeding can lead to abscess formation/cyst with milk called galactocele/diffuse mastitis (edematous breast).

All are fluid filled components and USG is the best modality.

Active space



## MSK : ARTHRITIS AND INFECTIONS

Q. A 45 year old male presented with backache since 20 years and difficulty during neck movements. most likely diagnosis based on this cervical spine radiograph is ?



(AIIMS may 2020 pattern)

- A. DISH.
- B. Ankylosing spondylitis.
- C. Cervical spondylosis.
- D. OPLL (Ossified Posterior Longitudinal Ligament)

Answer : A. DISH (Diffuse Idiopathic Skeletal Hyperostosis).

Cervical spine radiograph showing excess bone formation/ skeletal hyperostosis (idiopathic in nature) along the anterior longitudinal ligament. This is called Diffuse idiopathic skeletal hypertrophy (DISH).

Q. A 42 year old male presents with weight loss, intermittent low grade fever and back pain. A lumbar spine MRI was done, after reviewing the findings contrast was injected. Shown here is a postcontrast sagittal image with disc enhancement extending up to the epidural space. The most likely diagnosis here is :

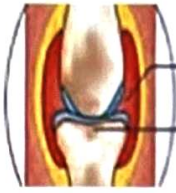
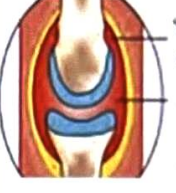




(AIIMS Nov 2018 pattern)

- A. metastases.
- B. Pott's spine.
- C. Ankylosing spondylitis.
- D. Degenerative disc disease.

Joint involvement

00:01:54

Parameters	Degenerative/ osteoarthritis(OA)	Inflammatory joint disease
Image	 <p>Cartilage loss Bony surfaces in contact</p>	 <p>Bone erosion Swollen/inflamed synovium</p>
Age	Elderly	Young-middle aged
Distribution	Assymetric distribution (because there is only focal degeneration of a particular joint)	B/L involvement (because it is a systemic condition and there is diffuse involvement)
Joint space loss	Non-uniform loss of joint space (in knee joint, medial side is affected first, as wear & tear more in medial side)	uniform loss of joint space.
Juxta articular findings	Periarticular sclerosis of the adjacent bone margins (increased density and opacity) This is due to friction between the bones.	Juxta articular osteopenia (due to reactive resorption of bone from increased blood flow)
Bone erosions and periosteal reactions	No	Yes
Loose bodies (osteophytes) and subarticular cysts (geodes)	Yes	No
X ray image		

60e6b3eeaa8ded0e4e7e5ea7

Active space



Q. Which of the following will not be seen in a case of osteoarthritis?

(JIPMER May 2020 pattern).

- A. Loss of cartilage.
- B. Bony outgrowths.
- C. Cyst formation.
- D. Erosions.

Erosion is a feature of inflammation which occurs due to hypervascularity of the synovial tissue.

### Rheumatoid Arthritis/RA

00:09:09

Connective disorder of unknown etiology which affects the synovial joints (usually small joints of hands



Early stage

Advanced stage

kumar.raj@india1@gmail.com

Early stages :

- uniform loss of joint space.
- Juxta articular

Advanced stages :

- Diffuse erosions.
- Deformities.

Features of Rheumatoid arthritis :

- Earliest joint involved : metacarpophalangeal (MCP) joints and proximal interphalangeal (PIP) joints of hand
- **RA factor positive** in 70% cases. So, it is called seropositive arthritis/RA.
- Earliest finding at the wrist joint : erosion of the ulnar styloid process.

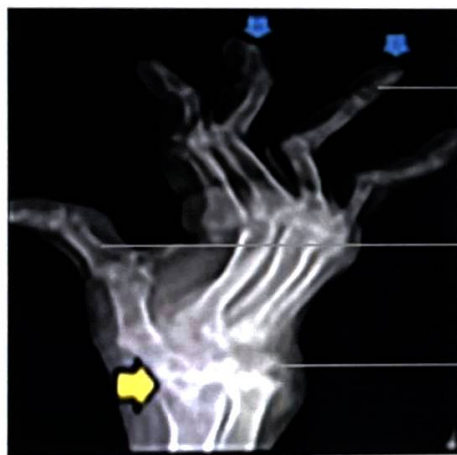
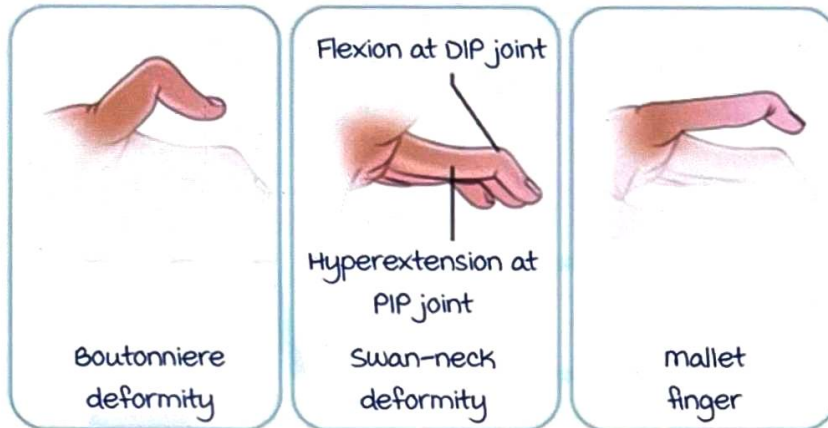
Deformities in RA :

**Boutonniere deformity** : Flexion at PIP and extension at DIP joints.

**Swan neck deformity** : Hyperextension at PIP joints & flexion at DIP.

**mallet finger** : Hyperflexion at DIP joints.

**Hitch hiker's thumb** : Hyperextension at MCP and PIP joints.



→ Swan neck deformity

→ Hitch hiker's thumb

→ multiple erosions at radiocarpal joints

Special features of RA :

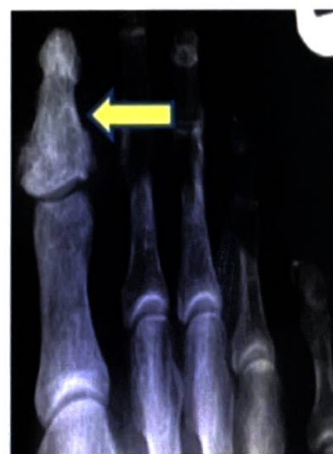
**Arthritis mutilans** : Polyarticular involvement with severe deformities.

**Dot dash appearance** :

Intermittent absence of cortex due to erosions on x ray.

**Ivory phalanx** : Increased density of a particular phalanx.

**Spotty carpal sign** : Extensive erosions involving the carpal bones leading to distortion of anatomy of the carpal bones.



Ivory phalanx

Active space



**Ulnar drift and zig-zag deformity** : Ulnar deviation of phalanges and radial deviation of carpal and metacarpals resulting in zig-zag deformity.

**Lanoi's deformity** : Foot deformity similar to the zig-zag deformity of the hand.

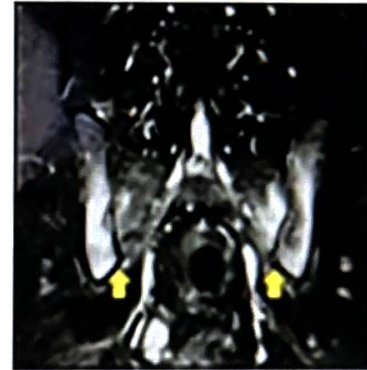
## Ankylosing spondylitis (AS)

00:18:01

Seronegative arthritis : RA factor negative but **HLA B27** positive.

First site of inflammation : Enthesis (point where a ligament or tendon is attached to the bone) : **Enthesitis**.

Tiny osteophyte like lesions and erosions may form.



Hyperintensity of sacro-iliac joint on coronal STIR sequence MRI

Earliest joint involved : **Sacroiliitis**.

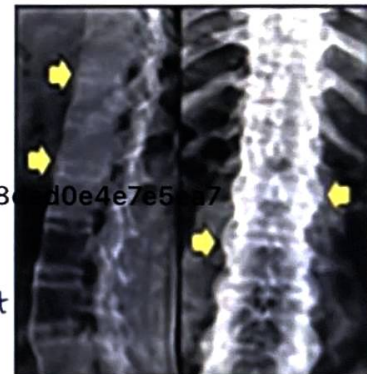
IOC : MRI for early diagnosis of AS.

STIR sequence : Short Tau

Inversion recovery sequence.

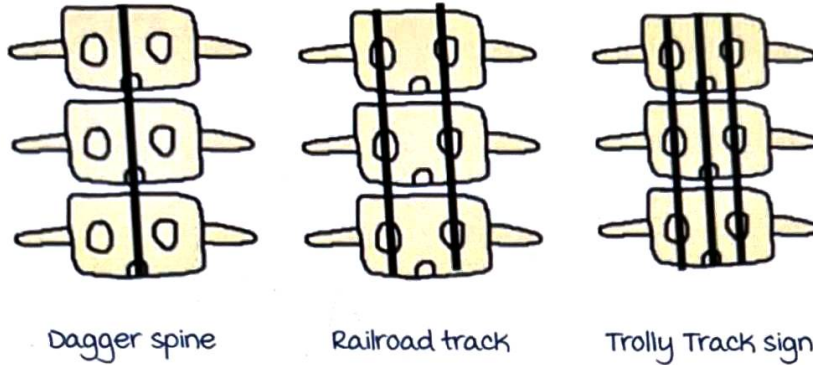
Skeletal appearances in AS :

1. **Shiny corner sign** : Sclerosis of the corners (white) of the vertebral bodies at the site of attachment of anterior collateral ligament due to inflammation.
2. **Romanus lesions** : Erosions of vertebral bodies at anterosuperior margins.
3. **Squaring of vertebrae** : Altered shape (appears as perfect squares) of the vertebral bodies due to erosions.
4. **Bamboo spine/poker's spine** : Fused appearance of the spine due to bridging syndesmophytes.
5. **Carrot stick fractures** : Complete through and through fracture of the weak bamboo spine which does not heal properly.
6. **Anderson's lesions** : Pseudoarthrosis at the fractured site of bamboo spine.



Bamboo/ Poker's spine

- 7. **Dagger sign** : Calcification of the interspinous ligament.
- 8. **Railroad track sign** : Calcification of the B/L paraspinous ligament.
- 9. **Trolley track sign** : Calcification of both interspinous and paraspinous ligaments.



### Psoriatic Arthritis

00:24:14

Seronegative arthritis along with psoriatic skin involvement.

**mouse ear sign** : Erosions along with fluffy periosteal reaction around it.

**Pencil in cup/ cup in saucer/ pestle and mortar/ balancing pagoda sign (spine)** : Due to a narrowed bone going into another bone.



Pencil in cup/Cup in saucer/Pestel and mortar/Balancing pagoda sign

**Sausage digit** : One shortened digit.



mouse ear sign



Sausage digit/opera glass hand deformity

**Opera glass hand** : multiple shortened digits.

Active space



Q. A 40 year old man presented with severe pain & inflammation at 1<sup>st</sup> MTP joint. He has hyperuricemia & eccentric erosions at the site of involvement with preserved joint space. most likely diagnosis ?

- A. OA.
- B. Gout.
- C. Pseudo-Gout.
- D. Rheumatoid arthritis.



Overhanging margin/  
martel's G. sign

Explanation : Destruction of bone at the periphery (eccentric). Bony margin projecting away from the bone is called overhanging/ martel's G. sign.

### Pseudogout/CPPD

00:28:23

CPPD : Calcium Pyrophosphate Deposition Disease.

MC joint involved : Knee.

Specific imaging feature : Chondrocalcinosis (calcification of the menisci).



Chondrocalcinosis

Q. A middle aged woman with history of backache underwent a Schober's test and came as positive. She had hyperpigmented nose and ears. Looking at this radiograph, most likely diagnosis is? (AIIMS MAY 2017)

- A. Ankylosing spondylitis.
- B. Fluorosis.
- C. Ochronosis.
- D. Degenerative disc disease.



Schober's test : Non specific test to assess the elasticity and flexibility of the spine.

Hyperpigmentation of the cartilages of nose and ears.

Radiograph : Predominant calcification (white) involving disc.

Diagnosis : **Alkaptonuria** (homogentisic acid deficiency).

MSK finding : **Ochronosis**.

## Erosive osteoarthritis

00:31:49

Atypical OA in which there is degeneration of the joint along with inflammatory component.

Usually presents in elderly females. Clinically presents as inflammatory arthropathy.



**Gull wing sign** : Central subchondral erosions.  
kumarankitindia1@gmail.com

Gull wing sign

## Neuropathic/Charcot's joints

00:33:20

Etiology : Destructive joint disorder in which there is loss of pain, proprioception & position sensation of a joint as neural feedback from the joint is impaired. Leads to extensive destruction and deformity.

MC site : Ankle and foot region joints.

Clinically, it is associated with 6D's :

- Destruction.
- Density.
- Dislocation.
- Debris.
- Distension.
- Disorganization.

Predisposing factors :

- Diabetes mellitus.
- SADC (Subacute Combined degeneration) of cord.
- Syring.
- Tabes dorsalis.
- Leprosy.

Oblique radiograph of foot : Licked candy stick appearance (tapered narrow metatarsals with destruction of phalanges).



Licked candy stick appearance

**Diffuse Idiopathic Skeletal hyperostosis (DISH)** : Excess bone formation along the tendons and ligaments.

Flowing hyperostosis along the anterior longitudinal ligament which is called flame shaped osteophytes/ dripping candle wax appearance.

MC site : Lower thoracic spine.

MC site of fracture : Cervical spine.



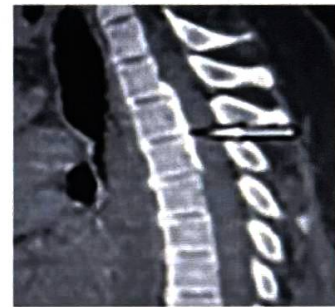


Flamed shaped  
osteophytes/dripping  
wax appearance.

### OPLL/Ossified posterior longitudinal ligament/ Japanese disease

00:36:56

MC site of involvement : Cervical spine.



OPLL

### Osteomyelitis/OM : Role of imaging modalities

60c6b3eaa8ded0e4e7e5ea7

00:37:37

1. X ray/CT scan : Bony changes are apparent only at later stages. Latent period : Infection present but no imaging signs can be seen.  
In extremities : 10 days.  
In spine : 21 days.
2. <sup>99m</sup>Tc MDP bone scan : It can detect OM at the earlier stages itself. But, it is a nonspecific test.
3. IOC/ overall best investigation : MRI.

Imaging signs in OM :

Subacute OM :

On T1W (T1 weighted) MRI, penumbra sign (focus of infection within the bone surrounded by hyperintense rim of vascularised granulation tissue) is seen.



Penumbra sign on T1W MRI

Chronic Om :

**Sequestrum** : Dead infected bone (due to infarction of the bone) which acts as the reservoir of infection. It should be excised for definitive management of the disease.

**Involucrum** : Thick periosteal new bone formation around the sequestrum to isolate the infection.

**Cloaca** : Defects in the involucrum through which pus comes out. Can extend upto skin and form sinus tracts.

**Brodie's abscess** : [kumarankitindia1@gmail.com](mailto:kumarankitindia1@gmail.com)

Aborted/ arrested form of localised subacute Om.

MC site : Proximal tibia.

MC organism : Staphylococcus aureus.

MC clinical presentation :

Child with severe nocturnal pain which is relieved on taking analgesics.

X ray : Abscess (black) surrounded by sclerosis (white).

MRI : Central bright area surrounded by hypointense rim.



Chronic osteomyelitis



Brodie's abscess

**Spina Ventosa** :

Spina : Short bones involved;

ventosa : Expanded.

Tuberculous involvement of the short bones of hand.

Ballooned out metacarpal which is known as **tubercular dactylitis** is a predominant feature.

Expansile diaphyseal lesions of short tubular bones of hands and feet is seen.





## Skeletal TB

00:45:49

MC site : Spine (TB spondylitis).

MC appendicular site :

Hip (tubercular arthritis of hip).



MC vertebral site in adults : Thoraco-lumbar spine.

MC vertebral site in children : Cervical spine.

Spina Ventosa : Tubercular dactylitis.

Caries sicca : Non exudative TB involving the shoulder region.

**Phemister triad of TB arthritis :**

- Juxta articular osteopenia : Earliest radiographic sign due to inflammation.
- Peripheral osseous erosions.
- Gradual narrowing of joint space.

**TB spondylitis :**

**Paradiscal involvement :** The disease begins at disc & then spreads to the adjacent vertebral segments.

Post contrast MR image : Enhancement of disc & **paradiscal** region.

Further extension of the exudate into the epidural space and psoas muscles leads to the formation of pre and paraspinal abscess formation.



60c6b3eeea8ded0e4e7e5ea7

ActiveSpace

## MSK : SYSTEMIC BONE DISORDERS & MISCELLANEOUS

Q. A child presents with this finding on a skull radiograph. All the following could be the differential diagnoses in this case except?

- A. Thalassemia.
- B. Sickle cell disease.
- C. Hereditary spherocytosis.
- D. Aplastic anemia.



Explanation :

Features of hemolytic anemias :

- Widening of the diploic space.
- Multiple trabeculae : Spiked appearance/crew cut appearance/ hair on end appearance.

Examples of hemolytic anemias : Thalassemia, sickle cell disease, hereditary spherocytosis.

Aplastic anemia : No widening of diploic space.

Q. A 10 year old child presented with limb pain with normal bone mineralization. His knee X ray is shown here. What is the most likely diagnosis?

- A. Scurvy.
- B. Rickets.
- C. Pyknodysostosis.
- D. Hemophilia.



Explanation :

Vitamin deficiency with preserved bone mineralization.

Features hinting towards scurvy :

- White line of Frankel at metaphysis (irreversible finding).
- Wimberger ring around the epiphysis.



## Rickets

00:01:24

vitamin D deficiency.

most common age group : 6-12 months of age.

vitamin D causes calcification of metaphyseal margin which leads to bone lengthening and hence growth.

Absence of this causes :

- Fraying : ill defined/blurred metaphyseal margin.
- Widening of physal plate due to excessive cartilage deposition at the metaphysis.
- Widening and cupping of metaphysis due to repeated stress and weakening owing to lack of calcification.

The above are the skeletal signs of rickets.

Other signs include rickety rosary, pectus carinatum (pigeon chest), Harrison's sulcus (sulcus at diaphragmatic insertion).

### Rickety rosary :

- Hypertrophied cartilage appearing as beads at costochondral junctions.
- Radiologically seen as expanded anterior ends of ribs.



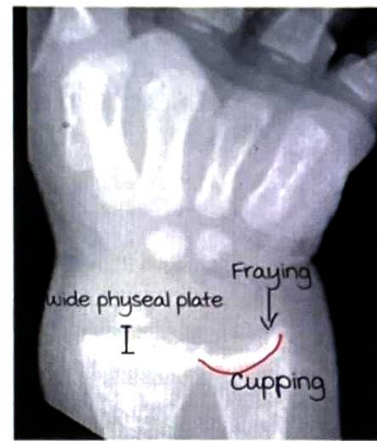
60c6b3eeaa8ded0e4e7e5a7

Rickety rosary

Healing rickets

### Healing rickets :

Calcification at metaphyseal margin (role of vitamin D).  
White line at metaphyseal margin indicates response to treatment.



Rickets

Osteomalacia (adult rickets) :

Vitamin D deficiency in adults.  
Lack of osteoid mineralization.  
Weak bones.

Diffuse osteopenia.

**Looser's zones/pseudofractures :**

Transverse lucencies involving the cortex.

Most common site : Femur, most commonly at the neck.



Osteomalacia

**Triradiate pelvis/ protrusio acetabuli :** Acetabula protrude into the pelvic cavity.  
Bell shaped thoracic cage.

## Scurvy

00:08:42

Vitamin C deficiency.  
Most common age group 8 to 14 months due to boiled/pasteurized milk feed.

Functions of Vitamin C :

- Crosslinking of collagen.
- Hydroxylation of proline/lysine residues.



1. Wimberger epiphysis : Loosened central portion of epiphysis.

2. White line of Frankel (the only irreversible sign).

3. Trummerfeld's zone of rarefaction : Dark band just proximal to the metaphysis.

4. Pelkan spurs : Sharp spurs at metaphysis.

**Pseudoparalysis / frog like appearance :** Painful subperiosteal hematomas due to which the child refuses to move.

**Pain is a feature of scurvy unlike rickets.**

kumarankitindia1@gmail.com



## Hyperparathyroidism

00:11:34

Parathormone increases serum calcium mainly through bone resorption.

**Parathyroid adenoma (MEN 1/IIa)**

leads to excessive parathormone production leading to excessive bone resorption (osteopenia).

**Subperiosteal resorption** : Cortical resorption occurring more commonly on the radial aspect of short bones of hands and feet.



Hyperparathyroidism

**Brown tumor (misnomer)** : In extremities, the bone may occasionally undergo complete resorption & appears round like a tumor. Appears brown on gross histopathology due to accumulation of mineral laden osteoclasts at the site.

**Salt & pepper skull/Pepper pot skull.**

**Rugger Jersey spine** : Striped appearance resembling a football jersey.



Rugger jersey spine



Pepper pot skull

60c6b3eaaa8ded0e4e7e5ea7

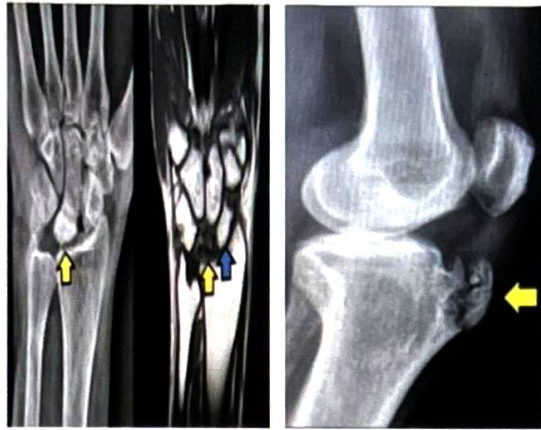
**Osteochondritis** :

Focal infarction involving bones.

**Kienbock's disease** : Osteochondritis of lunate bone due to which it appears hypointense on MRI.

**Osgood-Schlatter disease :**

Osteochondritis involving the tibial tuberosity.



Osteochondritis

**Hemolytic anemia :**

Widening of the diploic space  
multiple thickened trabeculae :  
Spiked appearance/crew cut  
appearance/hair on end  
appearance.

Examples :

- Hereditary spherocytosis.
- Iron deficiency anemia.
- Neuroblastoma metastases (focal).
- G6PD Enzyme deficiency.
- Sickle cell disease.
- Thalassemia major.



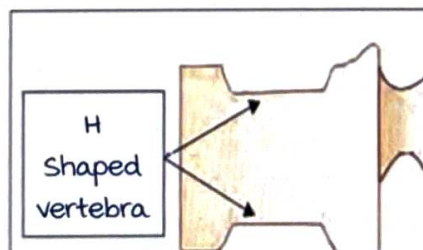
Crew cut/hair on end

**Miscellaneous imaging**

00:17:48

H-shaped vertebra : Sickle cell disease.

Due to infarction of the central part of the end plate leading to depression of the same.



Active space



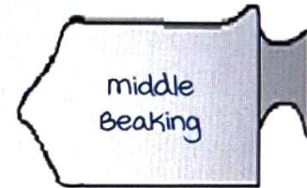
## Features of osteoporosis :

- **Wedge shaped vertebra** : Partial wedge collapse of vertebra.
- **Codfish/fish mouth/hourglass vertebra** : The disc itself creates an impression on the vertebral body due to its softening.



## mucopolysaccharidosis :

- **middle beaking** : morquio syndrome.
- **Inferior beaking** : Hurler syndrome.



## Paget's disease :

kumarankitindia1@gmail.com • Ivory vertebra.

- **Picture frame vertebra** : When only the border appears dense.

Sandwich vertebra : Osteopetrosis.



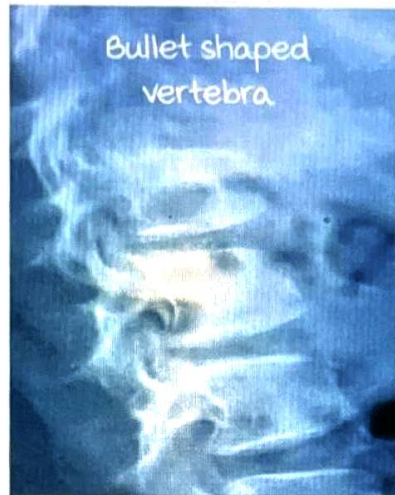
Ivory vertebra

vertebra plana/coin on edge vertebra/silver dollar vertebra :

- **Children** : Eosinophilic granuloma.
- **Adults** : multiple myeloma.



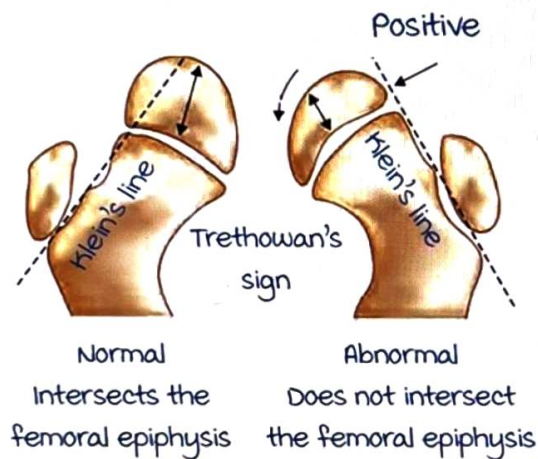
Bullet shaped vertebra :  
Achondroplasia.



60c6b3eaa8ded0e4e7e5ea7

00:22:02

## Slipped capital femoral epiphysis



Slipped capital femoral epiphysis

Obese children mostly 10 to 15 years of age.

Type I Salter-Harris injury.

Femoral head slips over the physal plate located at the proximal femur.

**Klein's line** is a line drawn along the superior edge of the femoral neck which usually intersects the femoral head.

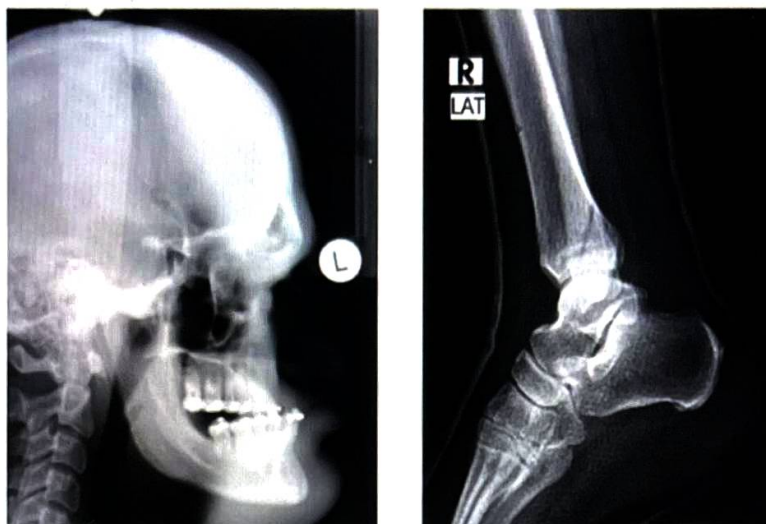
**Trethowan's sign** : Klein's line doesn't intersect the femoral head in case of a slipped capital femoral epiphysis.

Frog leg view X Ray is done.

Active space



## Acromegaly :



Acromegaly

Excess growth hormone secretion.

Soft tissue thickening seen at the heel pad  
(Thickness > 20 mm).

Enlarged sella due to underlying pituitary adenoma.

Hyperpneumatization of paranasal sinuses.

Prognathism : Protrusion of jaw/ angle of mandible becomes obtuse.

Spade shaped phalanx.

## Achondroplasia

00:26:18

m/c cause of congenital dwarfism.

Trident hand : Three axes in the hand.

60c6b3eaa8ded0e4e7e5ea7

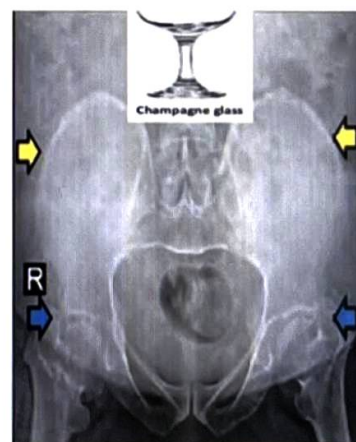
Chevron sign : v shaped distal metaphysis.

Bullet shaped vertebra along with scalloping of the posterior margin.

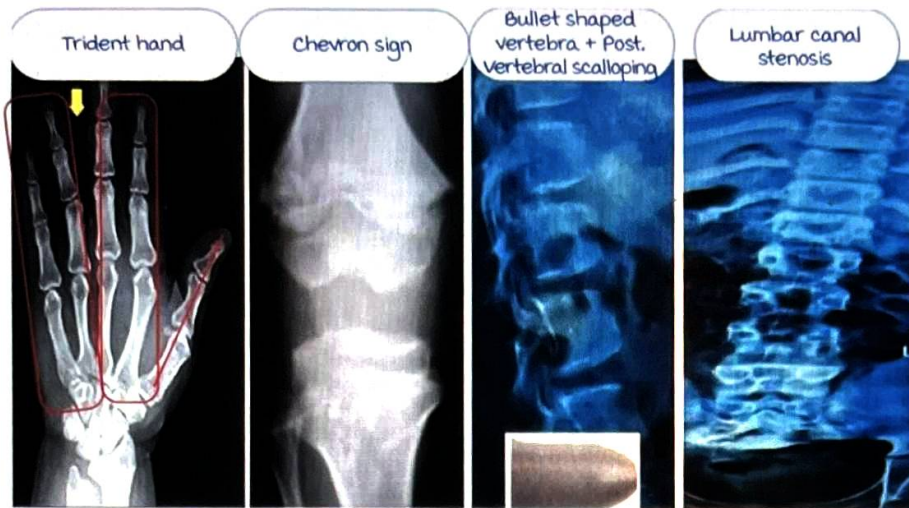
Lumbar canal stenosis : Progressive decrease in interpeduncular distance.

Pelvis :

- Champagne glass appearance.
- micky mouse iliac blades.



Champagne glass appearance



Achondroplasia

Wormian bones/Intrasutural bones :

Accessory bones within the sutures.

Mostly commonly within the

lambdoid sutures.

Mnemonic : PORKCHOPS

Pyknodysostosis.

Osteogenesis imperfecta.

Rickets.

Kinky hair syndrome.

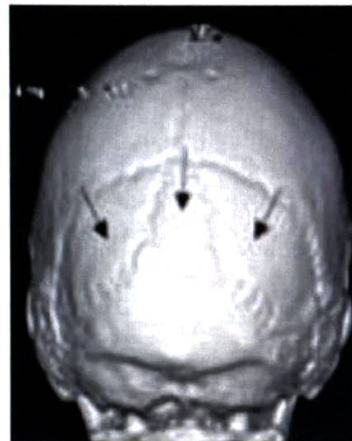
Cleidocranial dysplasia.

Hypothyroidism/Hypophosphatemia

Other causes (otopalatodigital syndrome).

Progeria.

Syndromes (Down's syndrome).



Wormian bones

## Osteogenesis imperfecta

00:30:54

Qualitative and quantitative defect of collagen type I.

Reduced bone densities leading to multiple deformities.

Shepherd crook deformity.

Antenatal fracture detection.

Wormian bones seen.



Shepherd crook deformity

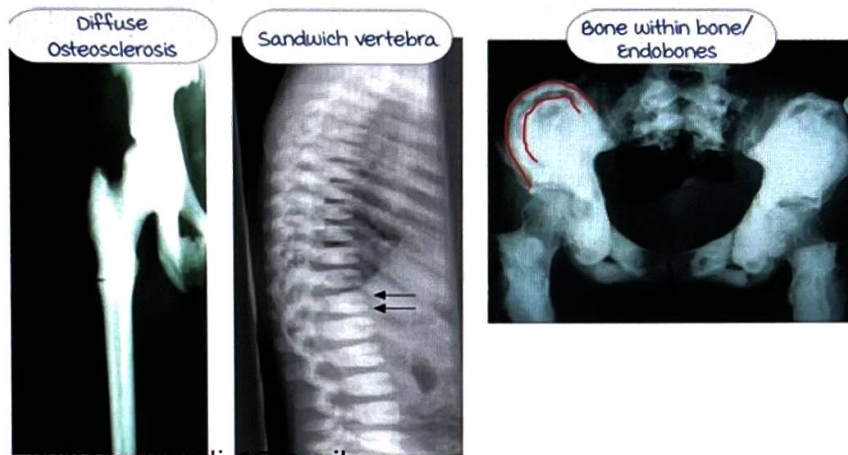


**melorheostosis :**

**Diffuse Idiopathic Skeletal Hyperostosis (DISH)** leading to flowing hyperostosis along one side of a limb.  
Flowing/molten/dripping candle wax appearance.



melorheostosis

**Osteopetrosis/Chalk bone disease/marble bone disease :**

kumarankitindia1@gmail.com

Diffuse osteosclerosis.  
Increased bone density.  
Sandwich vertebra.  
Bone within bone/endobone appearance.

**Acro-osteolysis :**

Acro : Periphery  
Osteolysis : Bone destruction.  
Resorption of distal phalanx of hand.  
mnemonic : PINCH OF Extremity

Pyknodysostosis.  
Infections (leprosy), Injuries (frost bite, electrical).

Neuropathic conditions.

Cleidocranial dysplasia.

Hyperparathyroidism.

Other causes (sarcoidosis, psoriasis, Kaposi sarcoma).

Familial.

Ergot poisoning.



Acro-Osteolysis

## MSK : BONE TUMOURS

Q. A 35 year old male presented with pain at wrist and swelling. His radiograph is shown here. What is the most likely diagnosis ?

- A. ABC.
- B. GCT.
- C. SBC.
- D. Enchondroma.



An expansile lytic lesion seen in metaphyseal-epiphyseal region, giving rise to soap bubble appearance, which is characteristic of giant cell tumour.

Q. An 8 year old child presented with pain at shoulder and arm. An X-ray reveals a uniform well-defined lucent lesion at the metaphysis. most likely diagnosis is :

- A. Simple bone cyst.
- B. Aneurysmal bone cyst.
- C. Giant cell tumour.
- D. Eosinophilic granuloma.



Image is that of an immature skeleton. Centrally located well defined lesion in proximal humoral metaphysis (not extending to epiphysis) in a child is most likely due to a bone cyst.

### Bone tumours : Age distribution

00:02:04

0-20 years :

Benign :

- Simple bone cyst.
- Aneurysmal bone cyst.
- Eosinophilic granuloma: (Lytic skull lesion in a child).
- Fibrous dysplasia.
- Osteoid osteoma.
- Osteoblastoma.

malignant :

- Ewing's sarcoma.
- Osteosarcoma.

20-40 years :

- Enchondroma.
- Osteoblastoma.
- Osteoma.
- GCT.
- Parosteal osteosarcoma.

&gt;40 years :

- Chondrosarcoma.
- Metastasis.
- Multiple myeloma.



**Bone tumours : Site distribution**

00:04:55

Epiphysis : Chondroblastoma (children).  
Giant cell tumour (adults).

Diaphysis : Ewing's sarcoma.  
Osteoid osteoma.  
Adamantinoma.  
Fibrous dysplasia (metaphysis + diaphysis).

metaphysis : Osteosarcoma.  
Osteochondroma.  
Simple bone cyst.  
Aneurysmal bone cyst.  
Non-ossified fibroma.

Ewing's sarcoma is diaphyseal tumour.  
Osteosarcoma is metaphyseal tumour.

**Bone tumours : Location clinchers**

00:06:51

Simple bone cyst :

Well defined lucent lesion in proximal humeral metaphysis (most common).

Fallen fragment sign : Fracture in the wall of the cyst that falls off inside the cyst.

Hinged fragment sign : Fracture piece stays attached at the fracture.



Adamantinoma :

Expansile soap bubble or honeycomb lesion.

most common sites :

- Tibial diaphysis.
- mandible.



Enchondroma :

Expansile geographic lucent lesion in the short bones of hand/feet with **stippled/punctate calcification** seen within an enchondroma.

kumarankitindia1@gmail.com



Enchondroma

Haemangioma :

Prominent vertical stripes in vertebral body.

Lesion in the body that causes resorption of the bone and remaining trabeculae appear excessively thickened.

most common site of bony haemangioma :

**Spine > Skull.**

**Striated vertebrae/corduroy cloth vertebrae.**

In cross section : **Polka dot sign.**



Osteoid osteoma :

**O shaped lesion** in the cortex

Dense periosteal reaction around it.

Central lucent area called as **nidus.**

most common site : **Femur > Lumbar spine.**

Nidus is **< 10 mm** in size in osteoid osteoma.

On angiography, nidus shows **vascular blush.**

On radionuclide scan, nidus gives **double density sign.**



Osteochondroma :

Outgrowth arising from metaphysis continuous with cortex directed away from adjacent joint. Also known as **exostosis.** Has a cap of hyaline cartilage (not seen on X-ray).

most common benign bone tumour.



Active space



**Coat hanger exostosis** : Very large tumour.

multiple exostosis > 10 in number : **Hereditary multiple exostosis/diaphyseal aclasia**.

Risk of malignancy in solitary lesions : 1%.

Risk of malignancy in diaphyseal aclasia : 20%.

### Eccentric cystic bone lesions

00:15:18

Q. Incorrect statement regarding this condition is ?

- A. Epi-metaphyseal lesion.
- B. Eccentric location.
- C. Has distinct margins.
- D. Chemotherapy is treatment of choice.



It is an **eccentric lesion** as it spares the cortex on one side and extends more towards a single side.

Aneurysmal bone cyst	Giant cell tumour
Eccentric, expansile lytic lesion with septae in metaphysis in immature skeleton (child).	Eccentric, expansile lytic lesion in metaphysis an adult.
<p>MRI : <b>Fluid-fluid level</b> appearance.</p> <p><b>Blown out</b> appearance.</p> <p><b>Finger in a balloon</b> appearance.</p>	<p><b>Soap bubble</b> appearance.</p> <p><b>Quasimalignant</b></p> <p>(Benign &gt;&gt;&gt;&gt; malignant.</p> <p>Definitive diagnosis : Histopathology).</p> <p>Treatment : Surgical excision.</p>



Q. A 10 year old child presented with swelling over leg region. He has a history of minor fall 15 days back. He also has mild fever. The radiograph here shows an ill-defined lesion with typical lamellated periosteal reaction pointing to a diagnosis

of ?

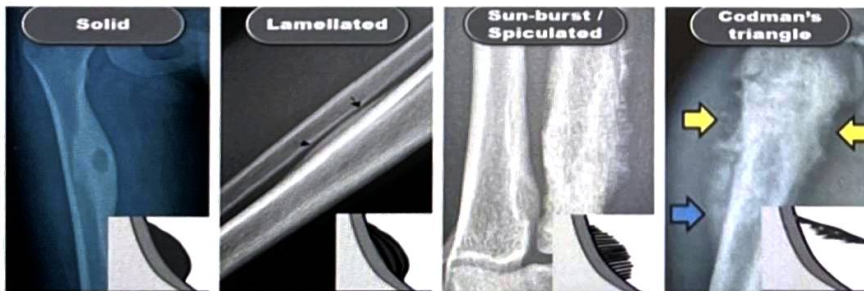
- A. Osteosarcoma.
- B. Ewing's sarcoma.
- C. Simple bone cyst.
- D. Osteoid osteoma.



Transition zone : 60c6b3eaa8ded0e4e7e5ea7

Narrow zone of transition	Wide zone of transition
	
Sharp, well-defined margins.	Blurred, ill-defined margins.
Suggestive of benign lesion.	Suggestive of malignant lesion.
Exceptions : <ul style="list-style-type: none"> <li>• &gt;40 years.</li> <li>• multiple myeloma.</li> <li>• metastasis.</li> </ul>	Exceptions : <ul style="list-style-type: none"> <li>• Infections.</li> <li>• Eosinophilic granulations.</li> </ul>

Periosteal reactions :

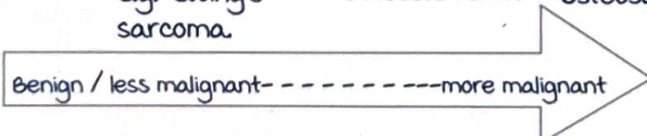


**Solid**  
Cortical lesion with dense periosteal reaction.  
E.g : Osteoid osteoma.

**Lamellated**  
multiple layers of periosteal reaction :  
**Onion peel appearance.**  
E.g: Ewing's sarcoma.

**Sun-burst / Spiculated**  
Tiny bony spicules seen.  
**Sunburst appearance.**  
e.g. : Ewing's sarcoma  
Osteosarcoma

**Codman's triangle**  
Periosteum lifted from the cortex giving a **triangular appearance.**  
E.g: Osteosarcoma



Active space



## Malignant tumours :

00:24:06

### Ewing's sarcoma :

- Ill-defined lesion involving diaphysis.
- Lamellated/sunburst periosteal reaction.
- Groomed/trimmed whiskers appearance.
- Gives rise to skip lesions.
- Seen in children in first decade of life ( $\leq 10$  years).
- MC bone tumour to metastasize to other bones.



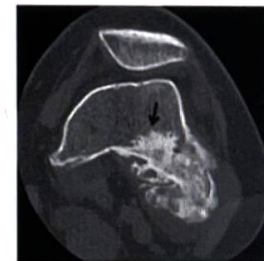
### Osteosarcoma :

- Seen in children in 2<sup>nd</sup> decade of life.
- Ill-defined lesion with wide zone of transition.
- Located in metaphysis.
- Periosteal reaction : Codman's triangle/sunburst reaction.
- Cumulus cloud appearance : Dense soft tissue mass surrounding the tumour.
- Lung metastasis : Canon ball metastasis seen.



### Paraosteal osteosarcoma :

- Tumour lies adjacent to the bone.
- most common site is posterior surface of distal femur.
- Cleavage plane sign : Cleft between tumour and normal bone.
- Well differentiated tumour.
- Seen between 30-50 years of age.



Q. A 65 year old patient presented with weight loss and generalized weakness. Along with a basic blood work-up a skeletal survey was done and is shown here. most likely diagnosis is ?

- A. Eosinophilic granuloma.
- B. Multiple myeloma.
- C. Metastasis.
- D. Hyperparathyroidism.



>40 years : Chondrosarcoma/  
metastasis/multiple myeloma.

Multiple punched out lytic lesions seen in skull : Raindrop appearance of skull, characteristic of multiple myeloma.

Chondrosarcoma :

most common site : Pelvis and proximal femur.

X-ray of pelvis :

Soft tissue mass which is an ill-defined lesion with multiple calcific foci.



CT image of scapula.

Soft tissue mass with multiple arc-like or broken-ring like calcifications.



Popcorn/ Fluffy/ Stippled/ Cotton wool/ broken ring appearance.

Q. Winking owl sign is seen in ?

- A. Osteoblastoma.
- B. Metastasis.
- C. Pott's spine.
- D. Multiple myeloma.

Pedicles on X-ray appears like two eyes of an owl.

Metastasis commonly involves posterior elements of spine.

When metastasis involves a pedicle, it will not be visible. Thus, only the unaffected pedicle will be visible in an X-ray, giving rise to winking owl sign.

Blind vertebra sign : when both pedicles are destroyed.



## Bone metastasis

00:37:03

most common overall malignant bone tumour.

Diagnosed best by  $^{99m}\text{Tc}$  MDP bone scan.

- metastasis appear as hotspots.
- Lesions of multiple myeloma appear as cold spots.

MC primary in males : Ca prostate.

MC primary in females : Ca breast.

MC primary causing lytic metastasis : Ca lung .

MC primary causing blastic metastasis : Ca prostate.

Syndrome	Tumour features	Risk of malignancy
Olliers syndrome	multiple enchondromas	10%
Maffucci syndrome	multiple enchondroma and Haemangioma	25%
Diaphyseal aclasia	Hereditary multiple exostosis (>10 enchondromas)	20%
Gardener's syndrome	Osteomas + GI polyps + Epidermal cysts + Desmoid tumours	-

Classical appearance	Diagnosis
Codman's triangle	Osteosarcoma
Onion peel periosteal reaction	Ewing's sarcoma
Corduroy vertebra	vertebral haemangioma
Raindrop skull	multiple myeloma
Soap bubble appearance	Giant cell tumour (adults), Aneurysmal bone cyst (children)
Fallen fragment sign	Simple bone cyst

# MSK : TRAUMA RAPID REVIEW

## Facial trauma

00:01:49

1<sup>st</sup> investigation for nasal fracture : X-ray.

IOC for any facial trauma : **3D-CT** (helps in better planning of treatment because vital structures are better seen.

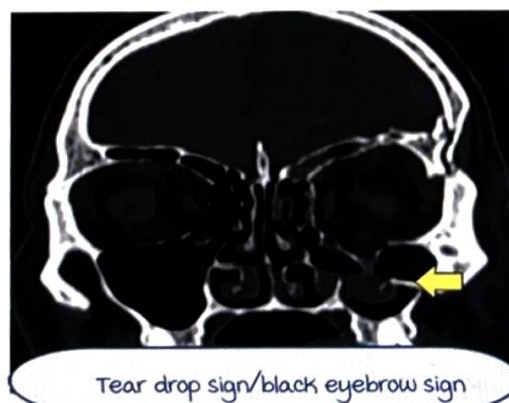
**m/c** facial bone fracture is nasal bone fracture.



Clinical scenario :

Q. A patient presented with history of trauma followed by periorbital swelling and diplopia. Diagnosis based on this CT image is :

- A. Le fort fractures.
- B. Fracture zygoma.
- C. Tripod fracture.
- D. **Blow-out fracture.**



Orbital floor fracture :

It is coronal reconstructed CT with bone window image.

Right orbit is well seen and normal.

**Tear drop appearance** in left maxillary sinus :

Orbital floor fracture/blow out # of orbit → Pressure

Active space



increases → transmitted along the infra orbital groove (weak point) → infra orbital contents herniate → trapped between fracture fragments, EOM also trapped causing diplopia → **Blow out fracture.**

**Tear drop sign/black eyebrow sign.**

Black eye brow sign : Air goes up into the orbit, rises to the non dependent part giving black lucency at the top of the orbit.

Le fort fractures : Fracture of pterygoid plate **mandatory.**

Type I : **Floating palate.**

Horizontal maxillary fracture separating the upper teeth from the face.

Passes through the inferior alveolar ridge & maxillary sinus floor. Also involves the lateral nasal wall.

Type 2 : **Floating maxilla.**  
Pyramidal fracture.

Base : at the level of the teeth,

Apex : By nasofrontal suture.

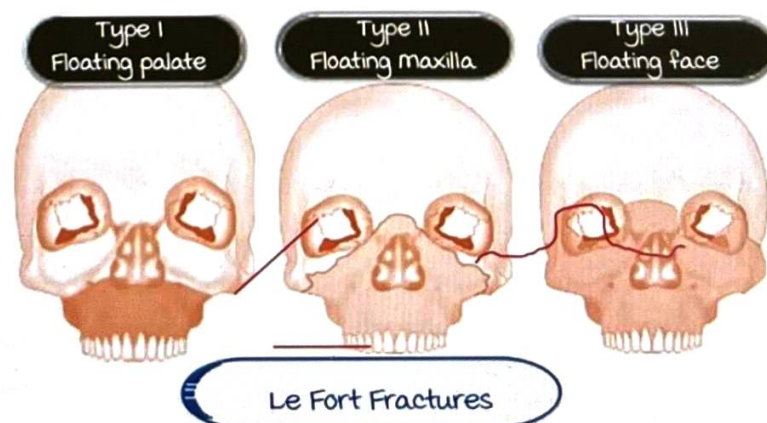
Fracture line passes from the nasal bone through inferior orbital wall.

Also runs along lateral wall of maxillary sinus to the posterior part of the alveolus.

Type 3 : **Floating face.**

Complete cranio facial dysjunction.

Fracture line passes through the nasofrontal suture, maxillo-frontal suture into the zygomatic arch.



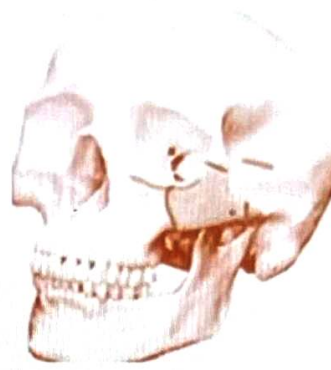
Tripod/Tri-malar/

Zygomaticomaxillary fracture :

Fracture of zygomatic arch +  
orbital process + maxillary process

Occurs when there is a direct blow  
to maxilla.

IOC : 3D-CT



## Spine trauma

00:08:34

Jefferson fracture : Due to fall from height

- Axial compressive force on head → Delicate ring of atlas (C1) # into 4 parts → Jefferson fracture/burst #.

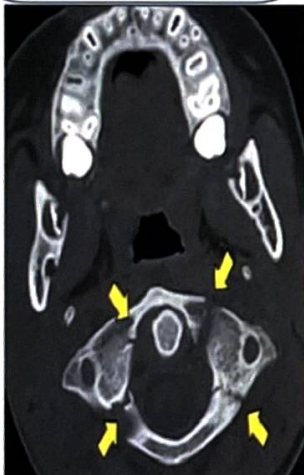
Hangman/Hangee's fracture :

- Fracture through pars interarticularis of C2.
- Seen in judicial hanging.  
No neurological deficit seen as spinal canal is large.

Clay shoveler fracture :

- Fracture involving spinous process of C6/C7.
- Due to pull of rhomboid & trapezius muscle.

kumarankitindia@gmail.com  
Jefferson fracture/  
Burst fracture of atlas



Hangman's fracture  
/ Hangee's fracture



Clay shoveler/  
coal miners/root  
pullers fracture



**SCIWORA** : Spinal Cord Injury without Obvious Radiographic  
Abnormality.

- used in olden days when only X-rays were available. used for spinal injuries in children.

Current IOC for spinal trauma : MRI.

- m/c used in Cervical spine fractures.

Active space



- High elasticity of pediatric spine → No fracture/dislocation of spine but neural injury like nerve root injuries, cord hematoma, cord contusion causing paraplegia are seen → SCIWORA (normal X-ray).

## Shoulder region trauma

00:13:32

Acromio-clavicular joint dislocation :

- Line drawn through inferior margins of acromion and clavicle not aligned → Dislocation.
- Humeral head : Normal.
- Gleno-humeral joint : Normal.

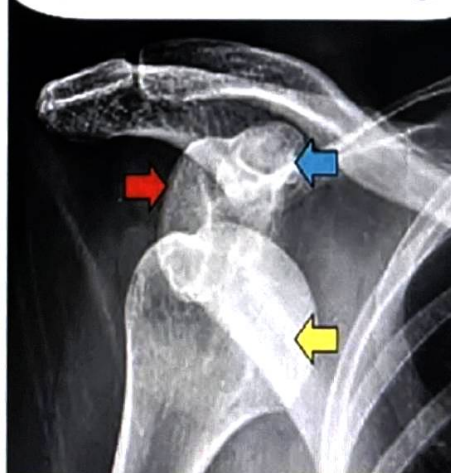
Acromio-clavicular joint dislocation



Anterior shoulder dislocation :

- Acromio-clavicular joint : Normal.
- Humeral head projecting away.
- Humeral head located in front of coracoid process.

Anterior Shoulder Dislocation (m/c type)



m/c type of anterior dislocation for clavicle and acromion

m/c joint dislocated overall in the body : **Shoulder.**

m/c complication of shoulder dislocation : **Recurrence.**

m/c early complication : Axillary nerve injury (circumflex branch).

m/c late complication : Recurrence.

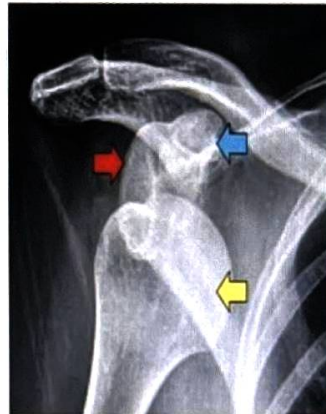
Recurrent anterior dislocation :

1. Bankart's lesion :

- Injury at antero-inferior glenoid rim.
- Cartilaginous labrum damaged → Labral bankart (viewed on MRI).
- Bone damaged → Bony bankart (seen on X-ray)

2. Hill-sach's lesion :

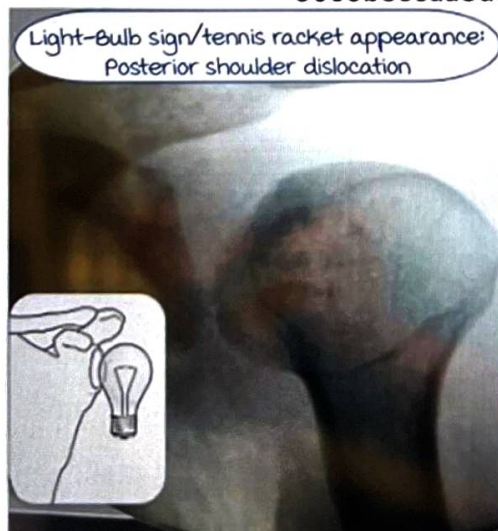
Humeral notch or indentation on the postero-lateral aspect of head because of glenoidal impingement.



Posterior shoulder dislocation :

- Shape of head changed to tennis racket/light bulb shape.
- Associated with triple E syndrome (bilateral locked posterior shoulder dislocation) :
  1. Epilepsy.
  2. Electric shock.
  3. Extreme trauma.

60c6b3eeaa8ded0e4e7e5ea7



Active space



## Upper limb trauma

00:19:51

Classification of humerus fracture by **NEER** is of 2 parts :

1. Number of fracture parts : 1-part, 2-part, 3-part and 4-part fractures.

Risk of **avascular necrosis** increases as the fracture progresses from 1-part to 4-parts → Poor prognosis.

2. Displacement.

m/c type : 1-part type of fracture.

m/c proximal humerus fracture :  
Surgical neck of humerus.



Named fractures :

1. Holstein Lewis fracture :

- Junction of upper 2/3rd and lower 1/3rd humerus.  
Fracture line runs along shaft of humerus.
- **Radial nerve** injury in the radial groove : Wrist drop →  
Cock-up splint used.

Holstein Lewis fracture : Radial nerve injured

kumarankitindia1@gmail.com



2. Supracondylar fracture :

m/c fracture around elbow in children.

m/c type : **extension type** (distal fracture fragment displaced posteriorly).

m/c nerve injured : **Anterior interosseous nerve**.

m/c artery injured : **Brachial artery**.

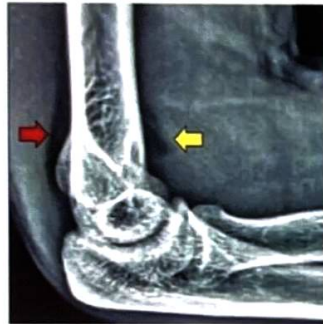
m/c late complication : malunion → Gunstock deformity.



### 1. Hemarthrosis

H/O child presenting with pain on moving the elbow with small intra-articular fracture.

- Bleed inside the elbow joint → Joint capsule becomes distended and lifts up the fat pads. Fat pads become visible (fat is darker than water & muscles) → Elevated fat pad sign.



## Forearm fractures

00:24:42

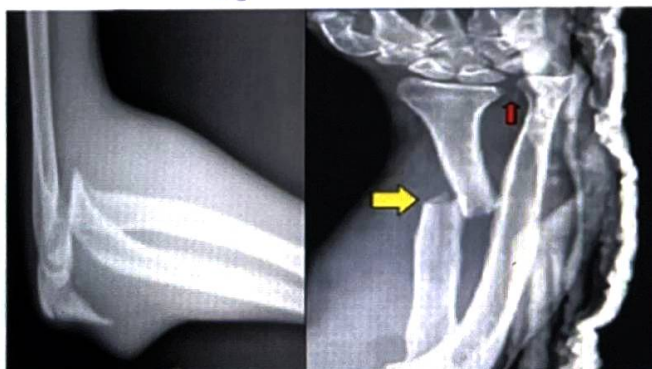
Acronym : MURK

### 1. Monteggia fracture :

- Ulnar fracture + Radial head dislocation.

### 2. Galeazzi fracture :

- Radial fracture + Distal Radio-ulnar joint dislocation.
- 60c6b3eaa8ded0e4e7e5ea7  
Monteggia & Galeazzi fracture



Active space



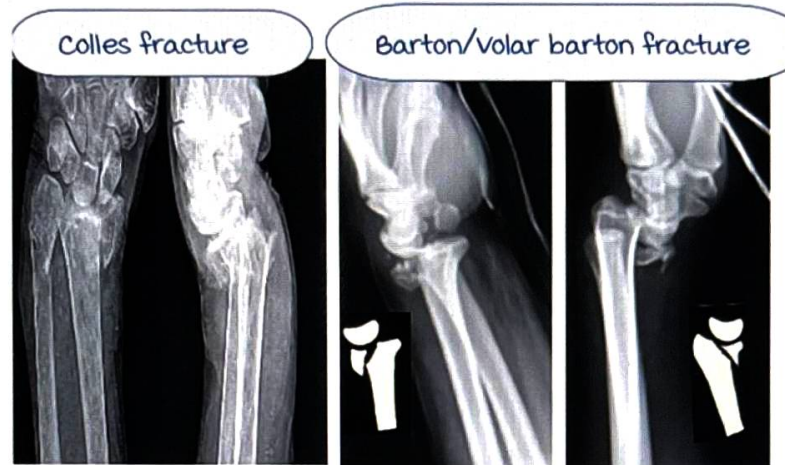
## 3. Colles fracture :

H/O fall on an outstretched hand + pain & swelling.

- Dorsal tilt of radial fragment + impaction at # site.
- Does not involve articular surface.
- m/c fracture seen in elderly patients.

## 4. Barton fracture :

Fracture passing through dorsal cortex of radius, extending up to articular surface.



## 5. Reverse barton/volar barton fracture :

- Fracture line extends through ventral/volar cortex involving the articular surface.

**Wrist/hand fractures**

00:27:10

## 1. Scaphoid fracture :

Seen in front of radius articular surface & in front row of carpal bones.

- most are radiographically occult (not seen on x-ray)
- H/O young/middle aged patient, fall on outstretched hand, with pain on radial aspect of wrist and tenderness at anatomical snuff box
- Complication : Avascular necrosis.
- Therefore, immobilize the hand in glass holding position.



wrist AP view : Scaphoid fracture, ulnar deviation

- Investigation of choice is CT.

Structures which can undergo avascular necrosis :

1. Head of femur.

kumarankitindia1@gmail.com

2. Scaphoid bone.

3. Neck of talus bone.

more proximal the fracture, higher is the risk for AVN.

2. Scapho-lunate dissociation/dislocation :

- Widened gap between scaphoid and lunate.  
(Scapho-lunate ligament damage).
- Also called Terry Thomas sign/madonna sign.

Scapho-lunate dissociation



3. Lunate & peri-lunate fractures :

- Saucer : Radius.
- Cup : Lunate.
- Apple : Capitate.

Dislocations :

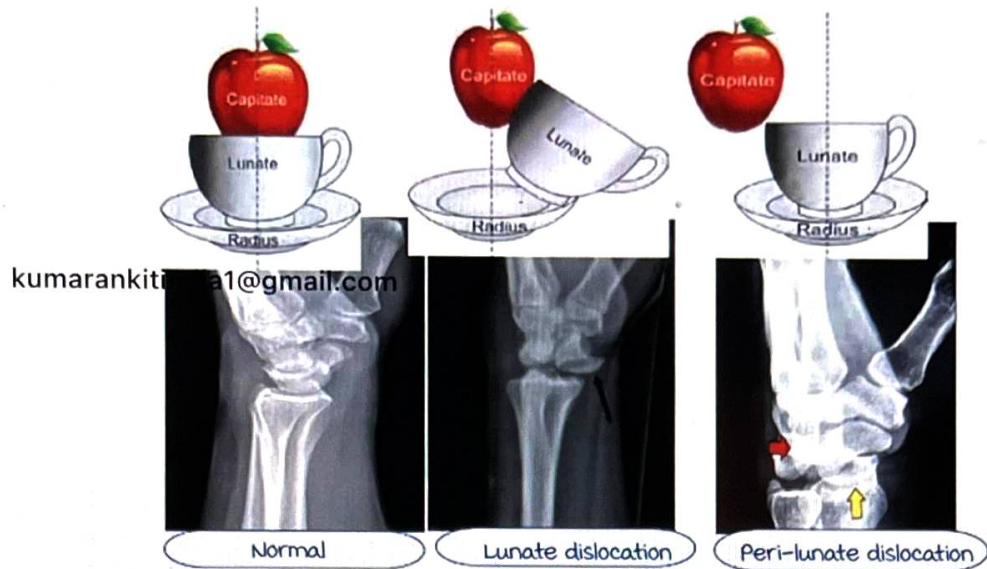
Lunate dislocation :

- Cup spills → Lunate dislocation.
- m/c carpal bone dislocation.  
median nerve injury is seen.

Peri-lunate dislocation :

- Apple goes backward → Peri-lunate dissociation.
- Associated with scaphoid fractures.



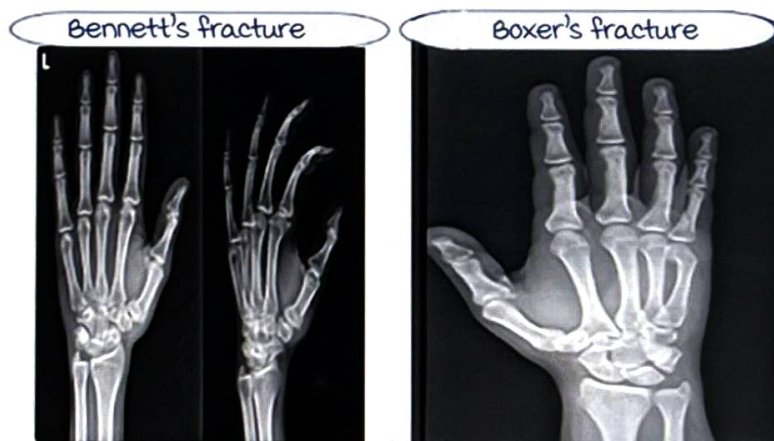


#### 4. Bennett's fracture :

- 1<sup>st</sup> metacarpal fracture, at carpo-metacarpal joint.
- Abductor pollicis longus (displaces # fragment) causes unopposed pull.
- Needs to be treated with internal fixation.
- It is a simple fracture while Rolando fracture is comminuted.

#### 5. Boxer's fracture :

Shaft of 5<sup>th</sup> metacarpal bone.



#### 4. Gamekeeper fracture :

- Proximal phalanx of thumb fractured.
- Ulnar collateral ligament pulls # fragment apart.
- Avulsion fracture.

Gamekeeper fracture/skier's  
thumb/ski pole fracture



Spine injuries :

1. Chance fracture :

- Seat belt injury.
  - Hyperflexion.
  - Fracture goes through vertebral body and posterior elements are widely separated.
- Horizontal splitting of spinous process, pedicle & body.

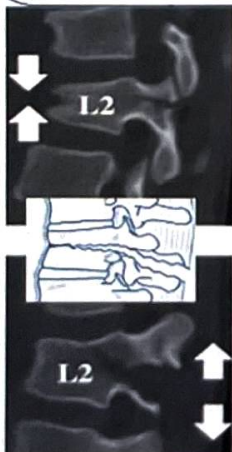
2. Compression/wedge fracture:

- Osteoporosis is a predisposing factor.

3. Burst fracture :

- Postero-superior fracture fragment goes into spinal canal.
- Compresses spinal cord.
- Neurological deficits.
- IOC : MRI.

Chance fracture



Compression/  
grandma fracture



Burst fracture :  
Neurological  
compression due to post-sup  
fragement



Active space



Spondylolysis & spondylolisthesis :

Lysis : Break.

Listhesis : Displacement.

Injury/fracture at pars interarticularis, which connects superior and inferior articular processes.

- **Fracture** : Spondylolysis.
- **Displacement of vertebra** : Spondylolisthesis (decapitated Scottish dog).



60c6b3eaa8ded0e4e7e5ea7  
Spondylolysis & spondylolisthesis

## Fractures of lower limb

00:39:08

Clinical scenario :

Elderly patient with H/O fall, inability to walk, helpless attitude of lower limb.

Associated with shortening, external rotation and mild abduction.

2 fractures possible :

1. Fracture of **neck of femur/capsular #**  
Risk of AVN because of arterial damage.  
Treatment : Replace with a prosthesis.
2. **Inter-trochanteric** fracture/extra capsular #

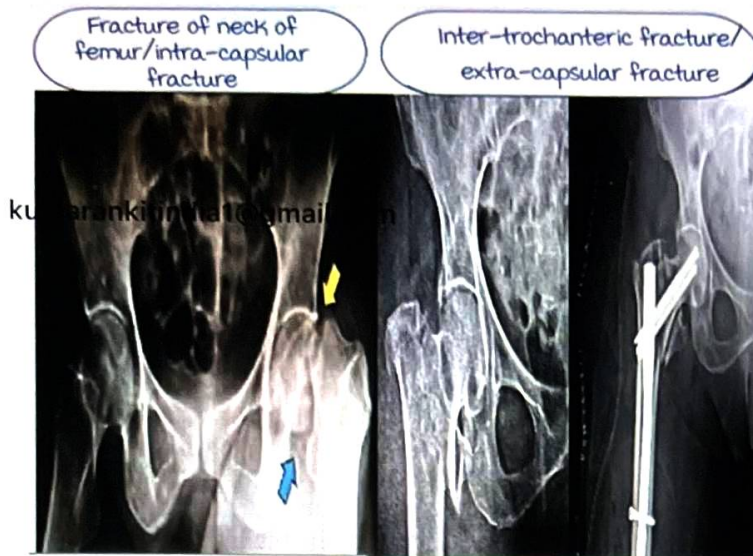
Fracture line runs from greater trochanter to less trochanter.

No risk of AVN.

Treatment : Fix it using a dynamic hip screw.

Shenton's line which runs along the inferior margin of the pubic ramus across the head & neck of femur, is interrupted.

**Garden classification** for neck of femur fracture.



Patellar fracture :

m/c type : Transverse type.

Proximally, quadriceps muscle  
+ distally, patellar tendon pull  
the fragments away from each  
other, fracture cannot heal.

Treatment : Create a bony  
cage entrapping fragments

**Tension band wiring** by  
distraction force-compression  
force.



Patellar fracture

Fracture of ankle :

1. Bi-malleolar/pott's/dupuytren fracture :

- medial + lateral malleoli affected

2. Trimalleolar fracture:

- All three malleoli (posterior tibial cortex).

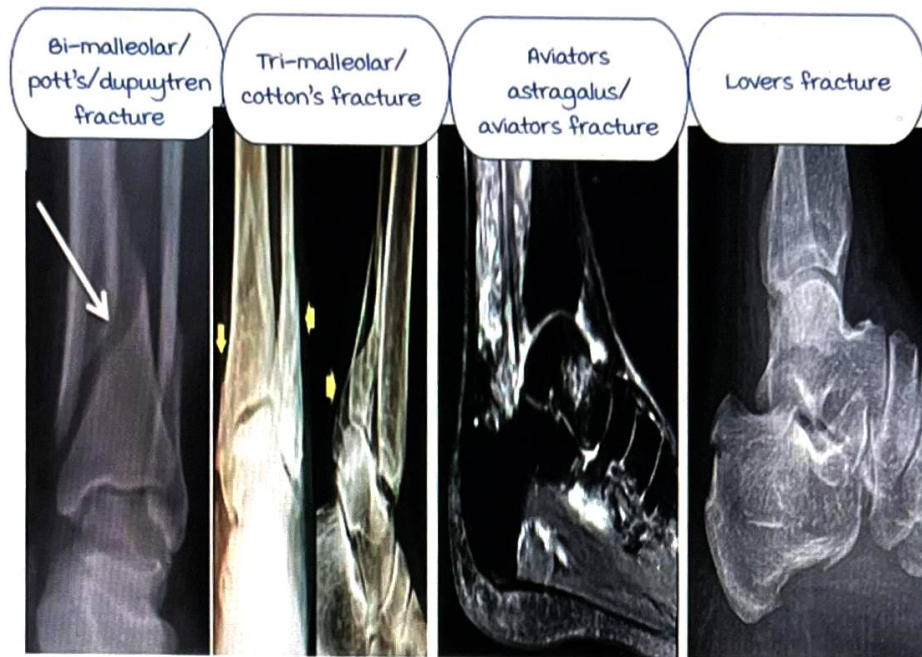
3. Aviators astragalus (talus):

- Crash landing → forced dorsiflexion → Neck of talus fracture.

4. Lovers fracture:

- Calcaneal fracture.
- Due to fall from height.





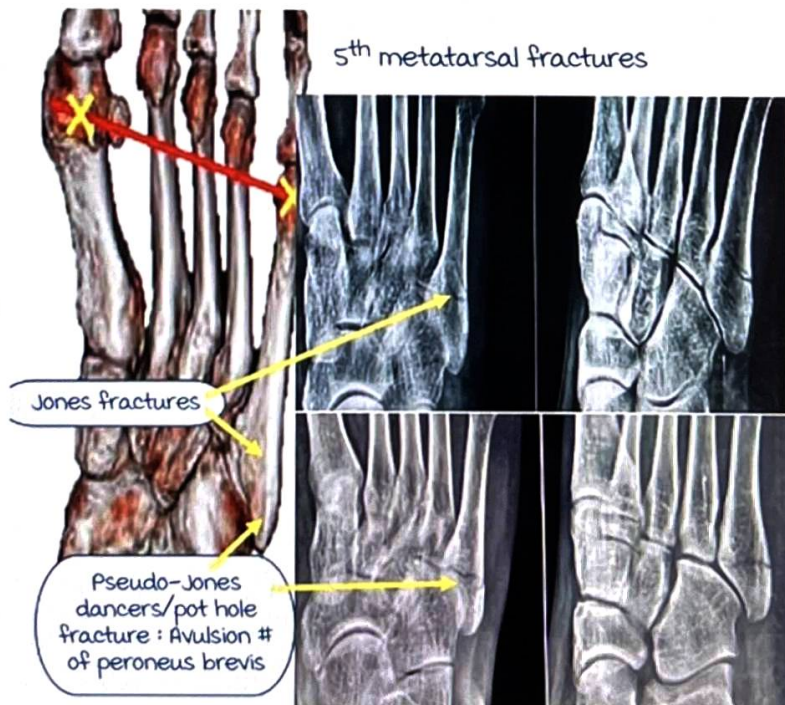
5<sup>th</sup> metatarsal fractures :

Zones :

- 1) Zone 1 : Proximal end (tuberosity) → Peroneus brevis tendon pull → Avulsion fracture → Pseudo-Jones fracture.
- 2) Zone 2 : Neck of metatarsal → True-Jones fracture.
- 3) Zone 3 : Shaft.

kumarankitindia1@gmail.com

Active space



Pediatric bone injuries :

Fractures of pediatric bones is uncommon due to flexibility of the bones.

Salter Harris classification of epiphyseal injuries :

**mnemonic** : SALTER

Type I : **S**traight across the physeal plate (no bone involved).

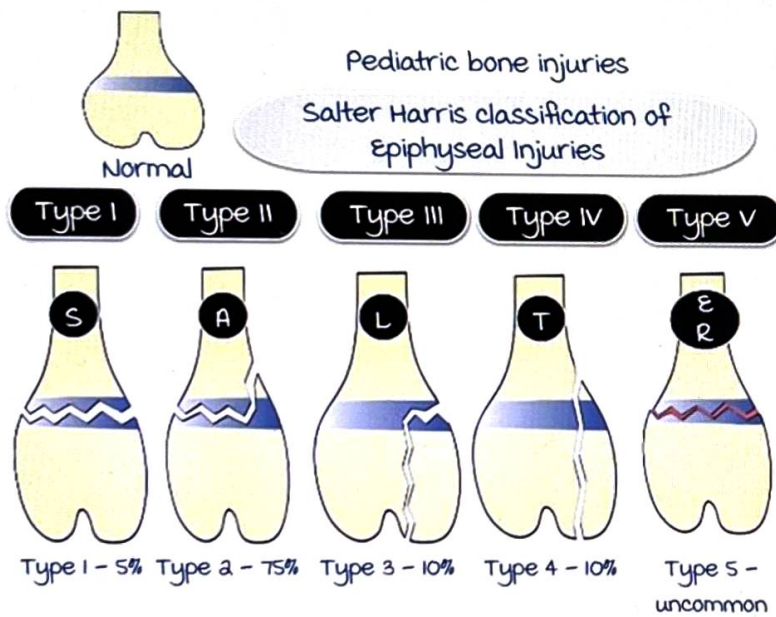
Type 2 : **A**bove metaphysis (m/c type).

Type 3 : **B**elow or **L**ow into the epiphysis.

Type 4 : **T**wo structures involved (metaphysis + epiphysis).

Type 5 : Complete **E**rosion of epiphyseal plates (worst prognosis).

Types 3 & 4 : Poor prognosis.



Torus fracture :

- Cortical buckling + trabecular impaction.
- Cortex gets buckled → Overlap of trabeculae → Increased density → Trabecular impaction.
- **No cortical break.**

Greenstick fracture :

- cortex break on 1 side of the bone.
- Other side → **Cortical buckling.**



Torus fracture



Greenstick fracture



## Stress fractures

00:49:07

### 1) Fatigue fractures :

- Excess of abnormal stress on normal bone.
- Seen in army recruits/athletes/dancers.

### 2) Insufficiency fractures :

- Result from normal stress on abnormal, weakened bones.
- Osteoporosis/osteomalacia/Paget's disease.

IOC : MRI

Bone scan, though not specific, can be used as an earlier modality of investigation.