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# Basics of Diagnostic Imaging

## MADE EASY FOR MEDICAL STUDENT


**BY**

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**2022**

# About Editor:


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# List of Contents

# Introduction

**Medical imaging** is a very important & common diagnostic tool for most of diseases, many modalities are used, but every modality has its advantages, limitations & hazards also. So any doctor must understand the basics of these modalities, hazards & how to choose the suitable one.

I must be understood,,,,,, so I try to make it easy for all of you.

**My best wishes**

*A.M. Abodahab – MD*

*Nov 2021*

**NB. This book is published online in PDF**

**For Free**

**for All Medical Student**

# Introduction to Imaging Modalities

# List of Imaging Modalities

- ✓ **X ray**
- ✓ **Ultrasonography & Doppler**
- ✓ **Computed Tomography (CT)**
- ✓ **Magnetic Resonance Imaging (MRI)**
- ✓ **Radio-isotope scan**
- ✓ **…….. & Others**

**In Every modality you will study the following:**

- ➲ Basics of work
- ➲ Energy used
- ➲ Main Indications
- ➲ Contraindications
- ➲ Finding of main Pathologies

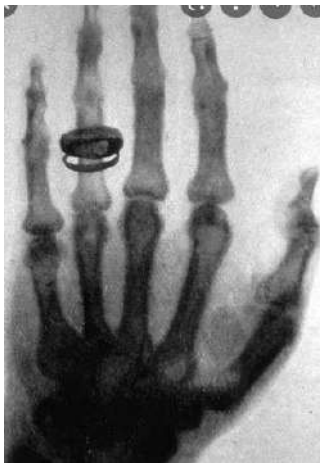
✍ **Please, don't request any imaging modality for any patient unless you know the value of it for diagnosis of the case.**

# X – Ray

## Historical Hints :

- ✓ The oldest imaging modality
- ✓ Discovered by **William Rontegen** at **1895**
- ✓ The first X ray film was done for Rontegens' wife hand.

Wilhelm Conrad Röntgen



1st X ray Film

X Ray machine

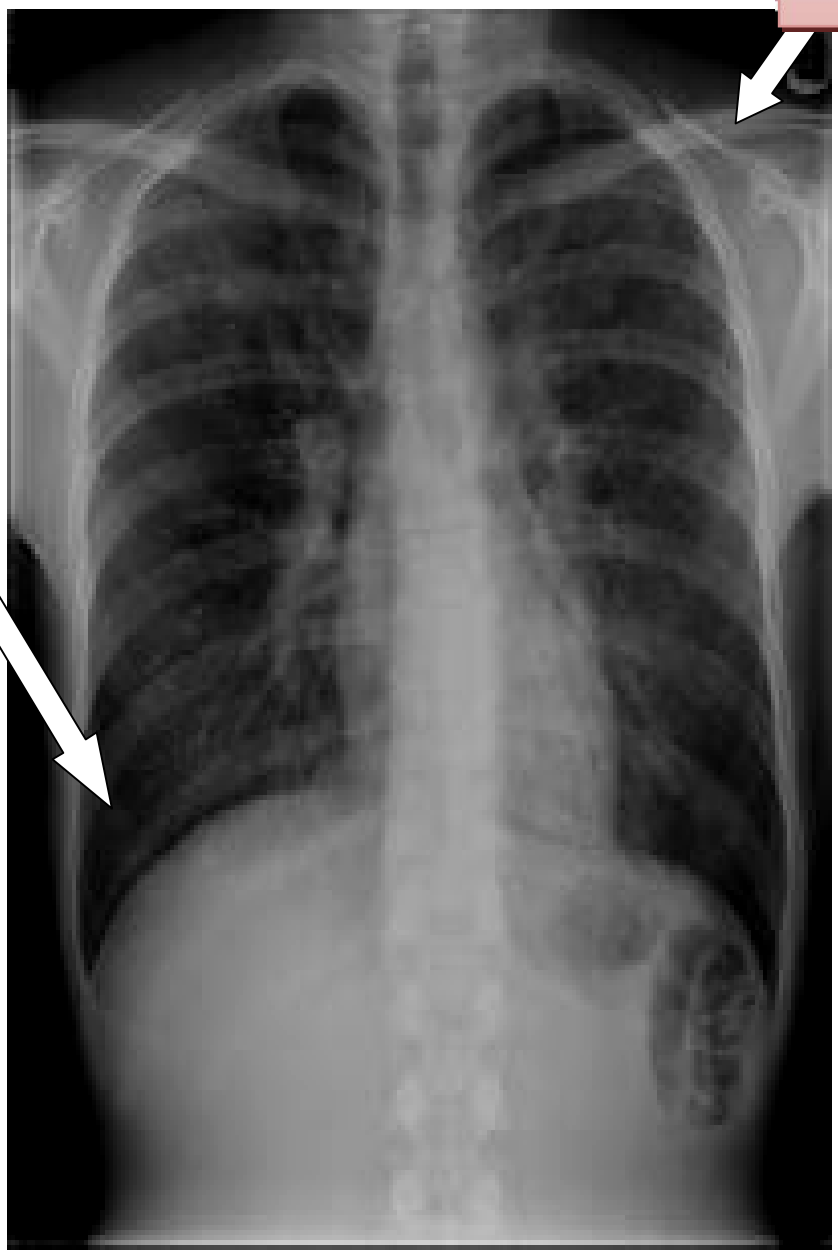
## Basics of Work :

- **Energy used** : **X ray** , an ionizing radiation
- **X ray** is from its source (X ray tube) is penetrating objects & images are formed on film.
- **Bright object,** which absorb X ray & prevent it from reaching Film is described as **Radiopaque** (eg. Bone , metals, barium, stones …..etc )
- **Dark object,** which permeate X ray & passing it to Film is described as **Radiolucent** (eg. lung , air……etc )

**In this Normal chest X ray (CXR) , Identify:**

Radioaque & Radiolucent structures

Bone is Radiopaque



Lungs are Radiolucent

## Contraindications :

- **Pregnancy**

  (Especially, early) , it can lead to **teratogenicity**.

- **Non indicated diagnosis ,**

  As you will expose patient to radiation without any benefit .

- **Contrast Hypersensitivity:** for X ray techniques using IV contrast as IVU.

## Indications :

X ray is a common used modality, & has many indications, such as diagnosis of:

- ✓ Fractures
- ✓ Foreign body inhalation or ingestion
- ✓ Basic Chest imaging
- ✓ Intestinal obstruction

- ✓ **Bone Tumors**
- ✓ Breast Imaging (Mammography)
- ✓ Urinary stones
- ✓ Perforated Gut

➲ **X ray techniques with Contrast** , as :

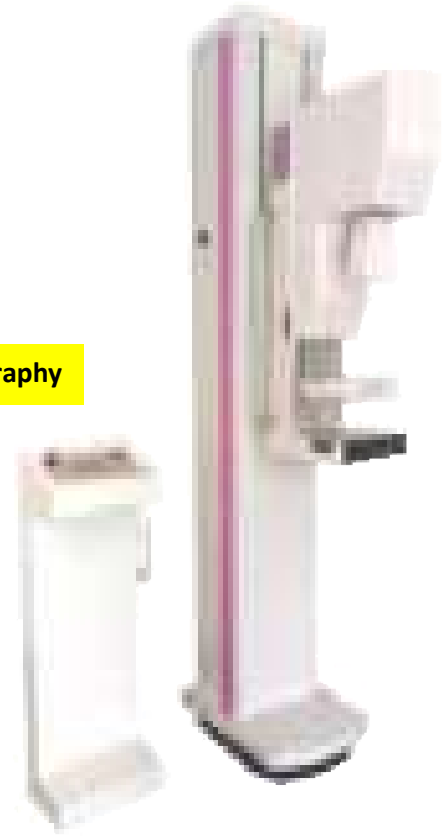
- **Barium studies** , for GIT (Barium Swallow, meal, enema)
- **IVU** (Intra venous Urography )
- **Vascular Imaging** (Angiography / Venography)
- T Tube Cholangiogram & Fistulograms

**Ionizing Radiation =** radiation that cause ionization of atoms exposed to it , so it has **hazards** on different organs espicially with higher doses of radiation & sensetive organs.

**Don't Forget**

. **X ray is mandatory** for diagnosis of any **Bone tumor**, even with using CT & MRI.

Portable X ray



Mammography

# Ultrasonography (US)

Commonest used modality in daily work

## Historical Hints :

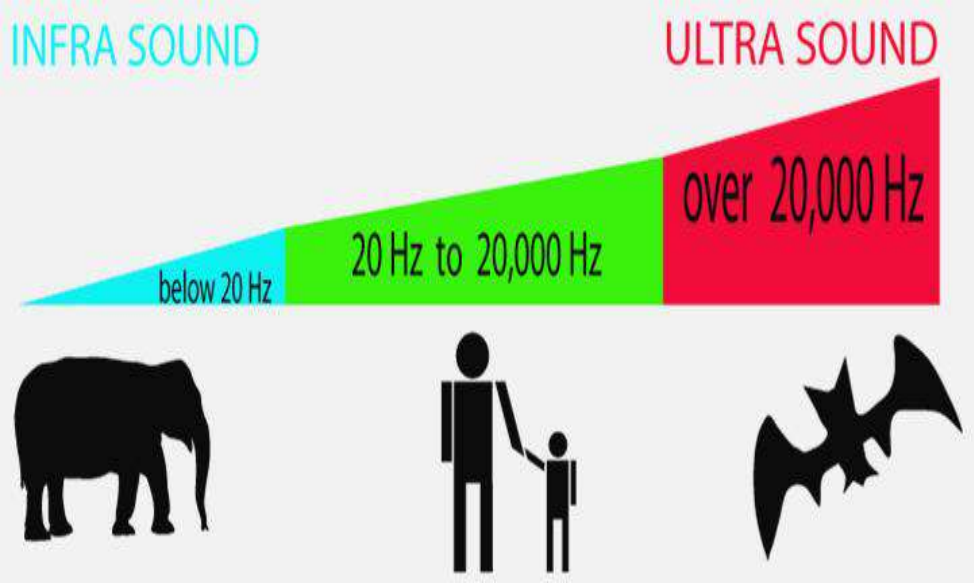
- The source of Idea of medical ultrasound is naval RADAR.
- Naturally, bats & dolphins are depending in US in hunting.

## Basics of Work :

- **Energy used** : Ultrasound (US) ,
- Ultrasound = Sound of frequency > 20.000 Hertz
- US waves are librated from probe (transducer) , penetrating patient tissues , reflected again

## Reporting terms:

- **Bright structures** = **Echogenic** or **Hyperechoic** (eg. Stones,fat)
- **Gray structures** = **Hypoechoic**
- **Dark Structures** = **Anechoic** (eg. Fluids)



## Advantages :

- Non expensive
- Non Ionizing
- Non invasive
- Real time imaging
- Diagnostic & interventional


**US image of Gall Bladder stone**

## Indications :

US have **wide range of indications**, for most of body organs & systems such as:

- **Abdominal US** : trauma, acute abdomen , tumors scan ……etc
- **Chest US** : detection of small amount of effusion *(more sensitive than X ray)*
- **Trans-cranial US:** in infants before Ant. Fontanel closure.
- Neck, Breast, Obstetric , Scrotal , Trans-vaginal, Trans-rectal, soft tissue , ……..etc
- **Color Doppler** : for examination of Vascular system



**Different Types of Ultrasonography Probes (Transducers)**

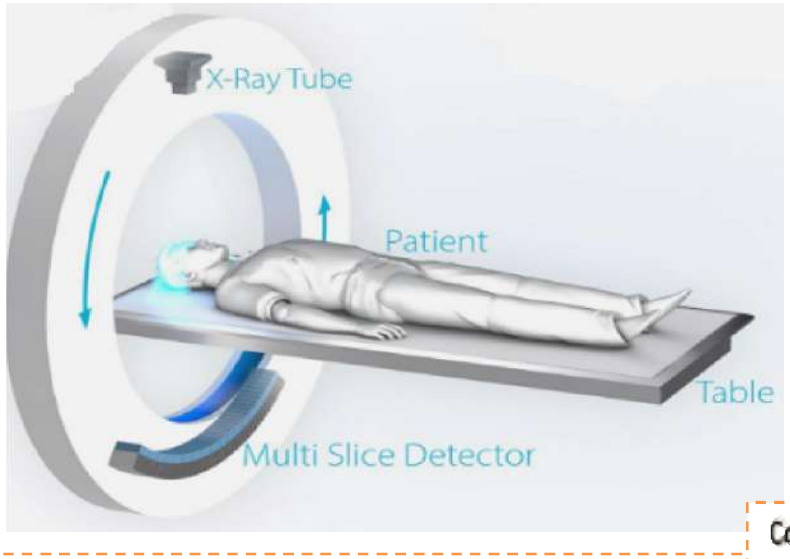
## Limitations of US use :

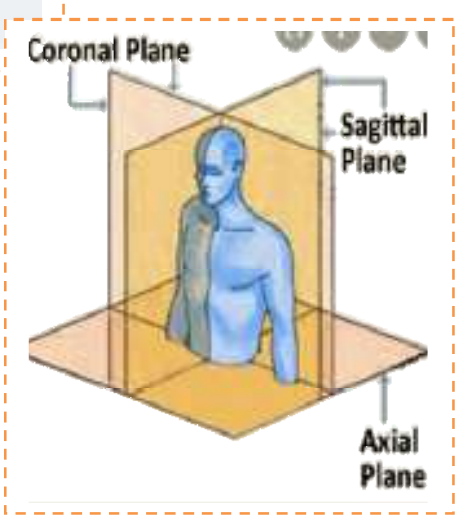
- **Gases**: Gases are scattering US waves → masking organs below it (eg. Emphysema, Intestinal gases)
- **Bandages :** as casts & postoperative bandages
- **Non co-operation**: almost all radiological examinations need calm, co-operative patient.

# Computed Tomography CT

## Basics of Work :

- **Energy used**: X ray , an ionizing radiation (higher Dose than X ray scans).
- **X ray** is librated from **rotating X ray tube**, around patient penetrating body & received on X ray sensors, → send to CT control → images are formed as a cut sections (mainly Axial scans).

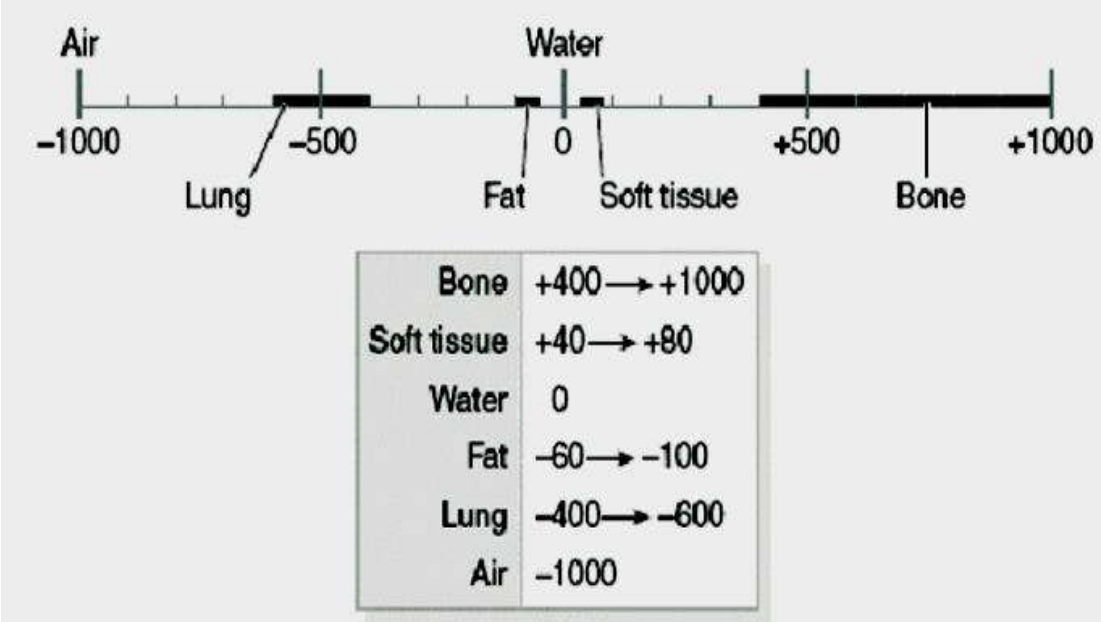


## Reporting terms:

- **Bright object,** *which absorb X ray* = **Hyperdense** (eg. Bone , metals, stones …..etc )
- **Dark object,** *which permeate X ray* = **Hypodense** (eg. , Fat , air……etc )

CT Densities of different structures is measurable , by the unit of **Hounsfield (Hu)** as described below :




| | |
|---|---|
| Bone | +400 → +1000 |
| Soft tissue | +40 → +80 |
| Water | 0 |
| Fat | −60 → −100 |
| Lung | −400 → −600 |
| Air | −1000 |

## ✍ Indications :

CT is usually indicated after **X ray** & **Ultrasonography** are not solving the problem or reaching definite diagnosis , many indications of CT such as :

- **Neuro Imaging :** Stroke, Trauma, Brain Tumors , vascular lesions, congenital malformations…..etc
- **Chest imaging** : Infections, trauma, Tumors ……etc
- **MSK imaging**
- **Renal Imaging :** stones , tumors, congenital diseases ……etc
- **Trunk Imaging**
- **Vascular Imaging:** CT angiography for vascular diseases.

**Don't Forget**

**IV Contrast is mandatory for any CT brain for diagnosis or follow up of any BRAIN TUMORS.**

## Contraindications:

☒ **Pregnancy** : especially early

(Patient or relative)

☒ **Contrast Hypersensitivity**


**X ray & CT**

**Are**

**Contraindicated**

**in Pregnancy**

**CT Machine**

# Magnetic Resonance Imaging MRI

## Basics of Work :

- **Energy used**: Magnetic Field + Radio Frequency
- Depending on **Magnetic Resonance Phenomena**
- **Reporting term** = Signal Intensity
  - ✓ Bright object = **Hyper intense**
  - ✓ Dark object = **Hypo intense**

### Summary of MRI Work Physics

للإطلاع فقط

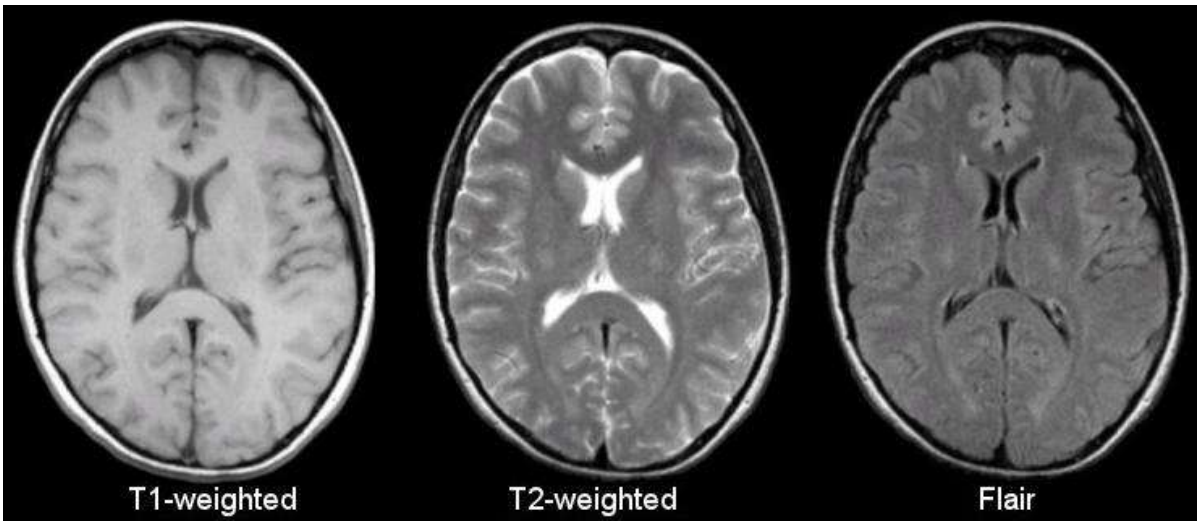
- Protons has +Ve charge.
- Hydrogen nucleus contains 1 **Proton**.
- Protons are rotating → Act as small magnet → Magnetic field around.
- **(Body net magnetization = near 0)** - Although all these H protons, as small magnets within the body , But due to direction of rotation is variable & against each others.
- **Magnet** → Uniting the direction of rotation of protons.
- **Coil** → **R**adio**f**requency **"RF"** → Change angle of protons by acquiring energy
- **"RF"** stop → Protons miss energy → apparatus receive energy & forming Image from

| Types of MRI | |
|---|---|
| • **According to shape:** | • **According to Magnet Type :** |
| ▪ Open<br>▪ Closed<br>▪ Dynamic<br>▪ Extremity | ▪ Permanent<br>▪ Electeric<br>▪ Super magnet |

## ⇨ Why to use Open MRI :

- For Cases of **Claustrophobia** & **Morbid Obesity.**


***MRI Sequences & appearance of different structures***




*Normal MRI in Different Sequences*

## Contraindications: Any Ferromagnetic material

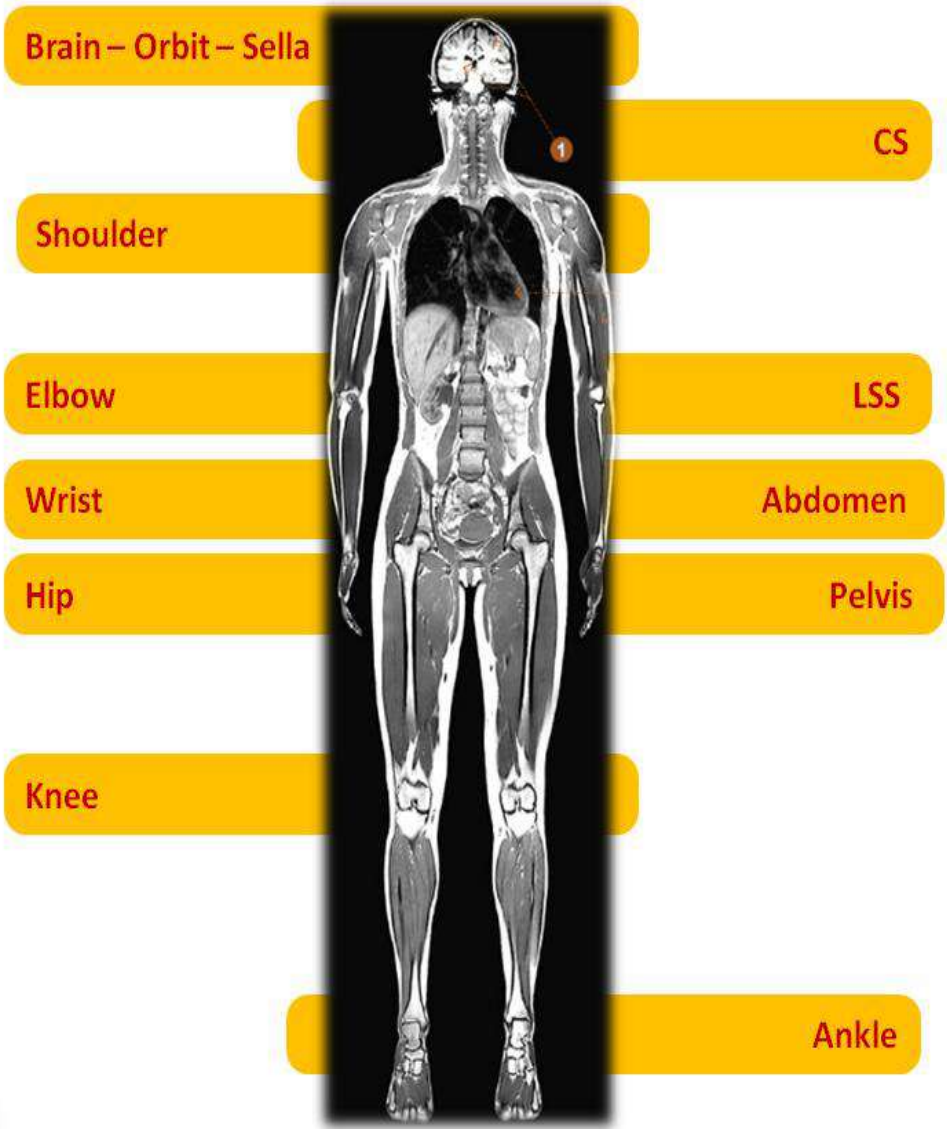
- ☒ Pacemaker (Fatal)
- ☒ Any Iron FB
- ☒ Contrast Hypersensitivity
- ☒ Fire arm / Vascular metallic clips

Don't Forget

MRI is large powerful Magnet


Warning of Use seen at every MRI Unit

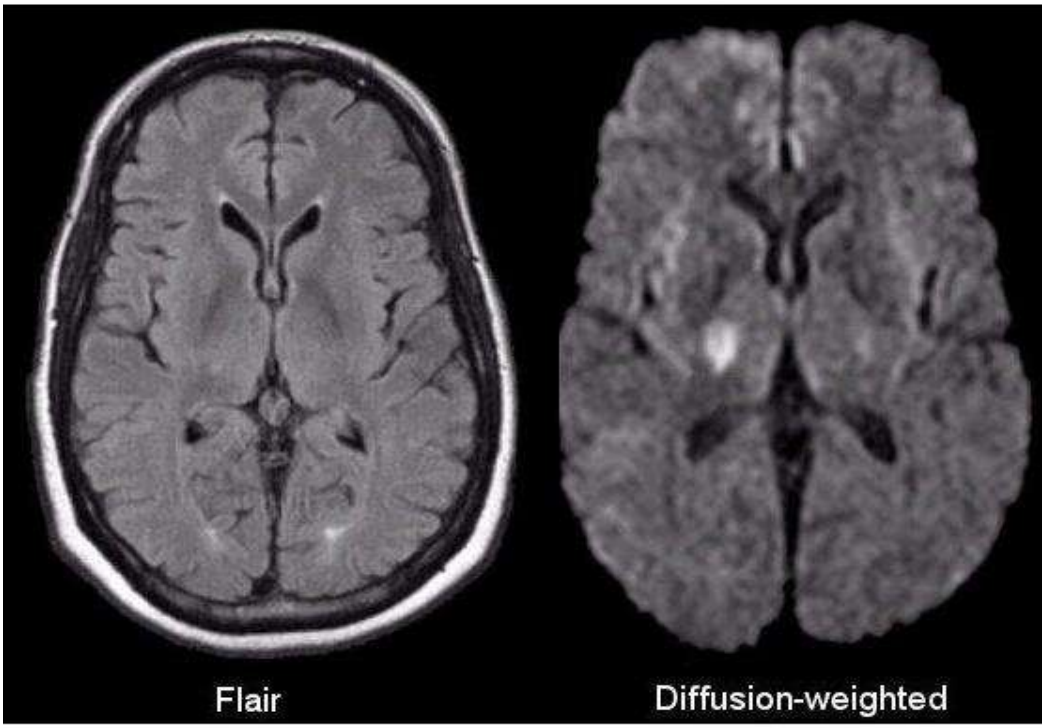
## Indications: (Many organs, Many Systems)



## Hints about Indications:

✓ **DW** (Diffusion Weighted MRI)

**The fastest Method to detect Acute cerebral infarction.**




Note the Acute Infarction Only Seen on DWI

## Advantages of MRI

- ✓ **Non Ionizing Radiation**
- ✓ **Non iodinated Contrast (Gadolinium)**
- ✓ **Best soft tissue differentiation** by **Multi Sequences**
- ✓ **Multi planner** : scan at any direction

**MRI** *Is*

**Multi planner**

**Multi Sequences**

## Disadvantages of MRI

- × **Expensive / Limited availability**
- × **Limited use in Lung / cortical bone Imaging**
- × **Ferromagnetic Contraindications**
- × **Long scanning time**

# Contrast

**Contrast:** Injected or ingested material that improve radiological detection of certain structure or organ.

## Type of contrast materials

**[A] Barium sulphate:** for evaluation of the gastrointestinal tract

**[B] Water soluble contrast materials**

- **Oral use :** Gastrographin
- **IV injection :** Urographin ,Telebrix


**[C] Oily contrast media :** Lipiodol ultra- fluida


Radiological examinations are generally Expensive +/- Hazards

So please .....

**Consult Radiologist before you chose the diagnostic modality.**

# Basics of CNS Imaging

## Imaging Modalities of CNS

- ✓ **CT :** Commonest Modality , & initial for assessment.
- ✓ **MRI :** usually used when CT is non-conclusive
- ✓ **Trans cranial US:** For initial assessment of hydrocephalus in infants.
- ✓ **X ray :** Limited use

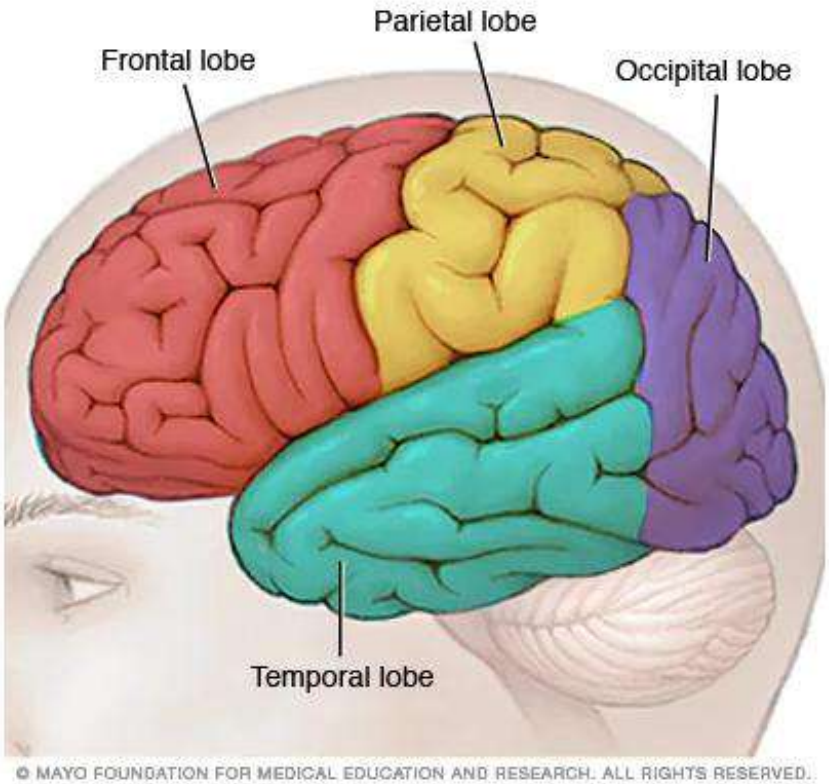
**…….. & Others**

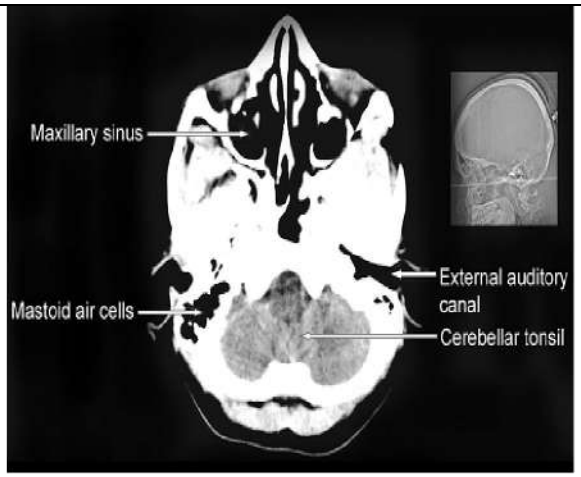
✍ **Don't Forget**

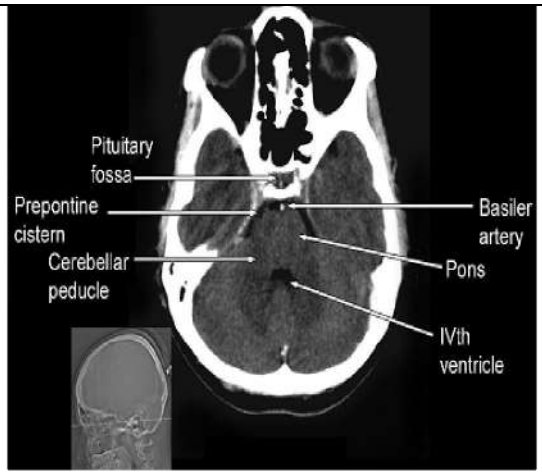
**CT is contraindicated in Pregnancy**

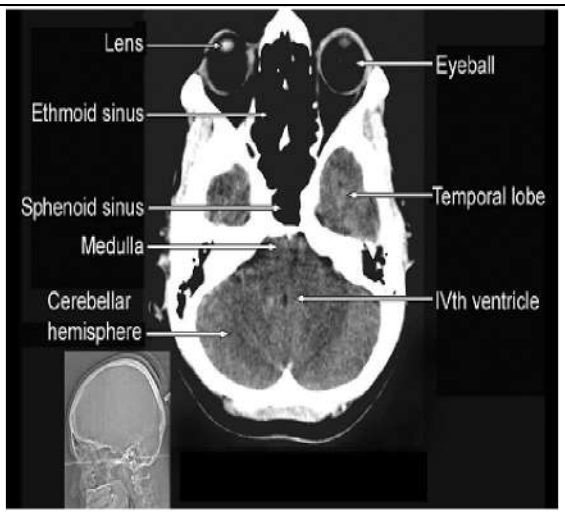
**MRI is contraindicated in pacemaker & Ferromagnetics**

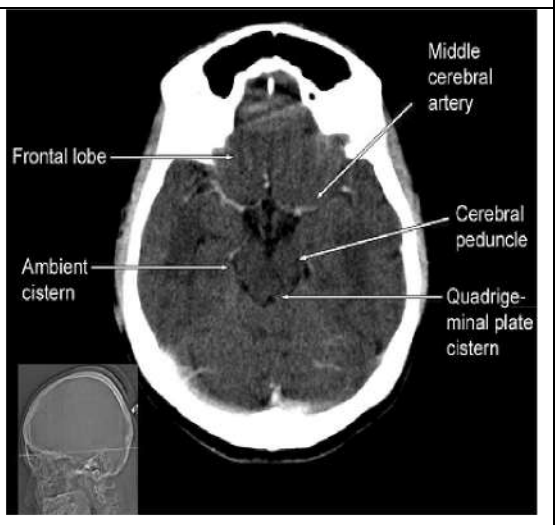
## Normal CT Brain Anatomy

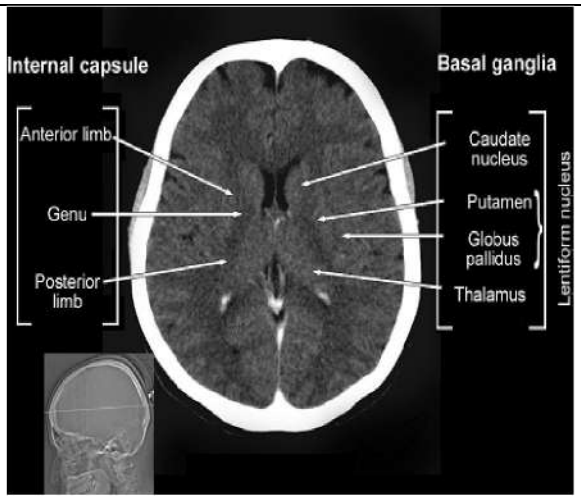


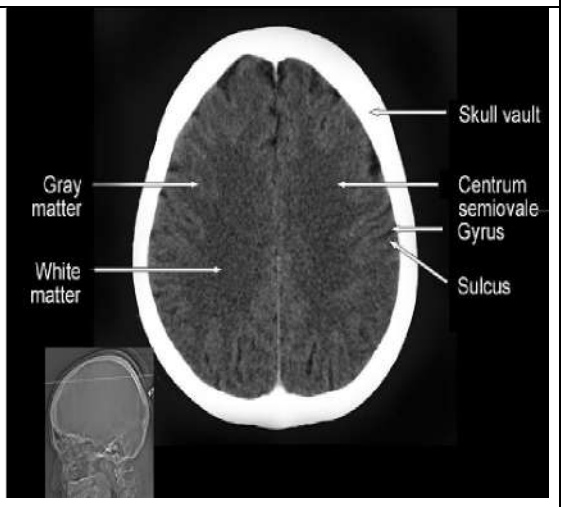

Maxillary sinus
External auditory canal
Mastoid air cells
Cerebellar tonsil


Pituitary fossa
Prepontine cistern
Basiler artery
Cerebellar peducle
Pons
IVth ventricle


Lens
Eyeball
Ethmoid sinus
Temporal lobe
Sphenoid sinus
Medulla
IVth ventricle
Cerebellar hemisphere


Middle cerebral artery
Frontal lobe
Cerebral peduncle
Ambient cistern
Quadrige-minal plate cistern

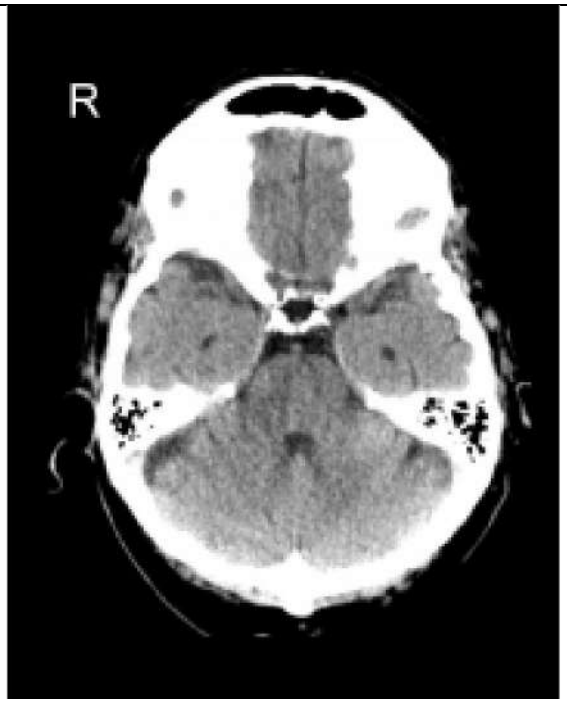

Internal capsule
Basal ganglia
Anterior limb
Caudate nucleus
Genu
Putamen
Globus pallidus
Posterior limb
Thalamus
Lentiform nucleus


Skull vault
Gray matter
Centrum semiovale
Gyrus
White matter
Sulcus

**Practical Question:**

**What is CT window?**

**Is imaging setting of the same cut section make cretin organ seen better**

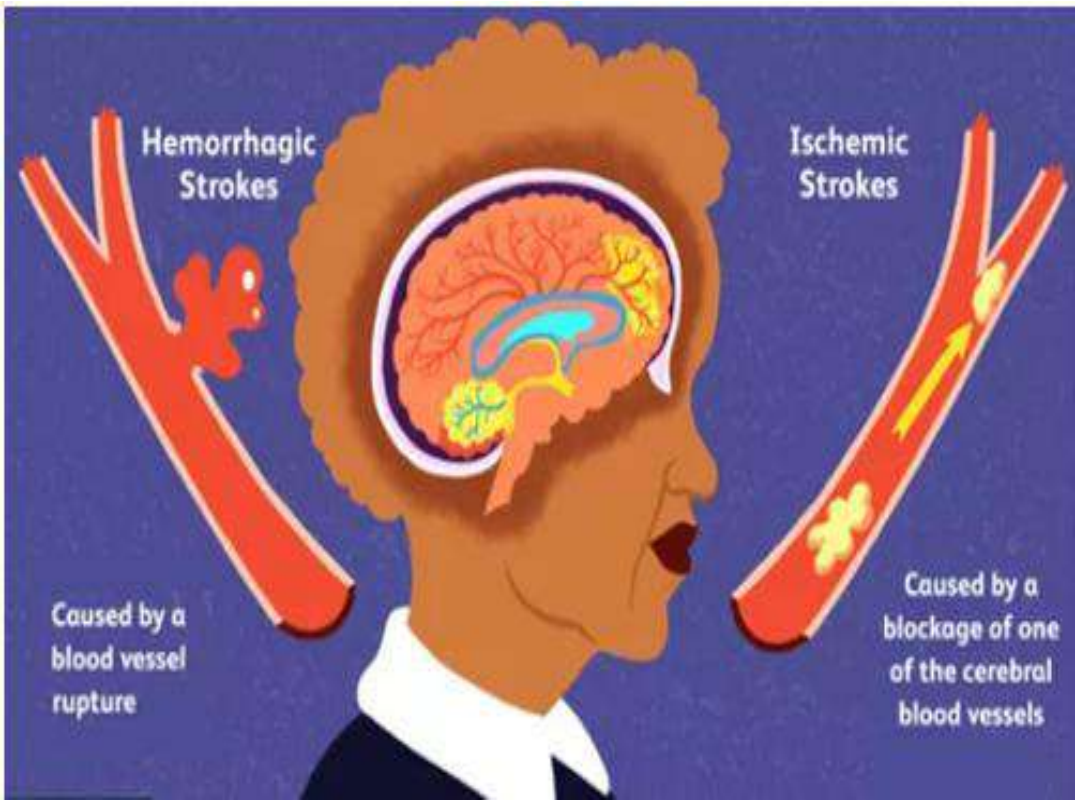
| | |
|---|---|
|  |  |
| **Brain Soft Tissue window** | **Brain bone window** |

# CVS (Cerebro-Vascular Stroke)

® **CVS :** interruption of the blood supply to any part of the brain

® **Types :** It may be

- **Ischemic** (Infarction)
- **Hemorrhagic** ( intra cranial Hemorrhage)




**Don't Forget**

® **Clinical Picture is the first Key for Radiological Diagnosis**

## ® Clinical Picture :

- **Neurological deficit :** according to site of lesion
  + Other Findings

## ® Imaging Modalities:

- **CT :** Main method

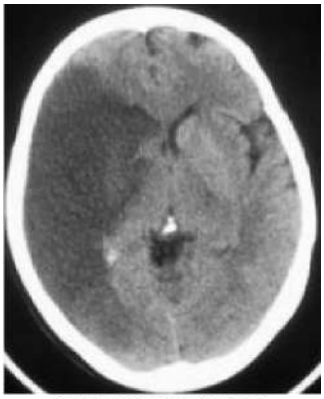
| | |
|---|---|
| **Infarction** | Hypo dense cortical lesion<br>*(the more duration , the more hypo dense)*<br>**So Chronic infarction appears as CSF density** |
| **Hemorrhage** | Hyper dense area of fresh blood density. **( 60 : 90 Hu)** |

**Cerebral Infarction may not appear in CT before 24 h**

**DW MRI can detect cerebral infarction after 2 min**

- **MRI:** Less commonly used than CT

| | |
|---|---|
| **Infarction** | **Hypo Signal** cortical lesion in **T1** &<br>**Hyper signal** in **T2** & **FLIR**<br>***DW :*** *restricted diffusion* |
| **Hemorrhage** | Variable appearance according to duration |


ACUTE INFARCTION


CHRONIC INFARCTION


I C Hemorrhage

➲ **Practical Question: What is mass effect?**

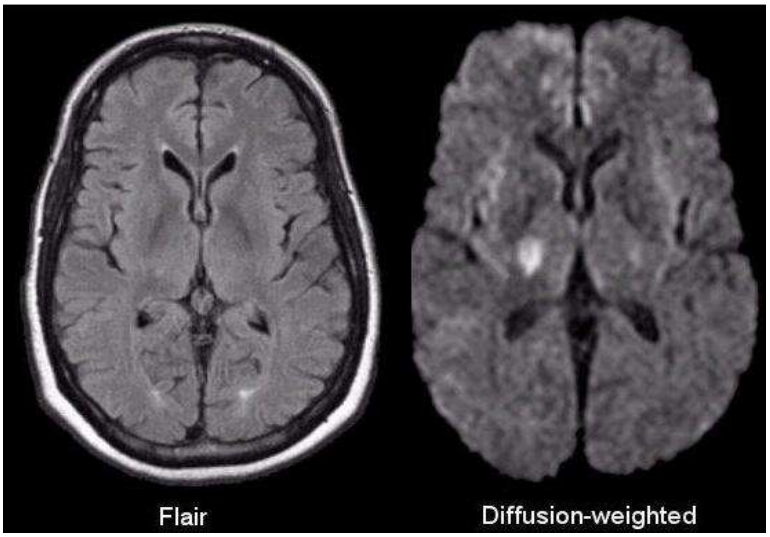
**Mass effect** = the effect of **S**pace **O**ccupying **L**esion **(SOL)**

As Tumor, Haemorhage , Abscess ….. etc

SOL → Mass effect (According to its size & Site)

**Mass effect =**

- ➲ Effacement of cortical Sulci
- ➲ Compression of ventricle
- ➲ Shift of medline




*Rt Thalamic Infarction appears as area of restricted diffusion in DW MRI*

➲ **Practical Question:**

**Why acute cerebral infarction is causing Mass effect?**

➲ **By related cerebral edema**

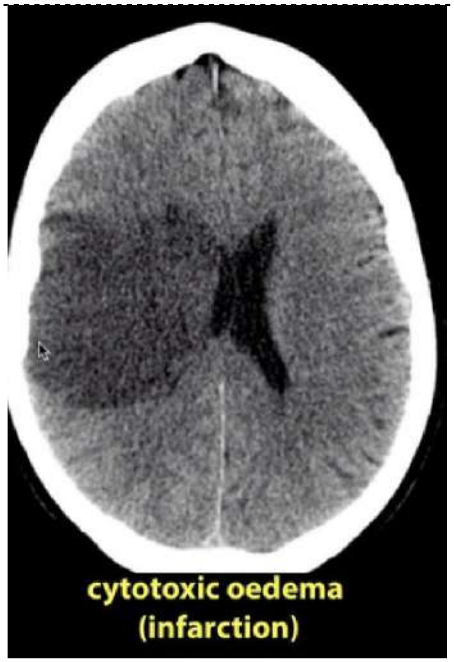
**Large Lt cerebral Infarction**

**Notice its mass effect due to associated cerebral edema.**

# CEREBRAL EDEMA

**2 Main types:**

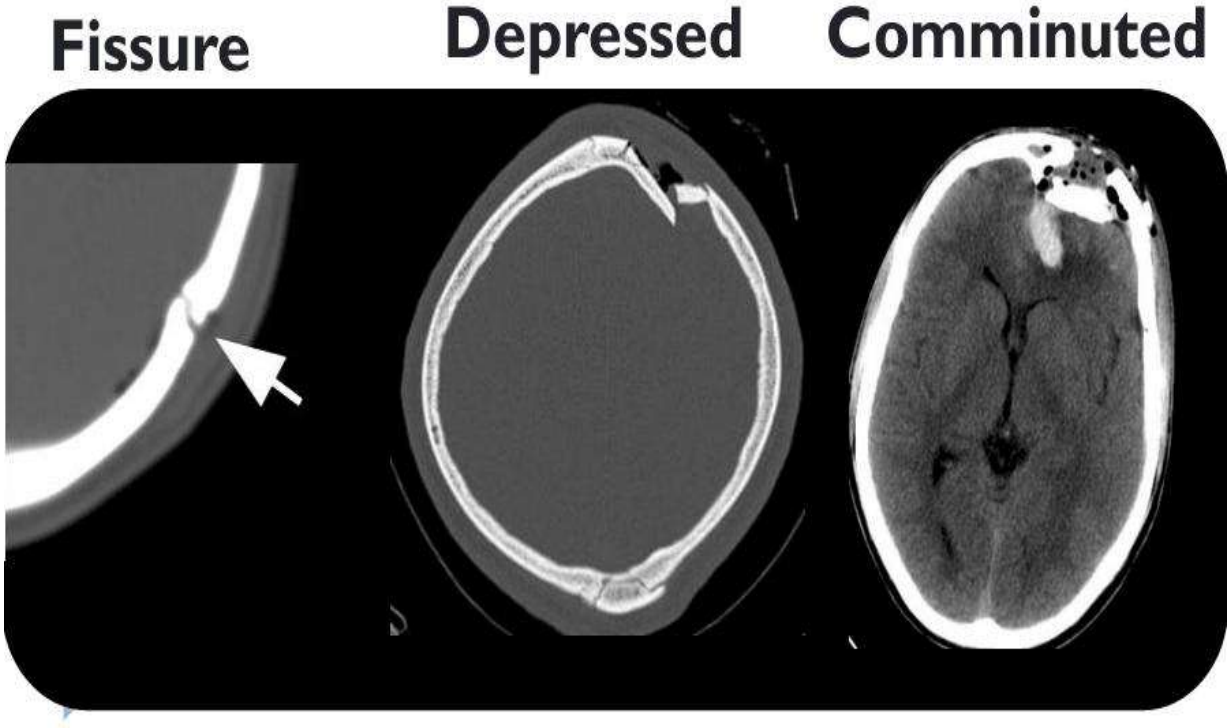
**- Cytotoxic & - Vasogenic**

| | Vasogenic | Cytotoxic |
|---|---|---|
| Pathology | Extracellular accumulation of fluid | Cell swelling caused by intracellular accumulation of fluid |
| Etiology | SOL (Tumors, Abscess….etc) | Cerebral infarction |
| CT Picture | Fingers like area around lesion   | Hypodense patch around lesion   |

# Head Trauma

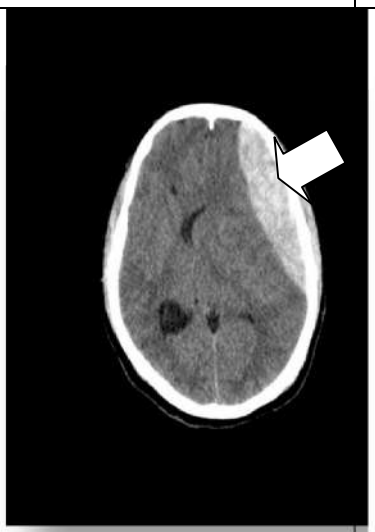
**Head trauma can lead to:**

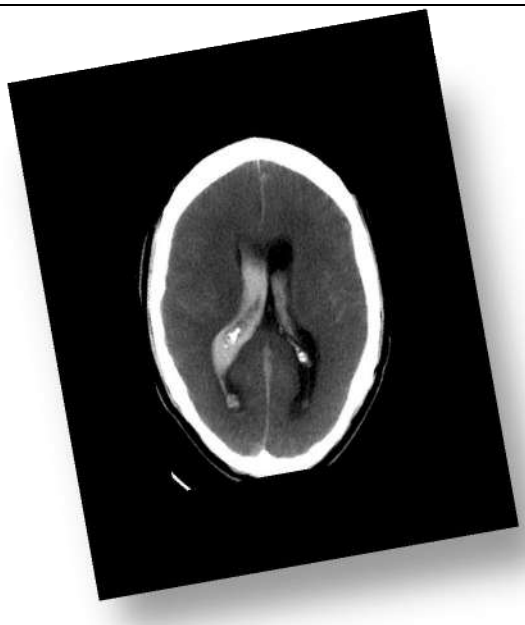
- ✓ **Skull Fractures :** *(Seen in bone window)*
  - **Fissure,**
  - **Depressed ,**
  - **comminuted &**
  - **skull base fractures**
- ✓ **Hematomas :**
  - **Extradeural ,**
  - **Subdural**
- ✓ **Cerebral Contusions**




**Types of Skull Fractures**

# Types of Intra cranial Hemorrhages

| Extra dural | Sub dural | Sub arachnoid |
|---|---|---|
|  |  |  |

| Intra cerebral | Intra ventricular |
|---|---|
|  |  |

| Hematoma Type | CT Appearance |
|---|---|
| Extra dural | Lens shape or Biconvex shape hematoma |
| Sub dural | Crescent Shape ( Inner convex border ) |
| Sub Arachnoid | Fresh blood density smearing sulci |
| Intra ventricular | Fresh blood density inside ventricles |

# CECT

# Contrast Enhancing CT Brain

## ✍ Contrast:

IV , Iodinated material eg. *Urografin, Omnepaque or Ultravist* .

## ✍ Indications :

- ✓ Brain Tumors: **MANDATORY** for suspicion, diagnosis or Follow up.
- ✓ Brain Abscess & infections
- ✓ Vascular Imaging

## Patterns of Enhancement

# Basics of Chest Imaging

# Chest Imaging Modalities

- ✓ **X ray (CXR ) :** Initial & basic
- ✓ **CT :** Commonest Modality
- ✓ **MRI :** Limited use (only for assessment of chest wall tumors invasion)
- ✓ **Chest US:** mainly For Detection of Small amount of effusion & **Aspiration under US guide**.

**…….. & Others**

✍ **Again …… Don't Forget**

**CT is contraindicated in Pregnancy**

**MRI is contraindicated in pacemaker & Ferromagnetics**

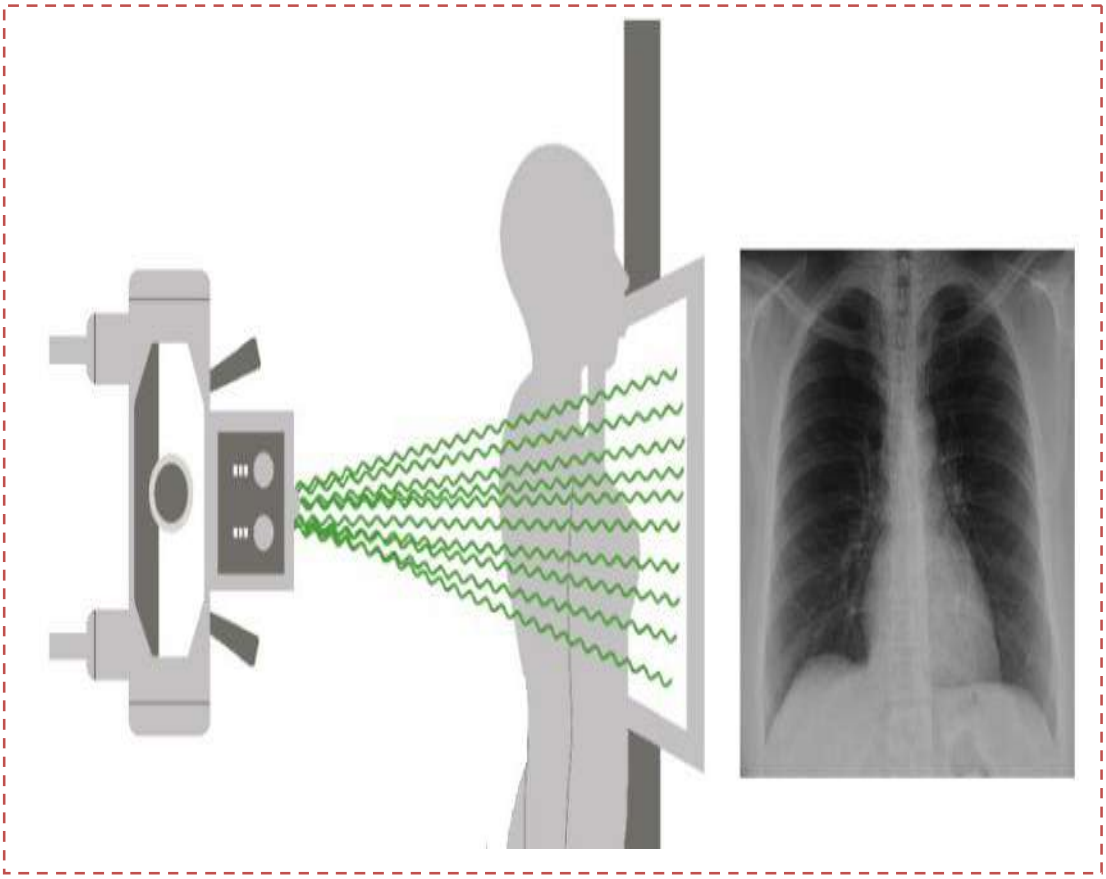
# CXR (Chest X Ray)

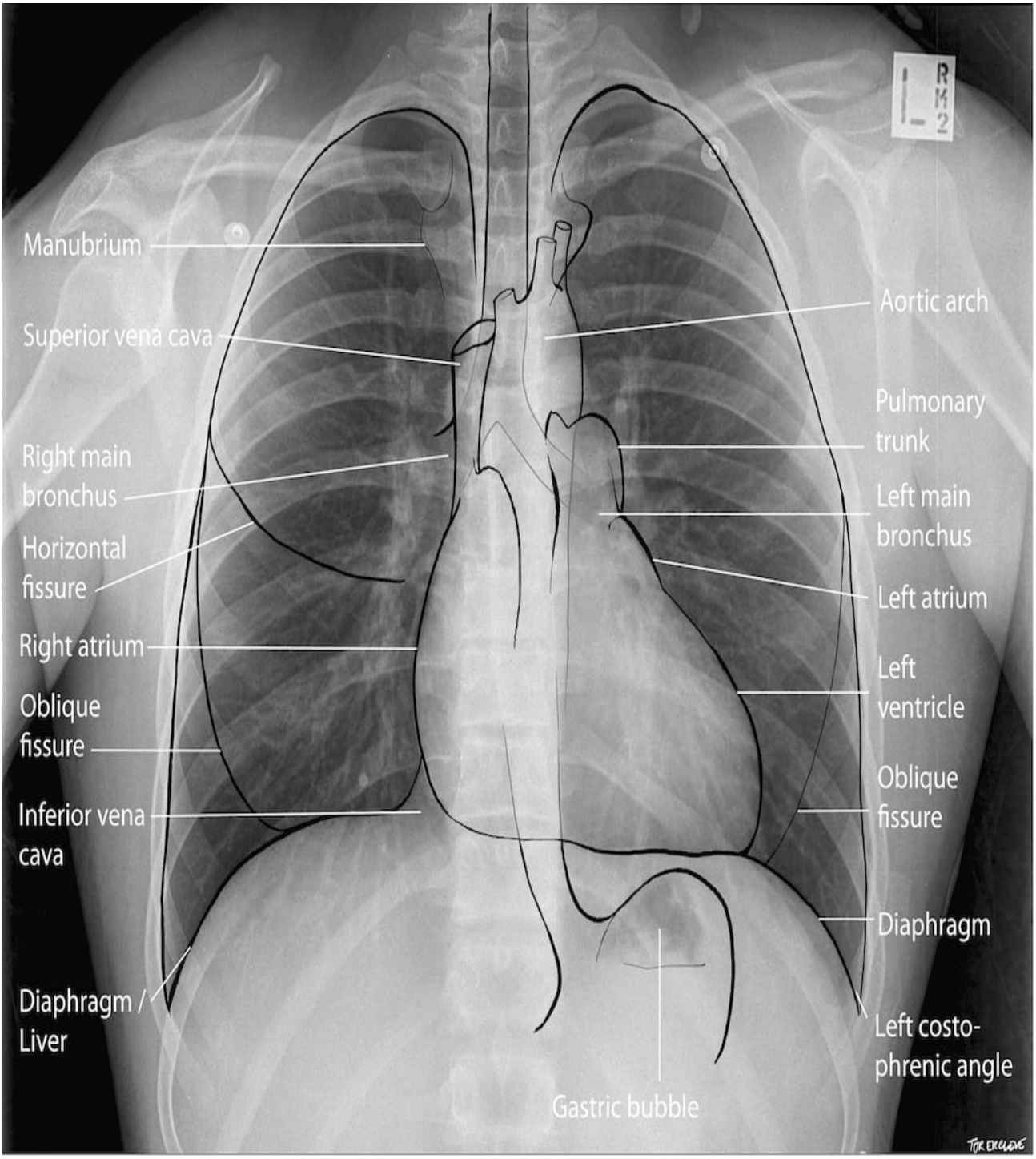
® **Basic radiological modality** for chest assessment

® Indicated For initial assessment of most chest diseases

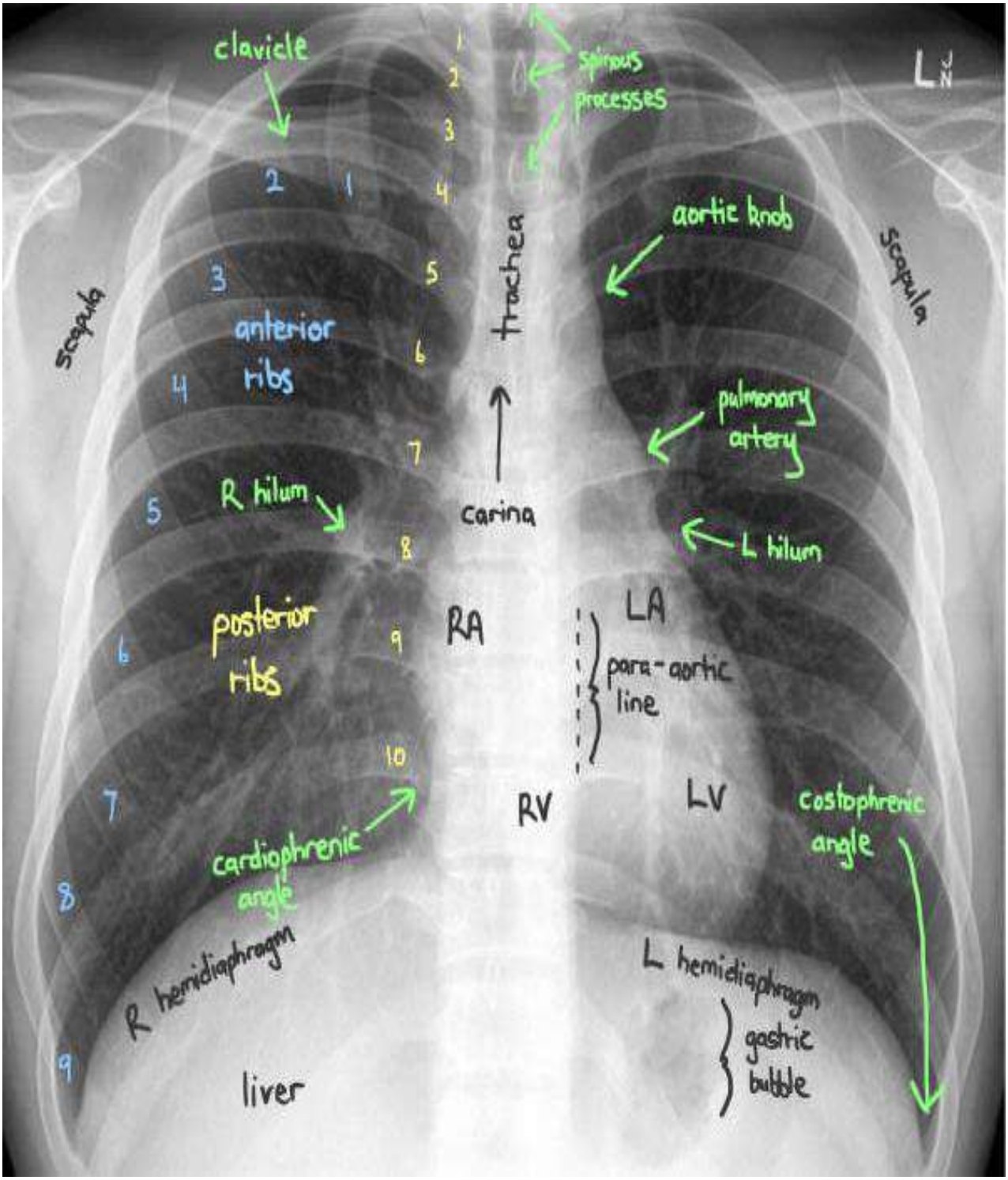
® Understanding of normal CXR anatomy & pathological descriptive terms is mandatory for good assessment of CXR.

® **P**ostro – **A**nterior view (**PA**) is the basic projection (*See the Figure*)






**Normal CXR Anatomy**

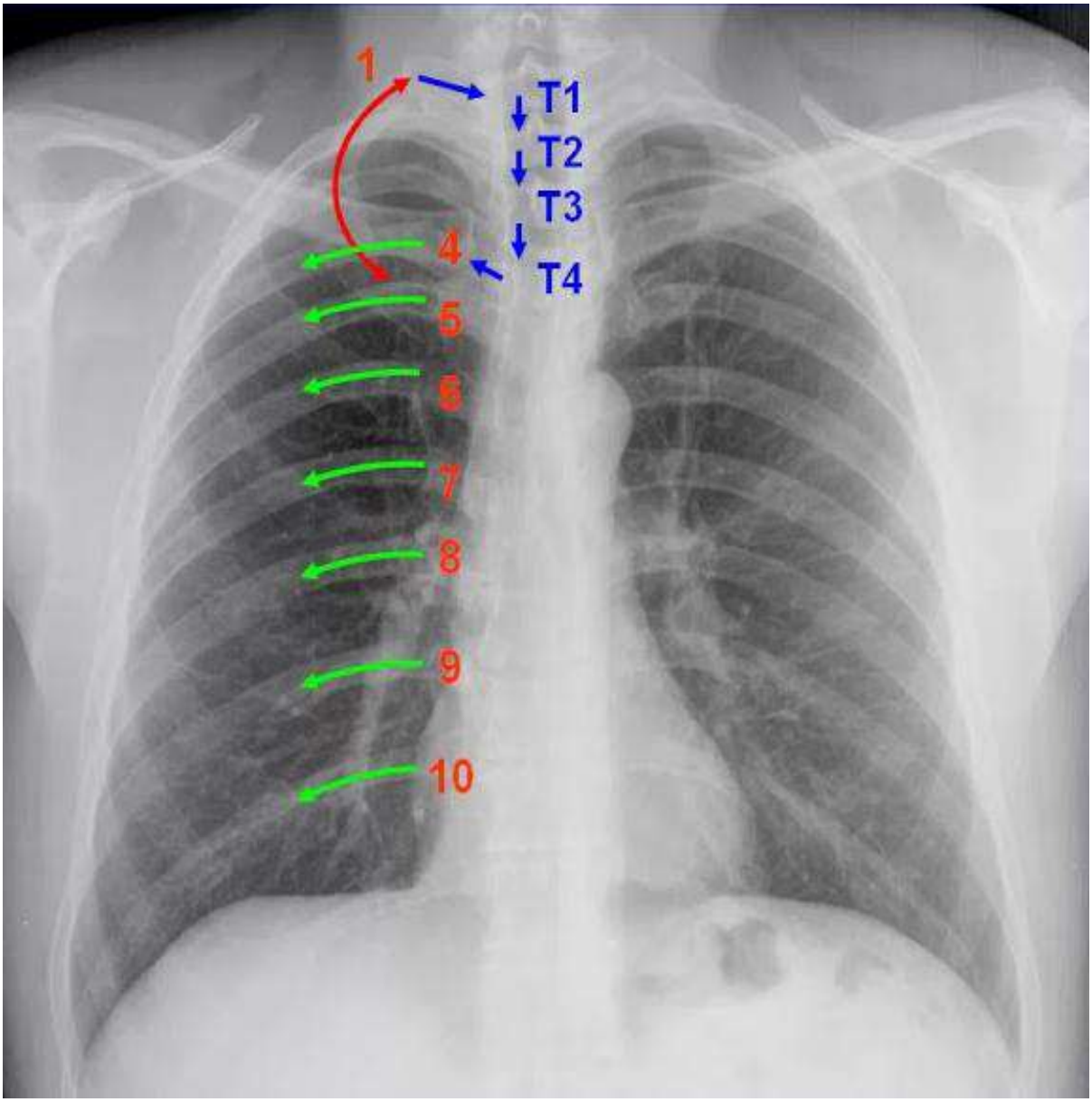


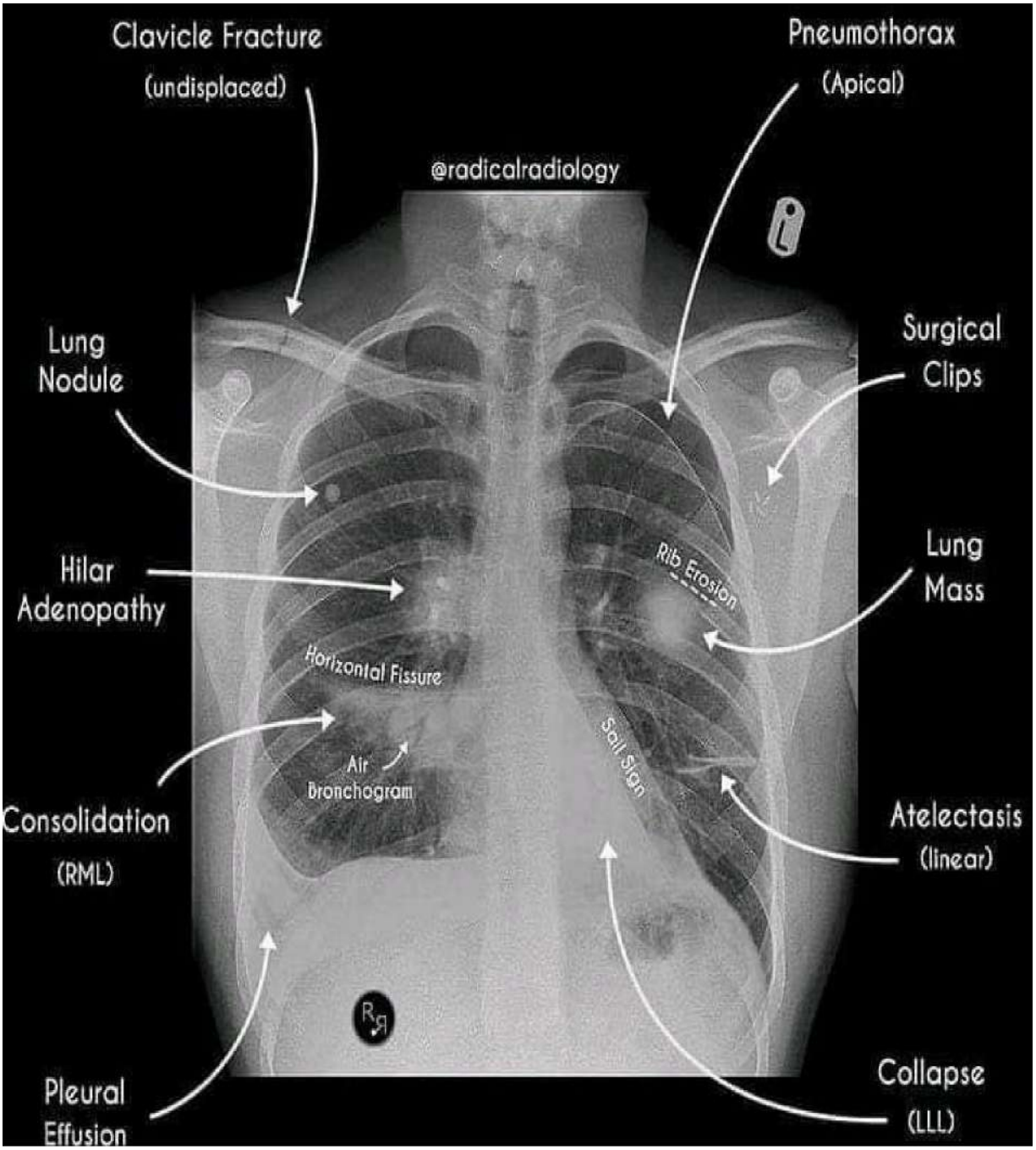

**Normal CXR Anatomy**

**Practical Question :**

## How to count Ribs?

**Begin from posterior to anterior from 1st rib & downward**






- **Main lesions of CXR**

**NB** CT examination of the chest should be the next step if you can not accurately diagnose any pulmonary lesion

® **Don't Forget :**

**Clinical History & finding is the key for radiological Diagnosis**

## In CXR:

**Item to be evaluated:**

- **Lung parenchyma**
- **Costophernic sinuses**
- **Cardiac** size and shape
- **Chest wall** including ribs, scapulae, clavicles and spine
- **Extra thoracic** soft tissues specially
  - Shoulder joints
  - Lower neck
  - Breast shadows [females]

## Chest Pathology

## FOCAL LUNG LESIONS X rays

**4 types of focal lesions**
- Nodules
- Masses
- Patches
- Cavities

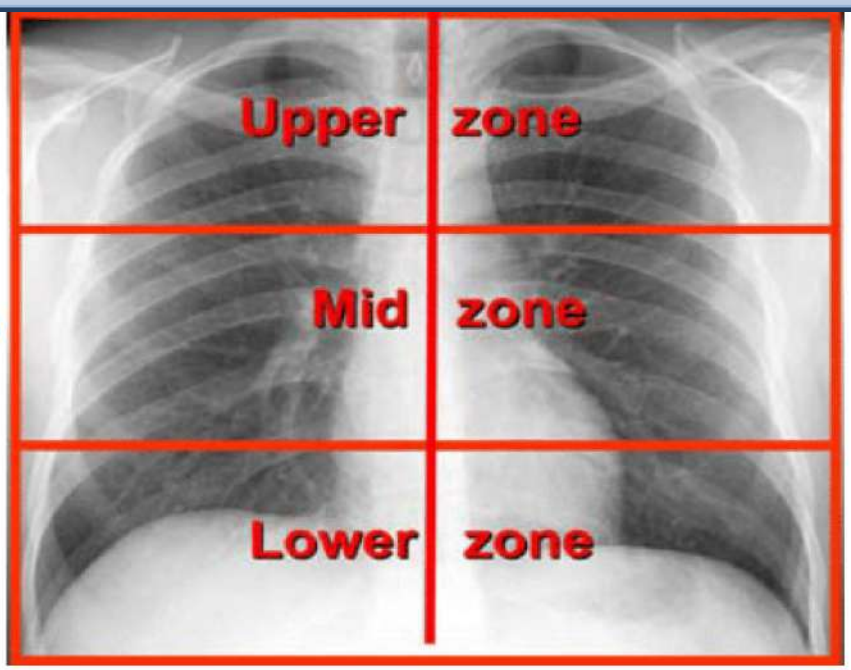
✓ **Nodule :** well defined focal lung Lesion , **less** than 3 cm

✓ **Mass :** well defined focal lung Lesion , **More** than 3 cm

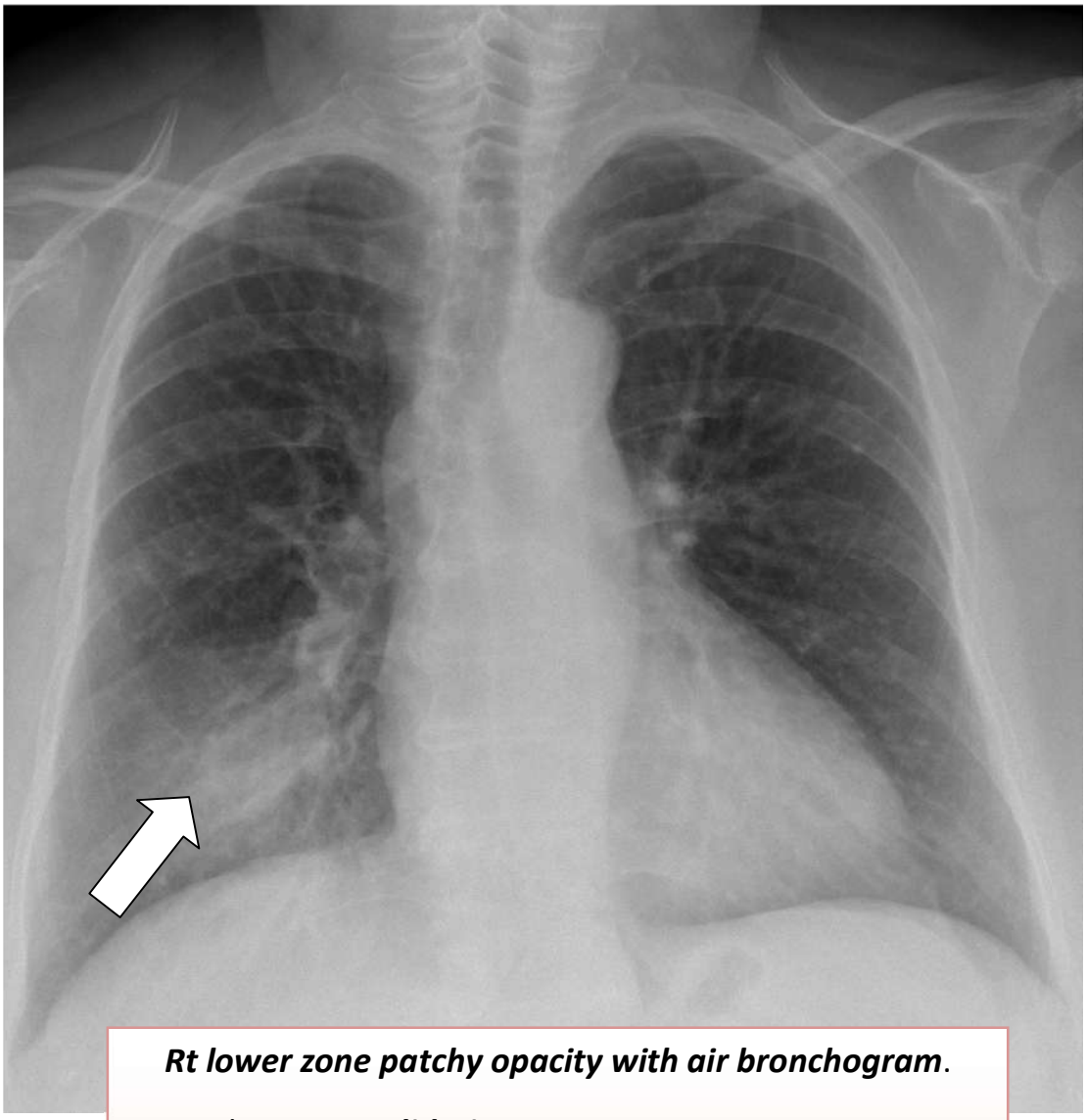
**Lt upper zone, peripheral lung nodule**

**Lt upper zone, lung mass**

## Q. What are CXR lung Zones?



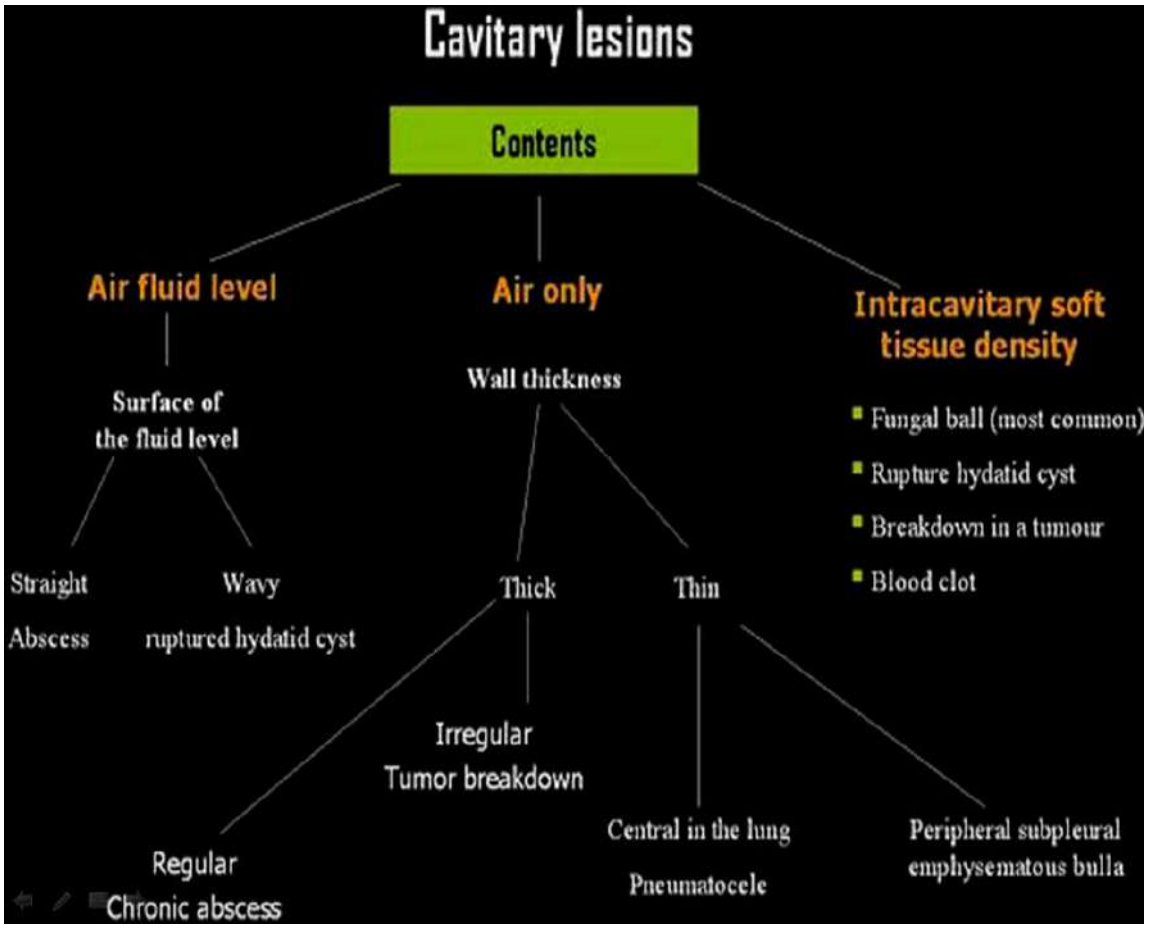
## PATCHY OPACITY [Ill- defined lesion showing air bronchogram]

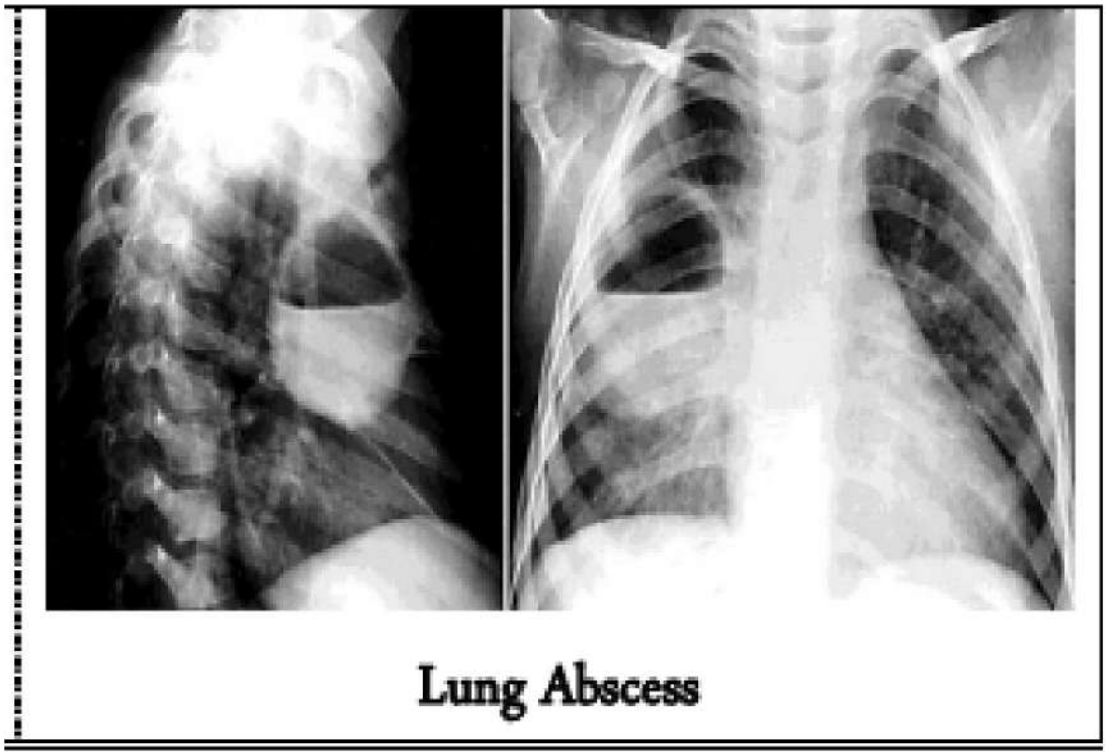


***Rt lower zone patchy opacity with air bronchogram***.

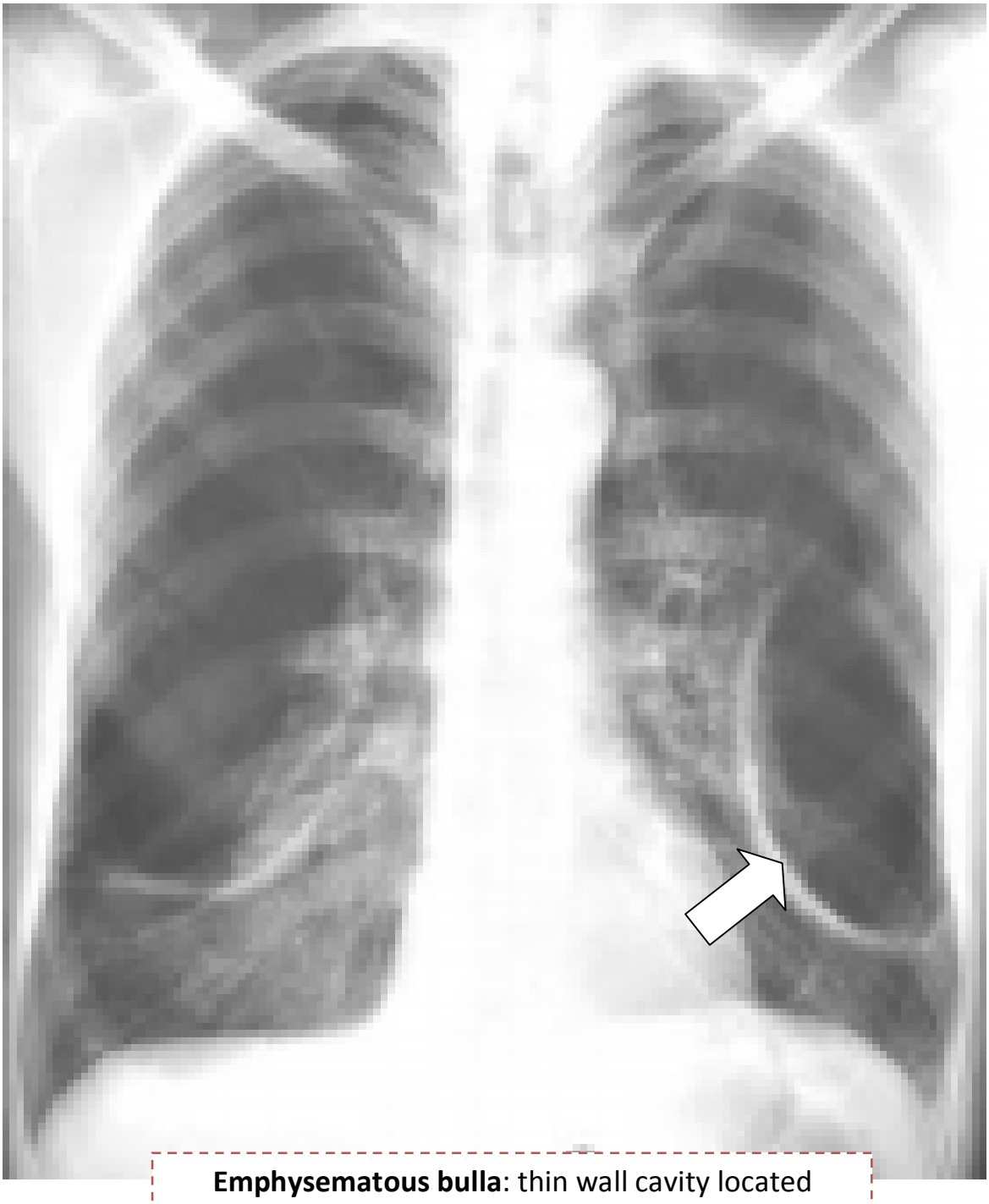
- Patch + = **Consolidation**
- Usually Pneumonia.
- Patch may be single or multiple
- **Air Bronchogram =** Patent airways between alveoli filled with fluid.

## CAVITARY LESION [A well defined lesion that is totally or partially containing air]



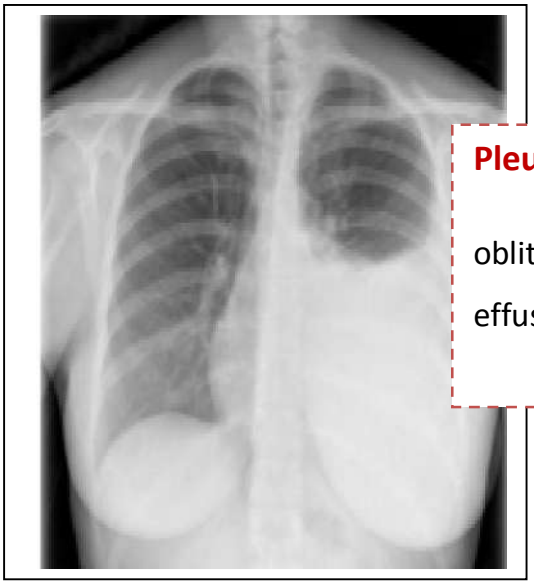



Lung Abscess



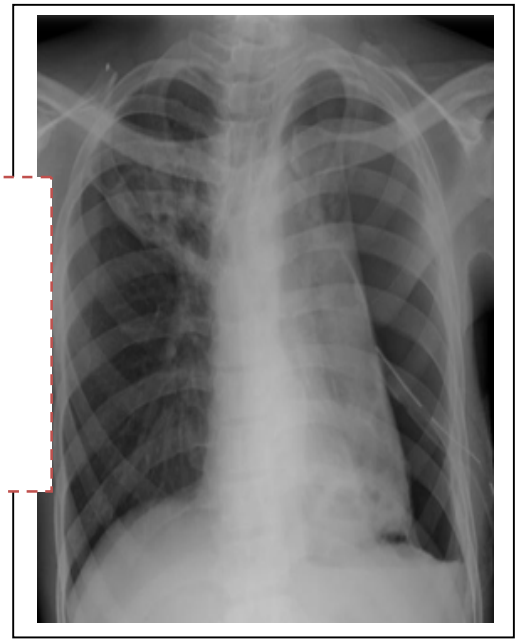
**Emphysematous bulla**: thin wall cavity located peripherally at lt lower zone near the chest wall

# Pleural Pathologies



**Pleural effusion:** *(Fluid in pleural cavity)*

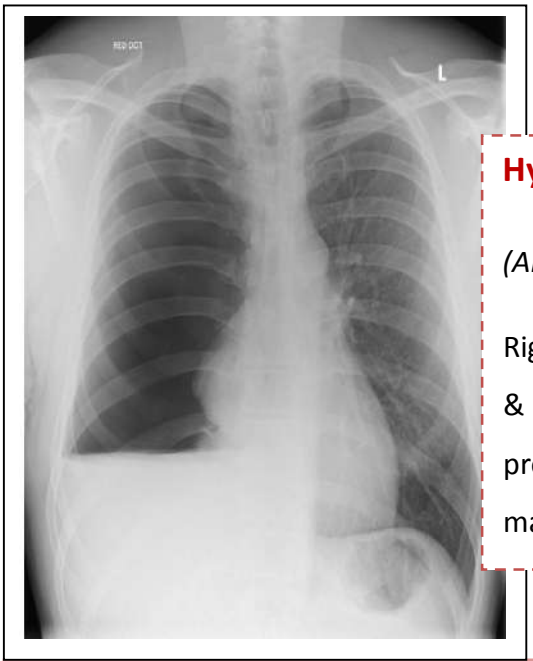
obliterated left costophernic angle by pleural effusion with upper border raising to axilla



**Pneumothorax :** *(Air in pleural cavity)*

Left side jet black lucency with no lung marks.

*Notice underlying lung collapse → No shift of mediastinum.*



**Hydro-pneumothorax :**

*(Air& fluid in pleural cavity)*

Right side pleural effusion obliterating Rt CP angle & lower lung zone, with straight upper border & proximal large jet black air lucency with no lung marks.

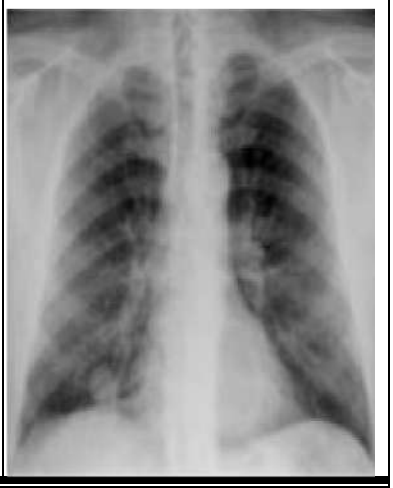
**Q. what is the difference between upper borders of Pleural effusion & Hydro-pneumothorax …. & Why ?**

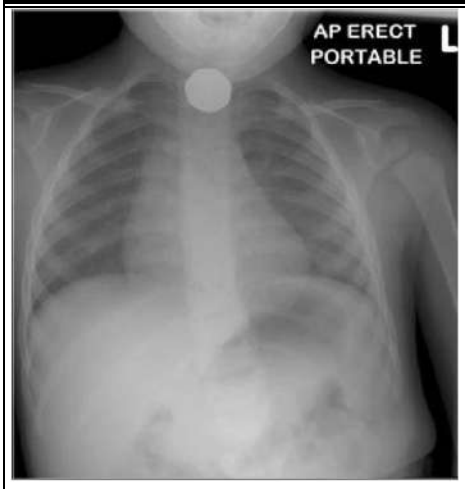
# Chest X ray Illustration Cases

**Bilateral Multiple lung masses**

**Bilateral Multiple lung nodules**

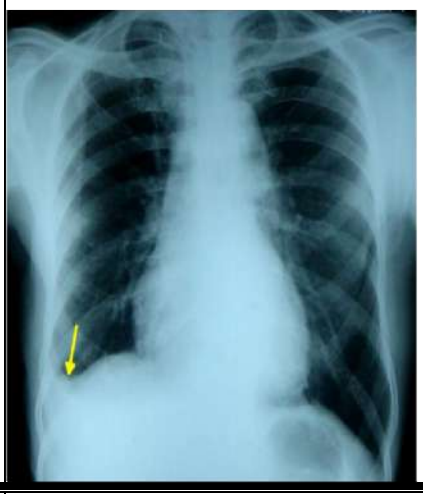
**Rt lower lung Nodule**

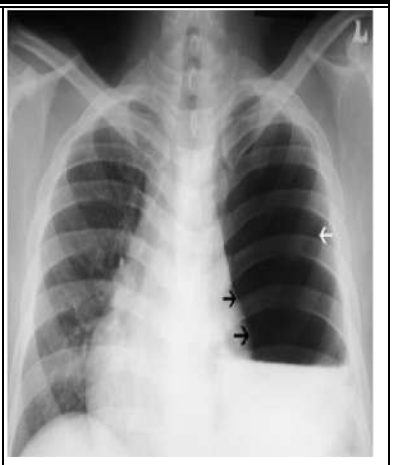





**F.B. Inhalation**

**Rt Minimal Pleural Effusion**

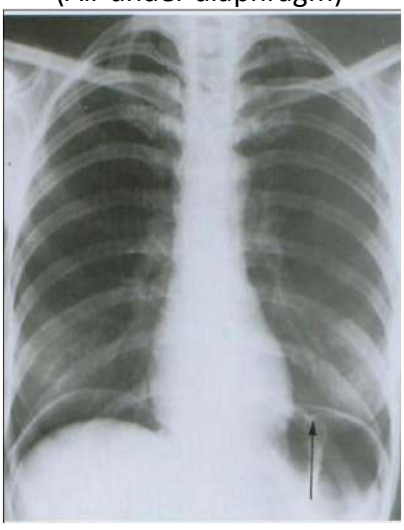




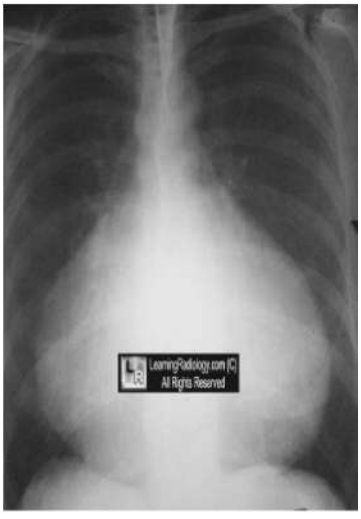
**Lt hydro-pneumothorax**

**Lt Middle zone lung mass**

**Pneumo-peritoneum**
(Air under diaphragm)



**Pericardial Effusion**
(Flask Shape Heart)



# CT Chest

## Indications:

- ✓ **Equivocal** plain x-ray findings assessment
- ✓ **Lung neoplasm** staging
- ✓ **Metastatic workup** of extra thoraces malignancies
- ✓ **Diffuse lung diseases Diagnosis** (with HRCT)
- ✓ **Bronchietasis** assessment
- ✓ **Posttraumatic complications** Assessment
- ✓ **Mediastinal** and **chest wall** lesions
- ✓ **Pulmonary embolism** Diagnosis

**Don't Forget:**

CT chest is done in *2 main windows*

**-Lung window** &

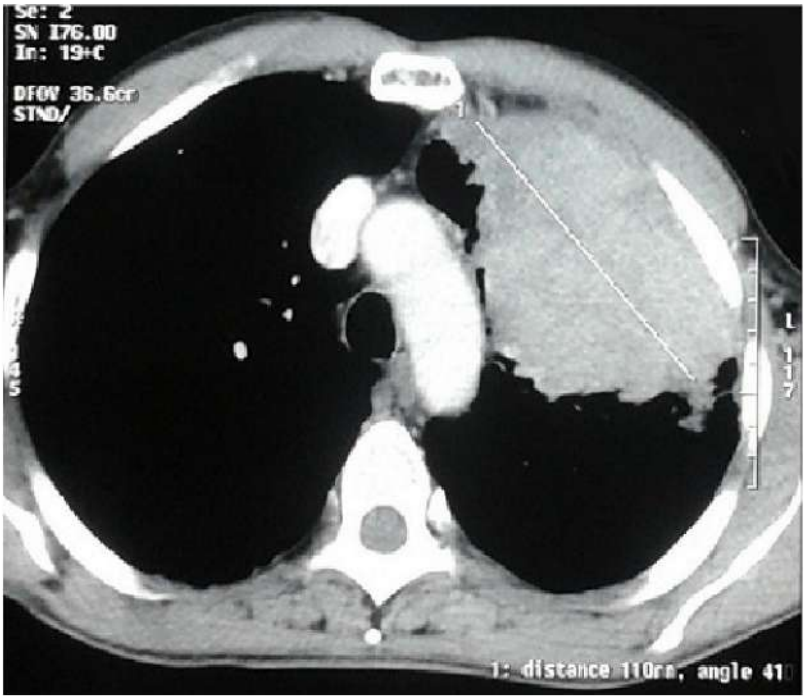
**-Mediastinal Window**

**Lung Window**

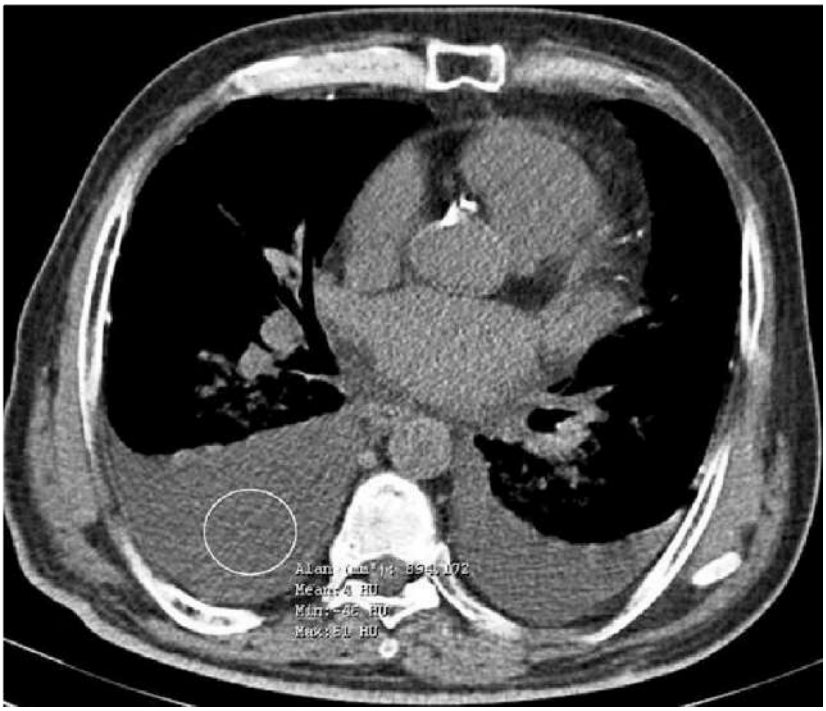
**Mediastinal window**

**Q. Do You remember what is CT window?**

Review previous chapter




**CT Chest – Mediastinal window – Lt lung large mass**

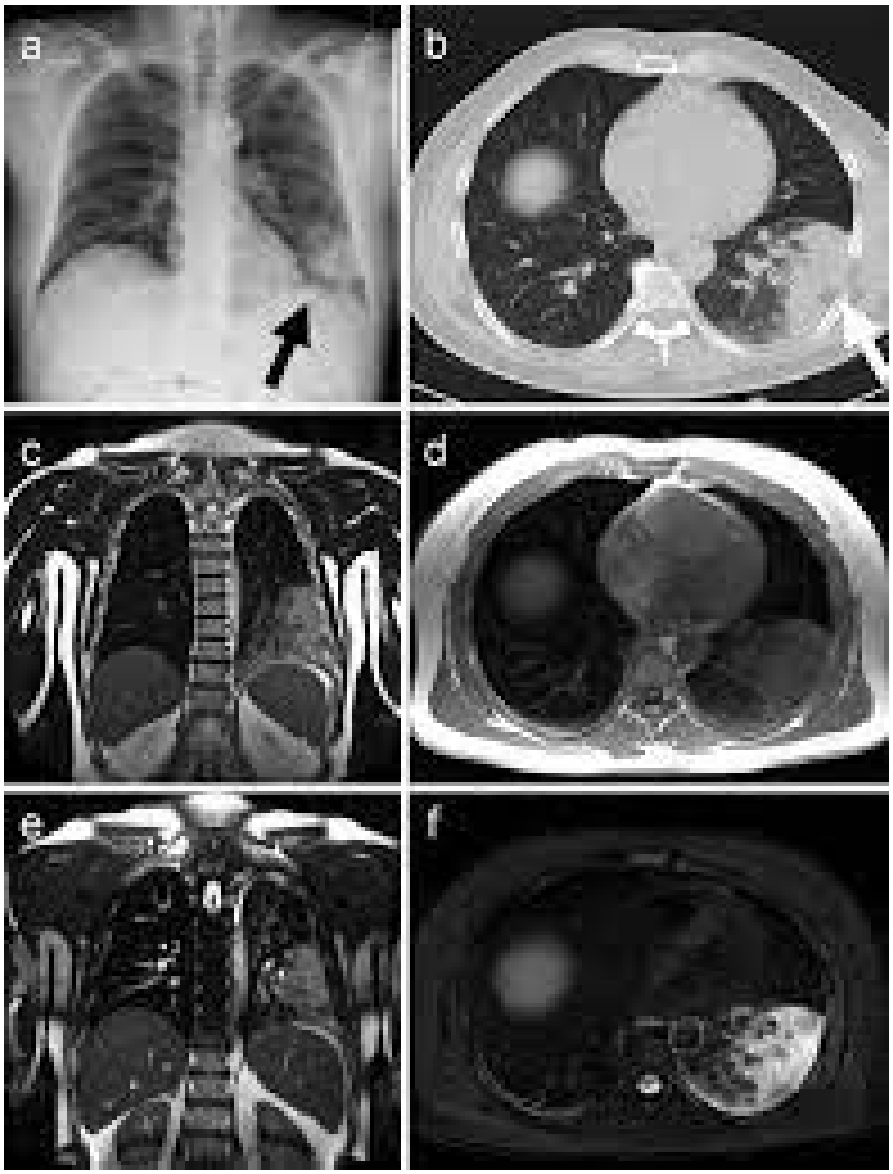


**CT Chest – Mediastinal window – Bilateral Pleural effusion**

# MRI Chest

## Indications:

- ✓ Assessment of **vascular abnormalities** *(aorta ،pulmonary arteries, veins, SVC )*
- ✓ Evaluation of **mediastinal masses**
- ✓ Staging of **bronchogenic carcinoma**
- ✓ Diagnosis of **chest wall pathology**




**Lt Lower lung mass invading chest wall in different modalities**

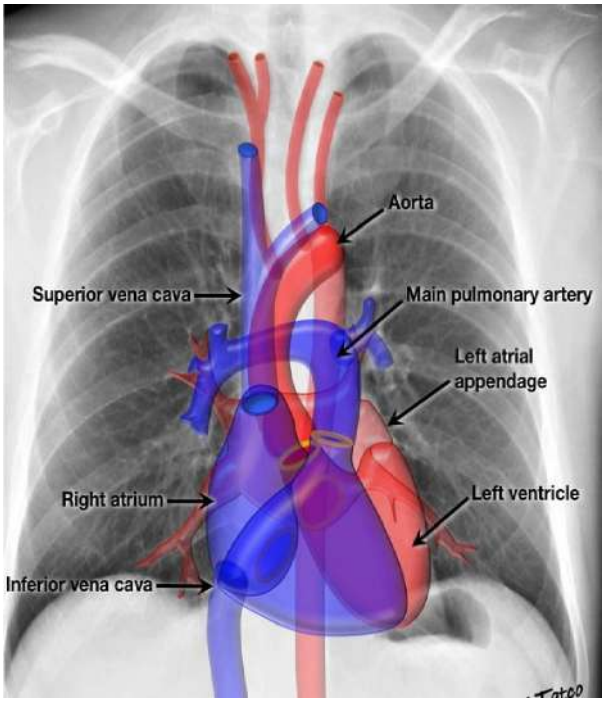
# Basics of Cardiac Imaging

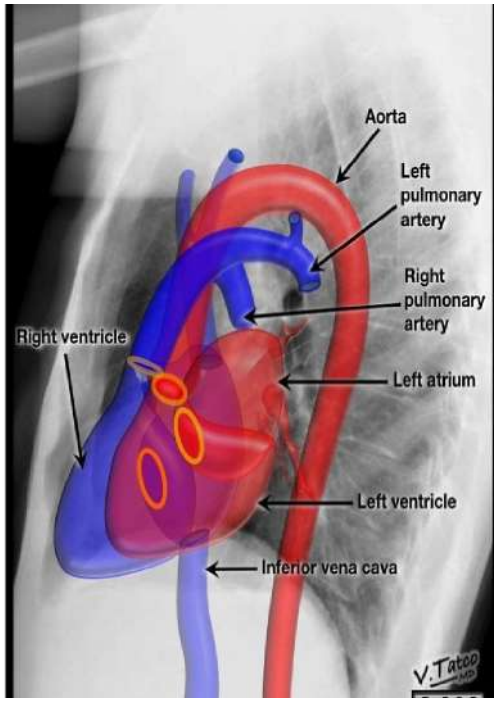
# Cardiac Imaging Modalities

- ✓ **CXR :** Initial & basic for cardiac size & shape.
- ✓ **Echocardiography :** Anatomical & functional assessment.
- ✓ **Conventional Coronary Angiography.**
- ✓ **CT Coronary:** need CT 64 Slice & more
- ✓ **MRI Coronary**

**…….. & Others**

## Normal Heart Anatomy in CXR



# (Chest X Ray)

## ® Abnormality of the heart in CXR may be :

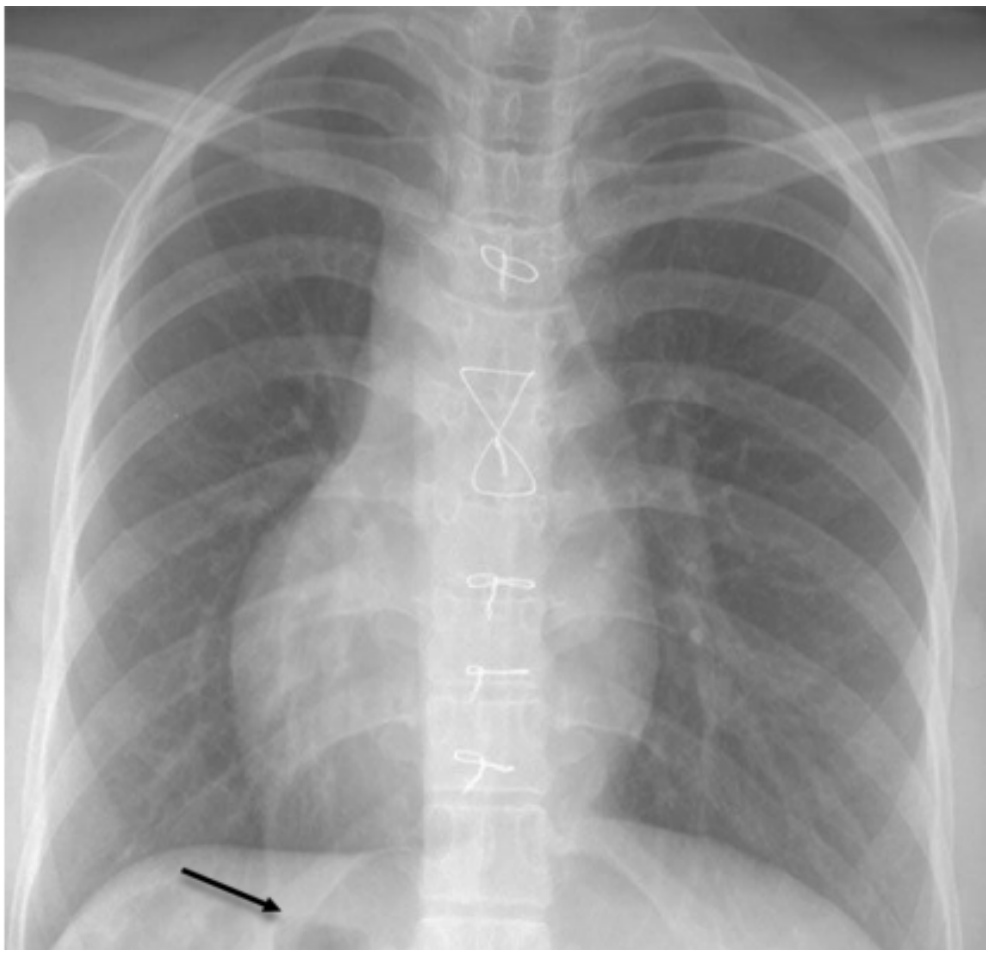
- Size
- Configuration ( Shape & Position )

### × Abnormal Heart Position:

- **Dextrocardia** : Heart only inverted
- **Situs Inversus Totalis** : both Heart & Gut are inverted

Heart is inverted in both (*Rt sided apex*)

*To Differentiate*: → **Side of Gastric bubble** (arrow)



**Situs Inversus Totalis**

**Dextrocardia**

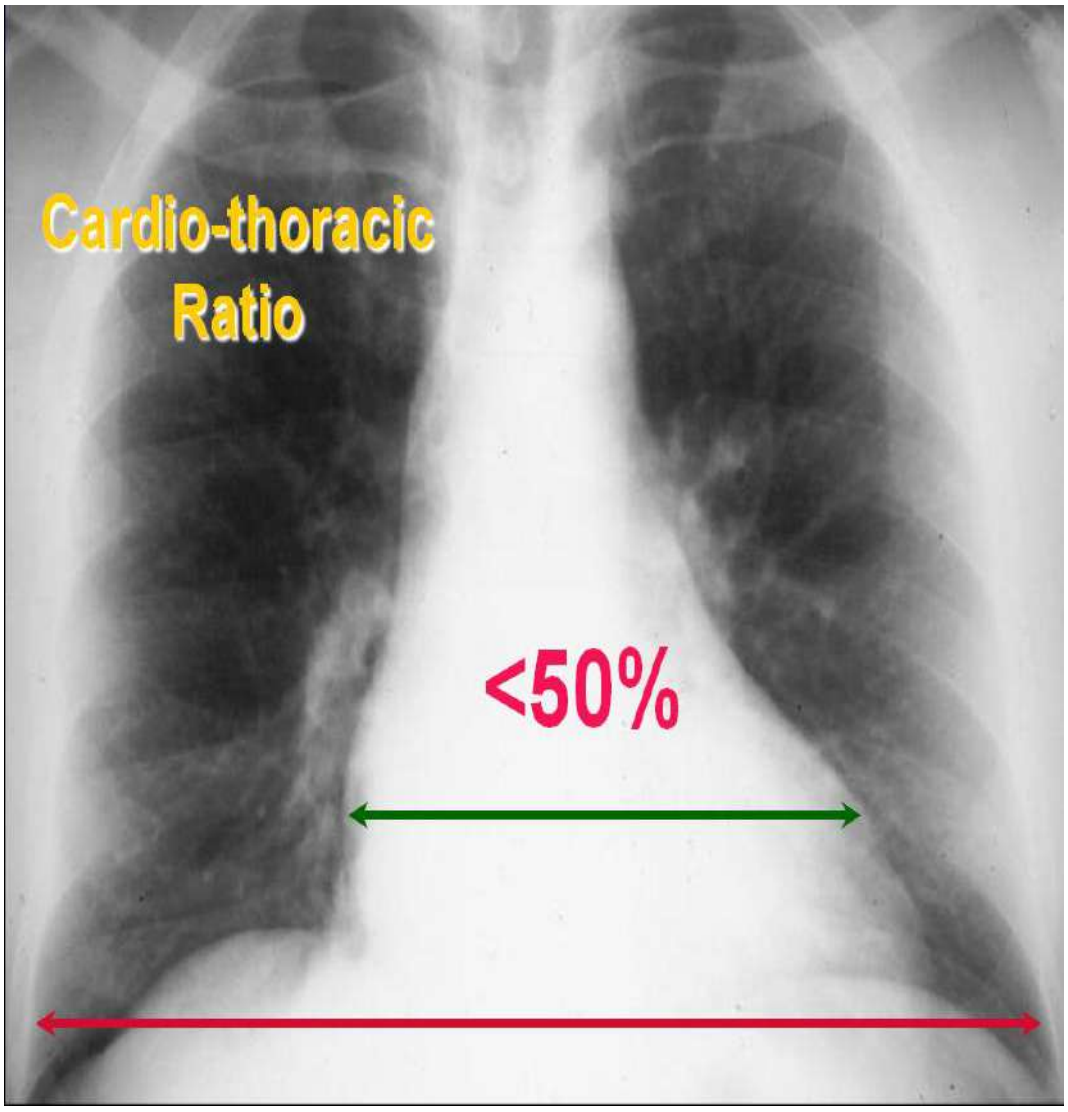
*Notice that gastric bubble is in normal position, Heart only is rotated*

## × Abnormal Heart Size: Cardiomegally

*(Enlarged cardiac shadow size)*

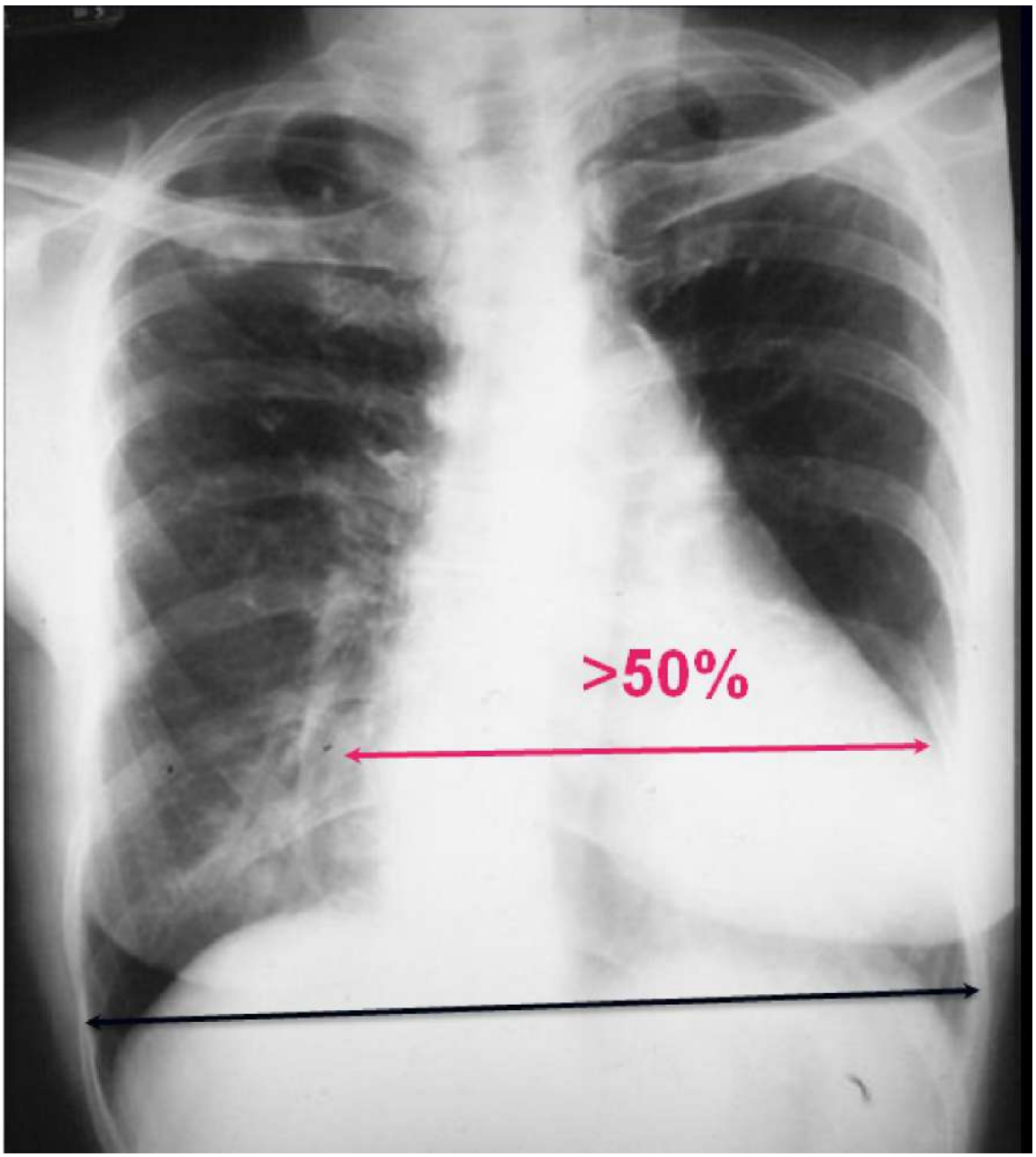
✓ *How to assess cardiac size in CXR ?*

*By **Cardio-thorathic ratio***




**Normal**

**Cardio-thorathic ration < 50 %**

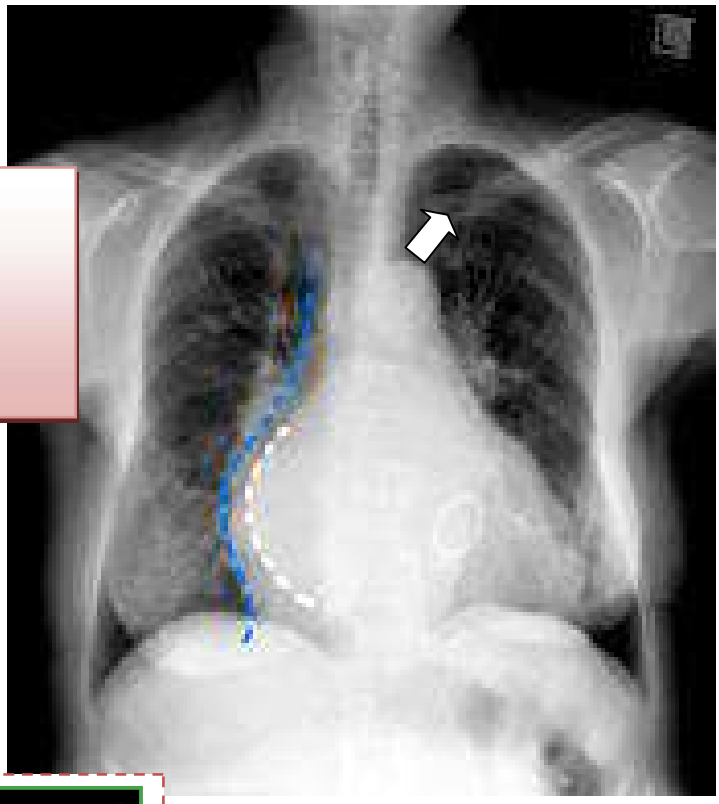



**Cardiomegally**

**Enlarged Cardio-thorathic ratio**

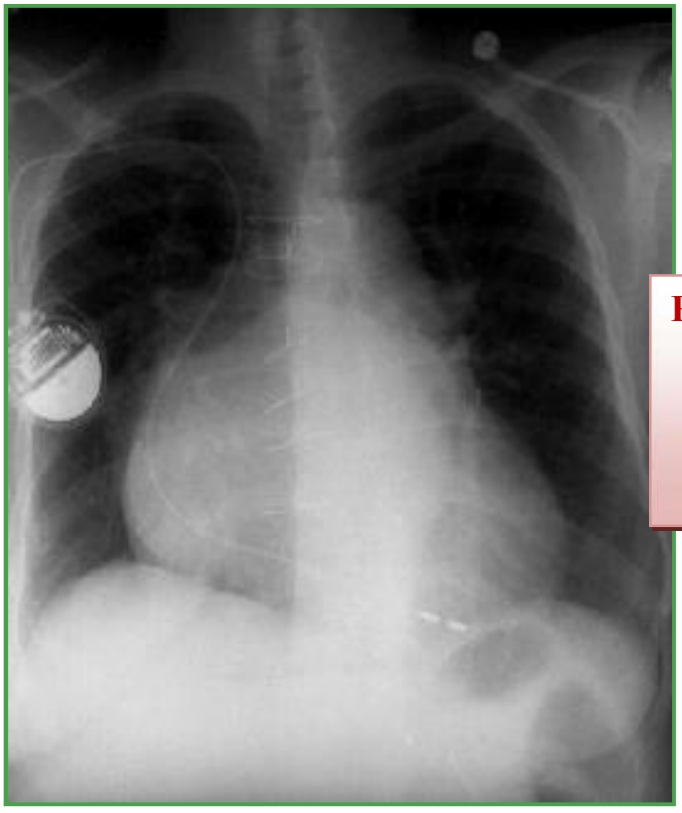
## Abnormal Heart Shape:

Abnormality of heart shape in CXR is usually part of cardiomegally



### Lt Atrial Enlargement:

- ✓ Double Rt Border (Dashed lines )
- ✓ Straight Lt border
- ✓ Elevated Lt broncus (white arrow)

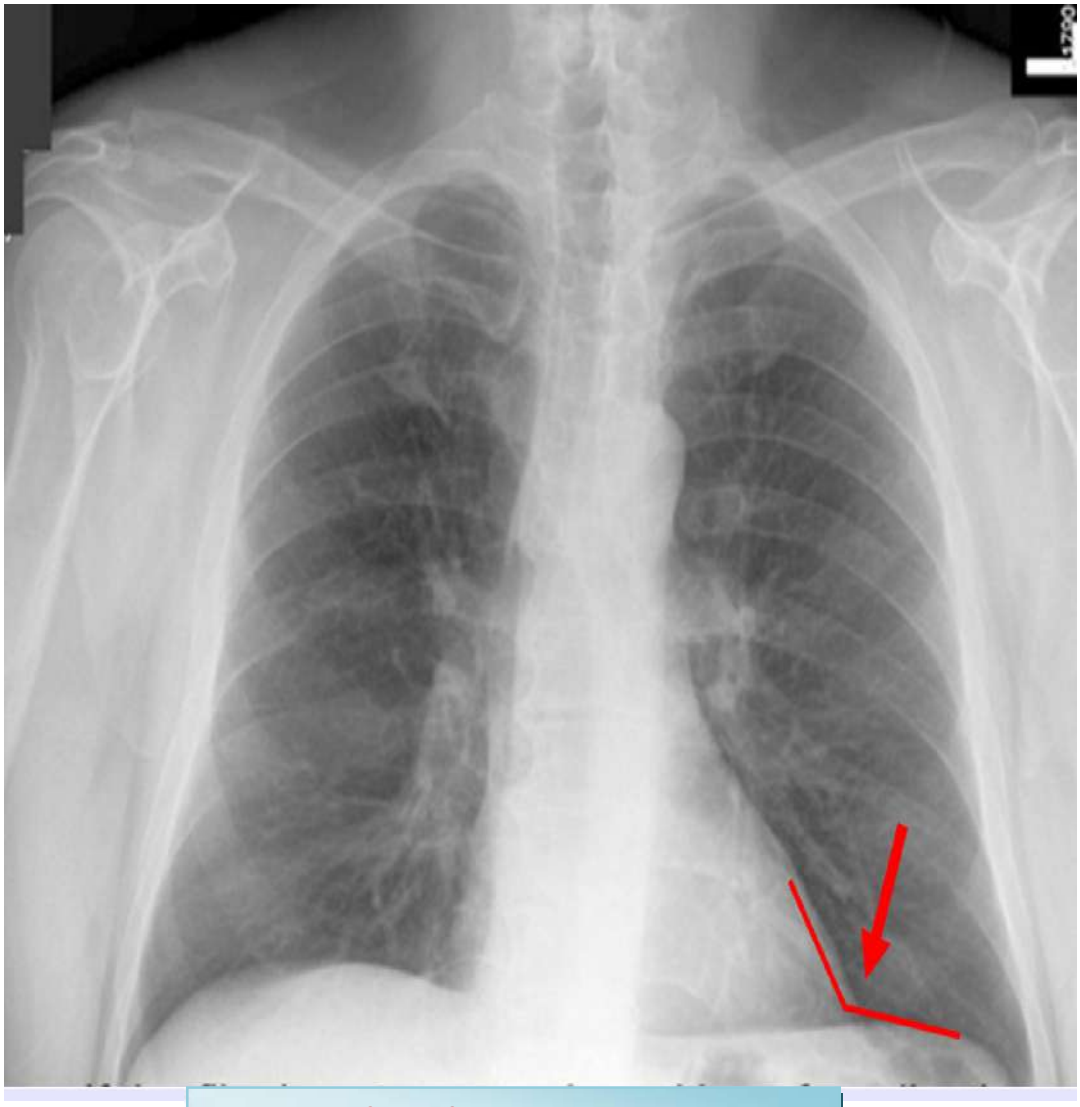


### Rt Atrial Enlargement:

- ✓ Lateral prominence of the right cardiac border

## *Ventricular enlargement Rt or Lt ?*

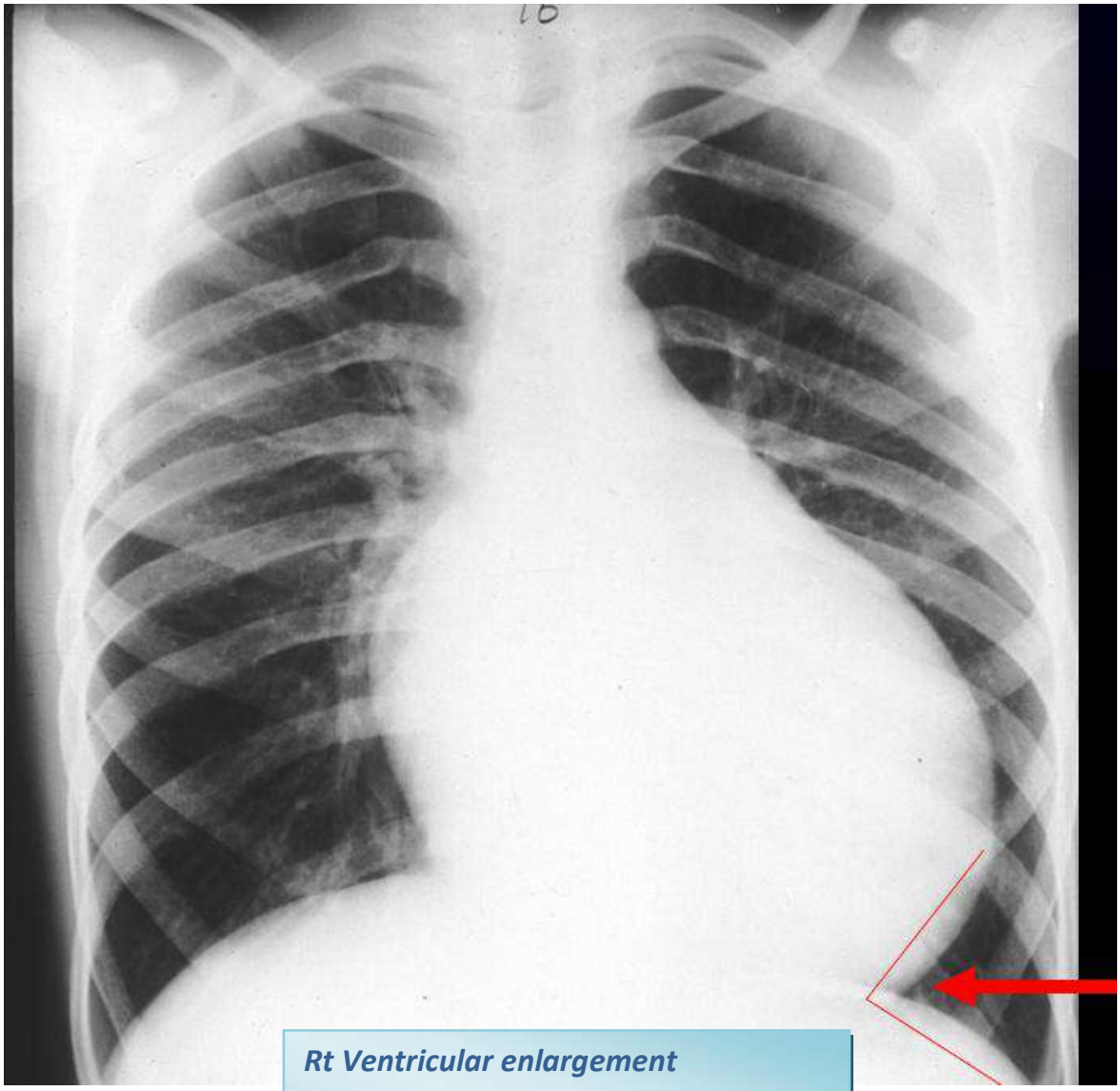
**According to angle between Lt cardiac border & Lt copula**



***Lt Ventricular enlargement***

→ ***Obtuse angle.***

"Looks like **small part of large circle"**

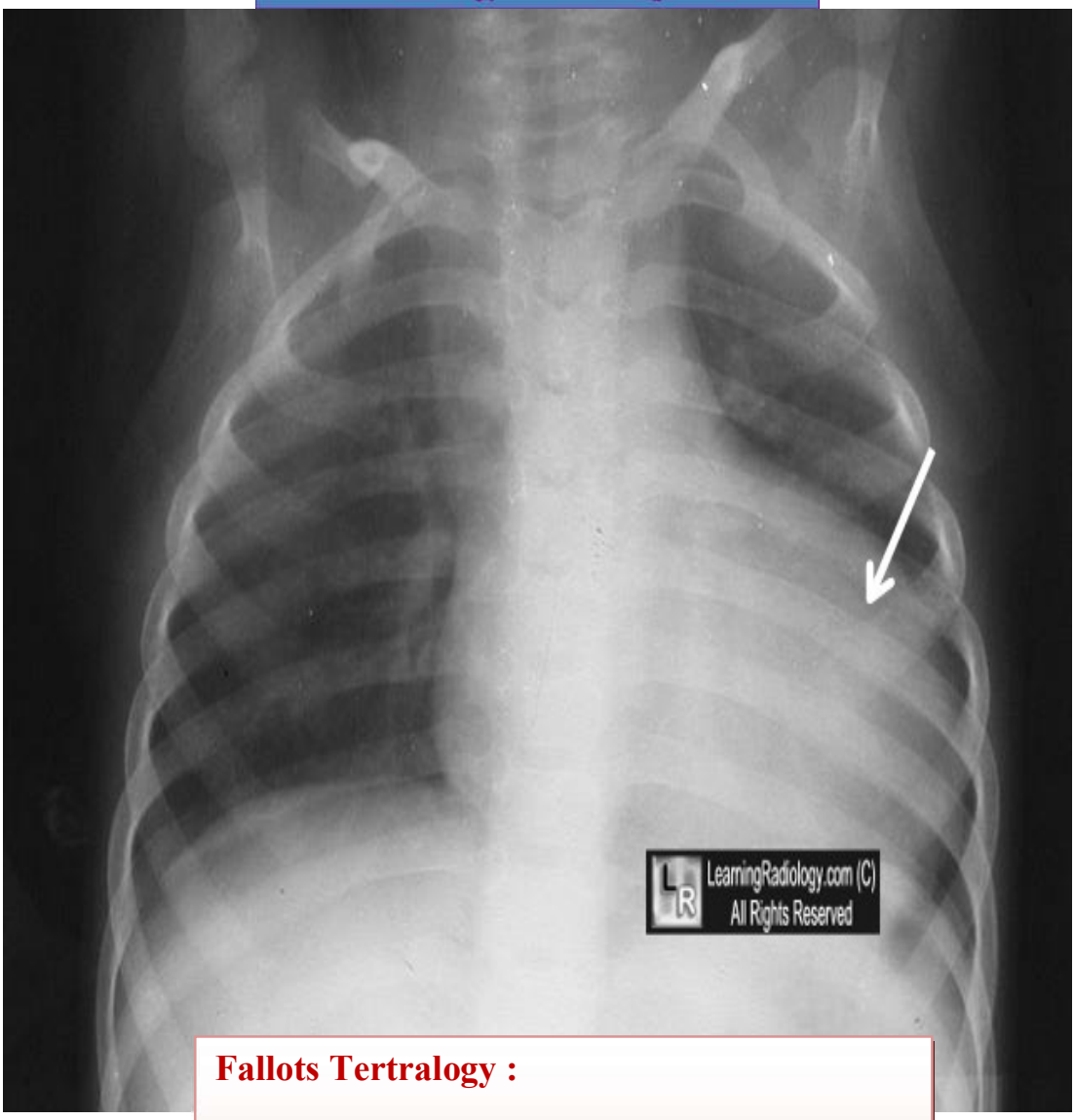


***Rt Ventricular enlargement***

→ ***Acute angle***

Looks like **large part of small circle"**

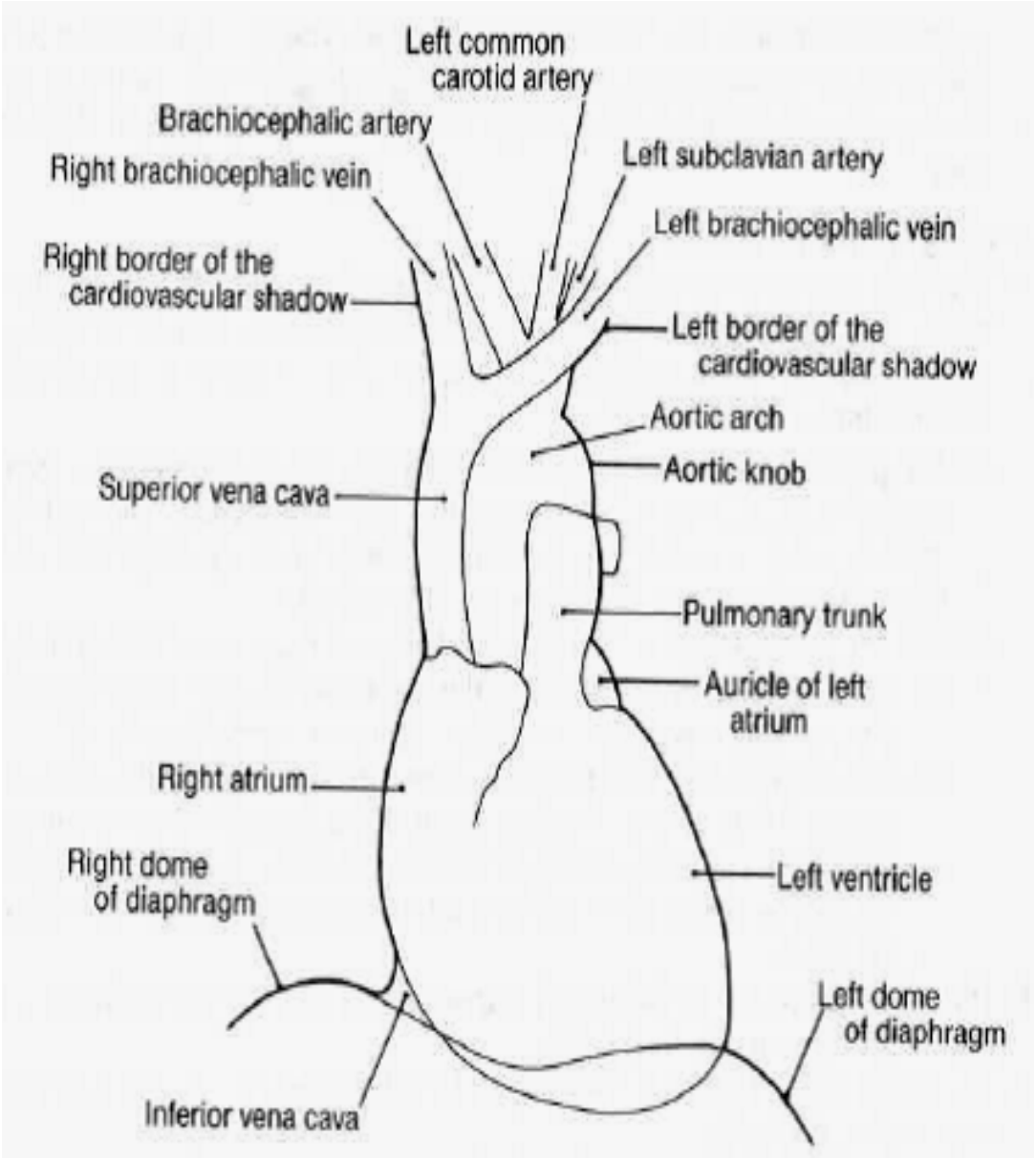
Fallots Tetralogy - Boot Shaped Heart

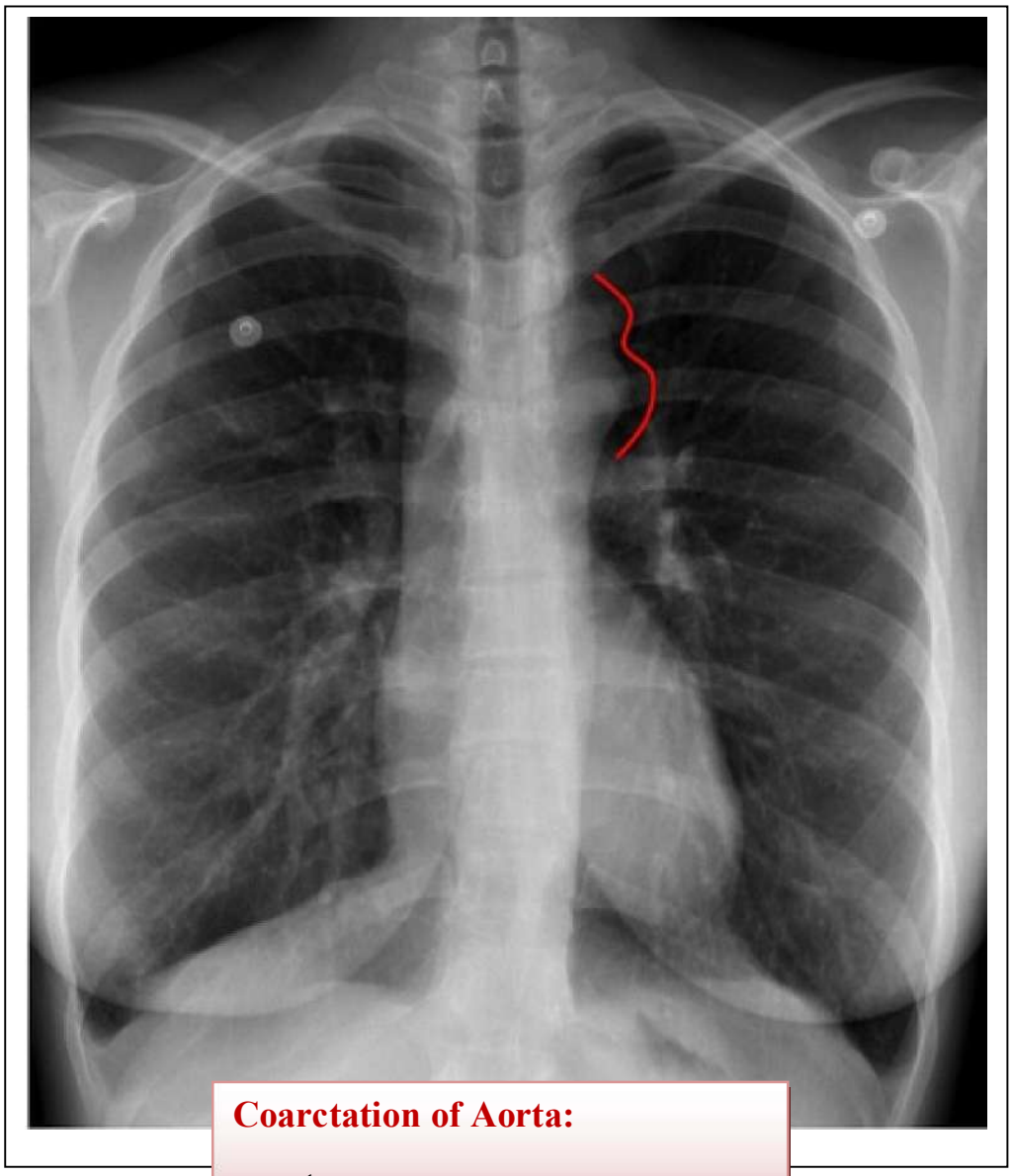



## Fallots Tertralogy :

- ✓ Pulmonary Stenosis
- ✓ Rt Ventricular hypertrophy
- ✓ VSD
- ✓ Aorta override VSD

# HINTS IN INTERPRETATON OF GREAT VESSELS ABNORMALITES





**Coarctation of Aorta:**

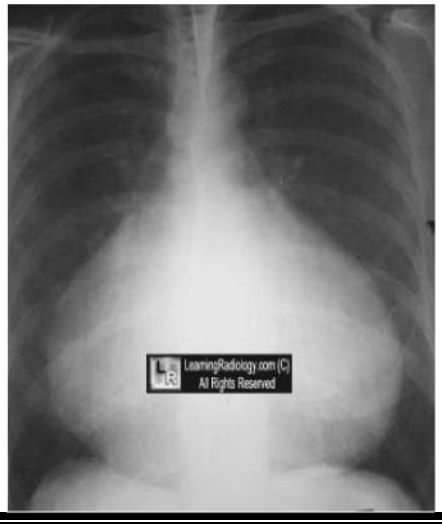
- ✓ **3 Sign**

**Details are much more …… But**

***Undergraduates need to know basics only***

## Chest X ray Illustration Cases:

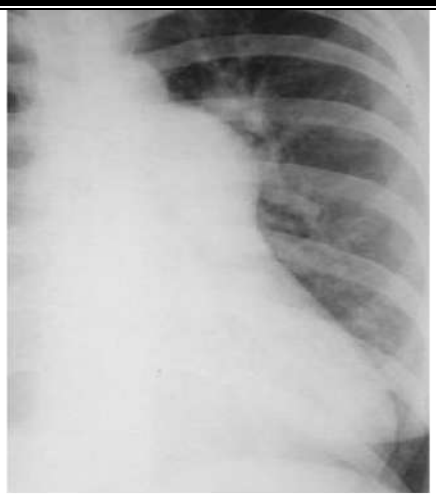
**Pericardial Effusion**
(Flask Shape Heart)





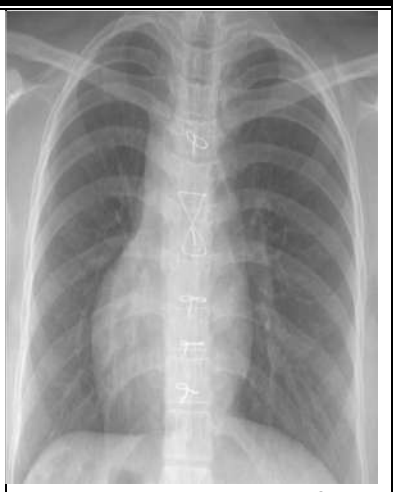
**Fallot's Tetralogy**
**(Boot Shape Heart)**

**Dextrocardia**



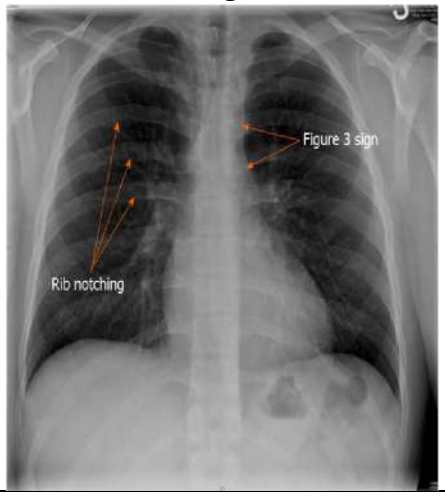
**Pulmonary Hypertension**

**Enlarged Aortic Knob**



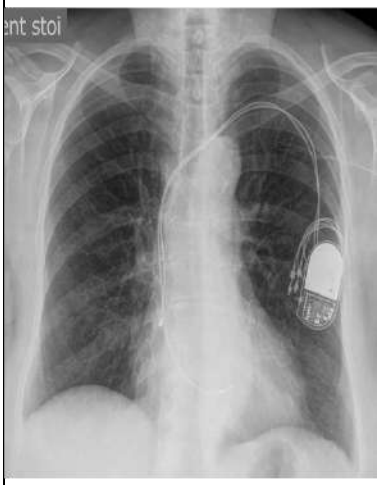
**Situs Inversus Totalis**

**Coarctation of Aorta**
3 Sign




**Pneumo-pericardium**

**Pacemaker**



# Basics of GIT Imaging

Hand outs of Scientific Society of Radiology

Is the main Source of this chapter

# GIT Imaging Modalities

- ✓ **Abdominal US:** Initial & basic for cardiac size & shape.
- ✓ **Plane X ray** : for intestinal obstruction , perforated viscous
- ✓ **X ray with contrast:** (Barium Techniques).
- ✓ **CT** : Enhanced CT & CT techniques as virtual colonoscopy
- ✓ **MRI**

**Plane X ray Abdomen – Erect Position**

**Multiple air fluid levels**

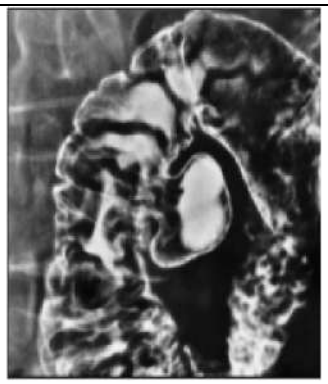
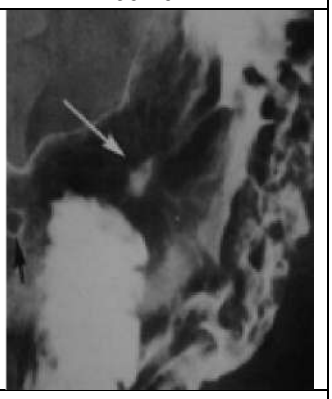
**Intestinal Obstruction**

## Barium examinations of the GIT

- ✓ Barium swallow ← (esophagus)
- ✓ Barium meal ← (stomach)
- ✓ Barium meal follow through ← (stomach , small intestine)
- ✓ Barium enema ← (colon)

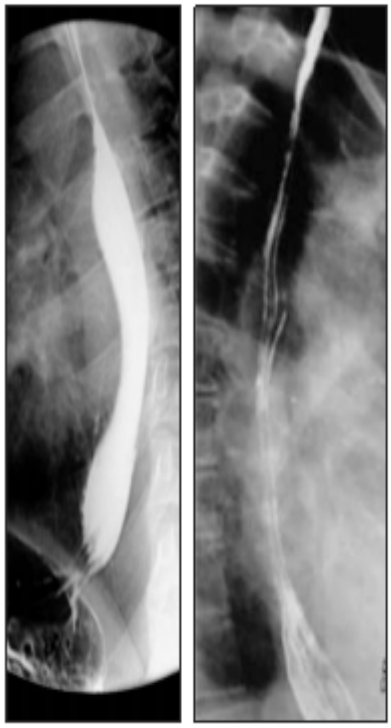
**Radiological terminology in barium studies**

**[1]** Filling defect **[2]** Stricture **[3]** Diverticulum **[4]** Ulceration

| Filling defect | Stricture | Diverticulum | Ulceration |
|---|---|---|---|
| A lesion inside or outside bowel lumen | segment luminal narrowing | saccular out pouching connected to bowel lumen | Injury of mucosa, visible when filled with barium |
|  |  |  |  |
| | | | |

## Esophagus (Barium swallow)

- ✓ The patient swallows **barium paste**
- ✓ The flow is observed on a T.V. monitor and films are taken
- ✓ With the oesophagus full to show **filling defects**
- ✓ With oesophagus empty to show the **mucosal folds**

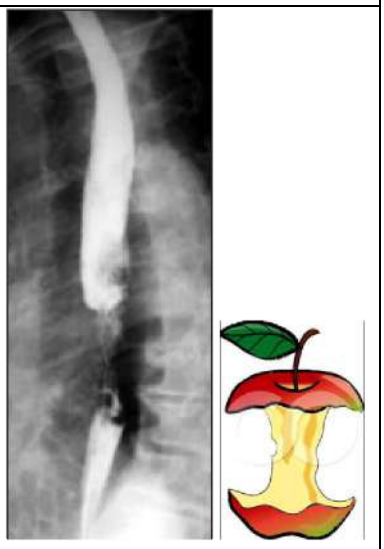


Normal barium swallow showing normal esophageal caliber with no evidence of filling defects, ulcerations, strictures or diverticulae

## Esophageal abnormalities

| Filling defect | Stricture | | Diverticulum |
|---|---|---|---|
| × **Benign :** as lyomyoma<br>× **Malignant :** carcinoma | × Corrosive<br>× Peptic | × Achalasia<br>× Malignant | -Zenker's<br>-Mid esophageal<br>-Epi - phrenic |

## 1- Esophageal Stricture

| × Corrosive | × Achalasia | × Malignant |
|---|---|---|
| Long segment starts at level of **aortic arch**<br>× Accidentally in children<br>× Suicide in adults | primary esophageal motility disorder | × Anywhere in oesophagus<br>× Commonly seen in the middle third<br>× Lower third lesions may simulate achlasia |
| **Radiographic appearance :**<br>–long, smooth outline<br>–Upper end is funnel shaped and tapers into normal oesophagus<br>–Lost mucosal pattern | **Smooth tapering** of distal sophageal segment , with marked proximal esophageal destination (**Parrot Beak sign**) | stricture with esophageal overhanging edges<br>→ typical **apple core** configuration |
|  |  |  |

### [2] Filling defect

- × **Benign** lesion as : liomyoma or
- × **Malignant** lesion: carcinoma or lymphoma.

**In all cases endoscopic evaluation is needed for biopsy taking**

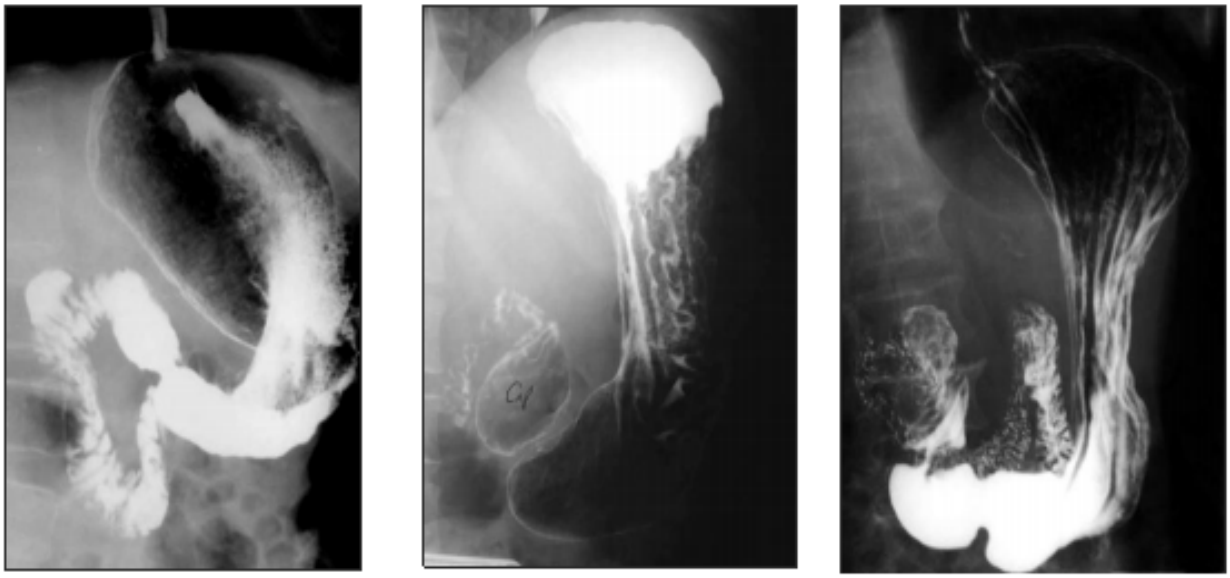
### [3] Diverticulum

**Barium swallow** showing: a small mid-esophageal diverticulum

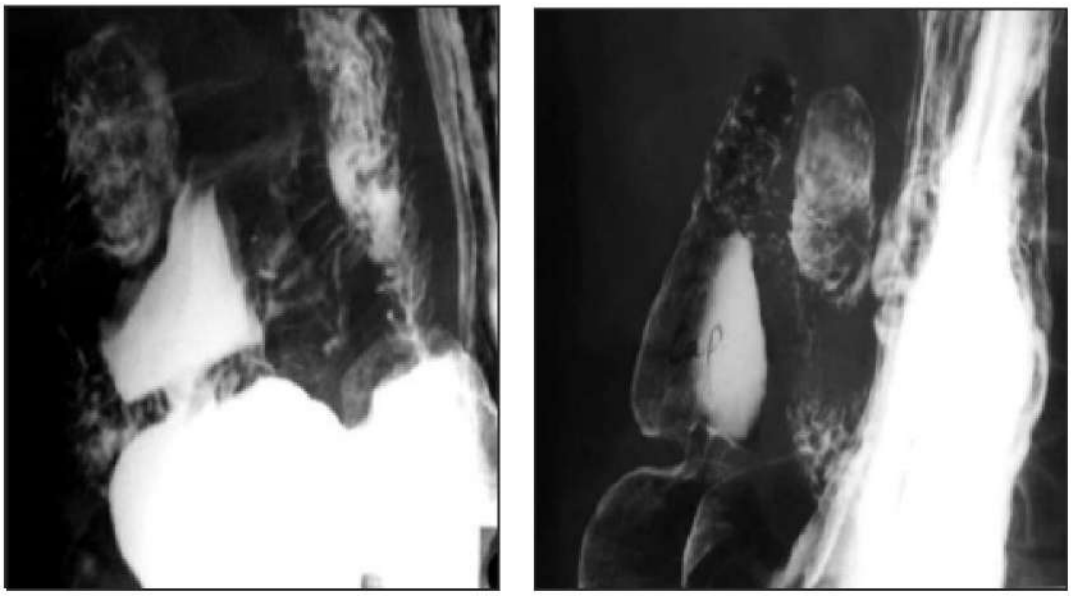
**Barium swallow**: diverticular out poaching in the neck at junction of hypopharynx & upper esophagus

## Stomach and Duodenum (Barium meal)

- ✓ Patient **fasting for 6 hours** before the exam
- ✓ Patient drinks **fluid barium**
- ✓ **Different views** for the stomach are taken by changing the patient's position

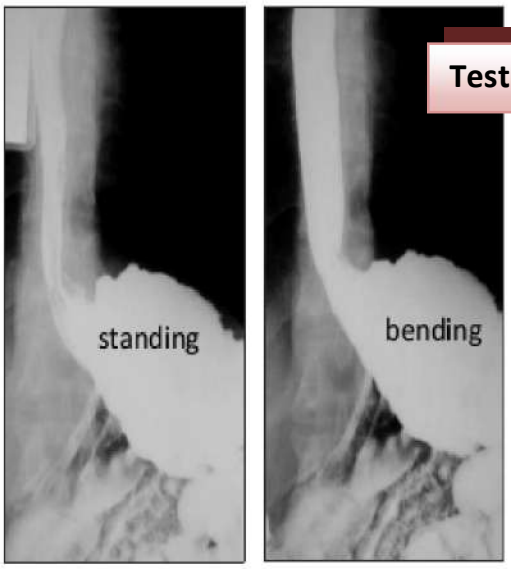


**Normal barium meal:** In the erect position, the stomach will appear 'J' shaped. The gastric fundus will normally contains gas bubbles. The gastric body and pylorus will be filled with barium



**Normal duodenal cap:** Spot view of barium meal showing the normal triangular shape of the duodenal cap which should be radiographed when it is filled with barium (left image) and while filled with air (right image)

## Stomach abnormalities

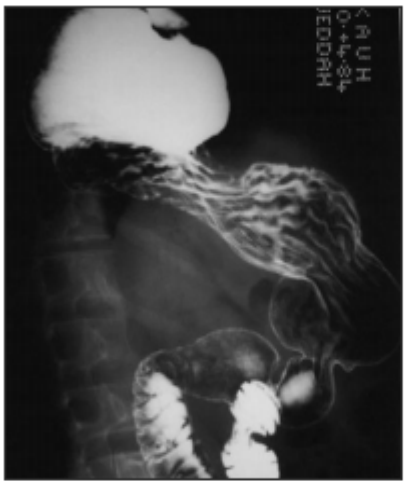



### Testing for Reflux

Barium swallow while standing showing normal esophagus. When the patient bends to pick up something at the end of the examination table reflux of barium into the lower esophagus is noted

## Hiatus hernia

Herniation of the stomach through the esophageal hiatus above the diaphragm



**Hiatus hernia:** Barium meal examination showing herniation of the gastric fundus above the diaphragm

**[A] Filling defect**

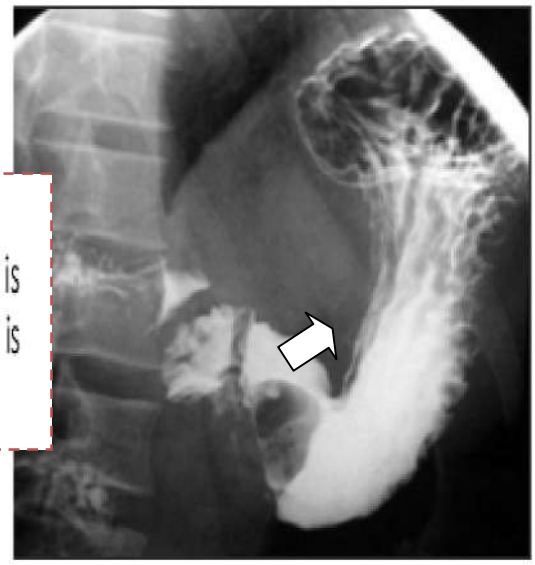
- Gastric bezoar
- Benign lesions
- Malignant lesions

**Bezoars** Mobile intra-gastric F.B surrounded by Barium

- Tricobizoar made of hiar
- Phytobizoar made of plant fibres
- Pharmacobizoar made of drugs

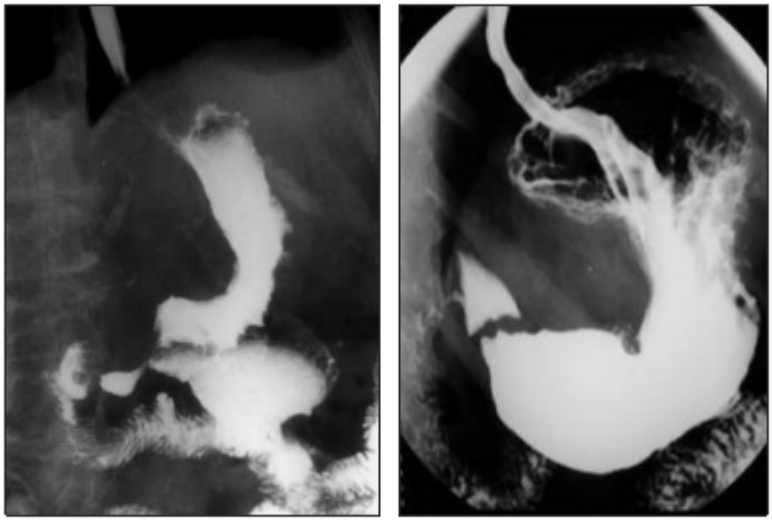
**lling defects**

n between benign and malignant filling defects is accurate on radiological bases. Endoscopy is biopsy taking



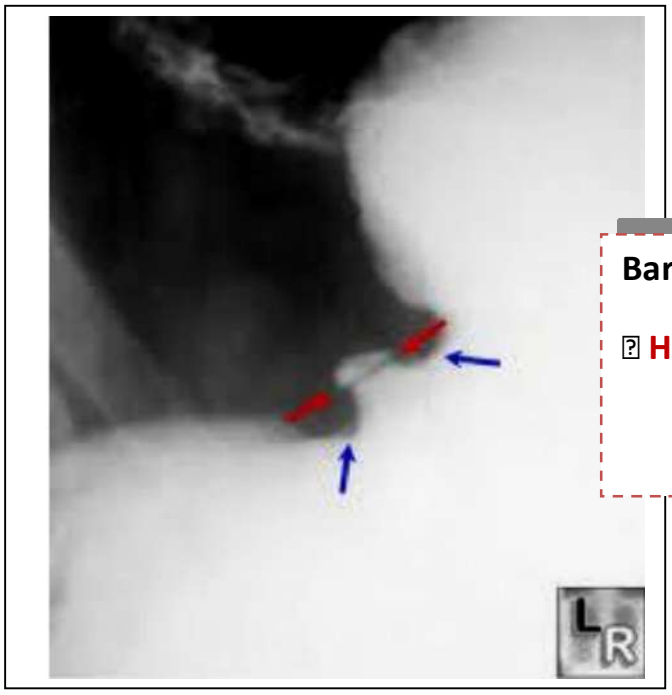
**Linitis plastica**

Malignant lesions produce irregular filling defect with destruction of the normal mucosa.



**Linitis plastic:** Barium meal showing marked reduction of the gastric lumen with irregular outlines compared to the normal stomach seen in the right image

**Acute duodenal ulcer:** Double Contrast barium meal study demonstrating an ulcer in the duodenal bulb with radiating mucosal folds. This was confirmed at endoscopy, performed 3 weeks later

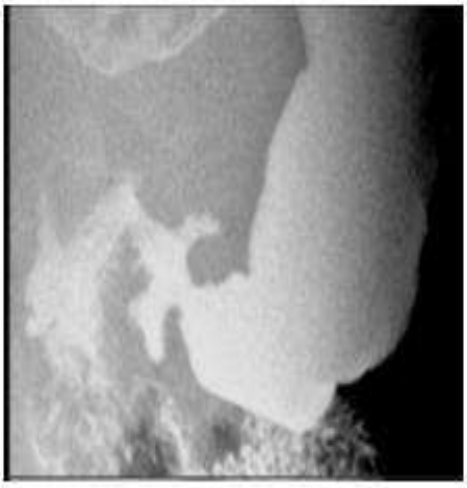


**Barium Meal**

- **Hampton line sign**
  - ‹sure sign of benign peptic ulcer

## Chronic duodenal ulcer

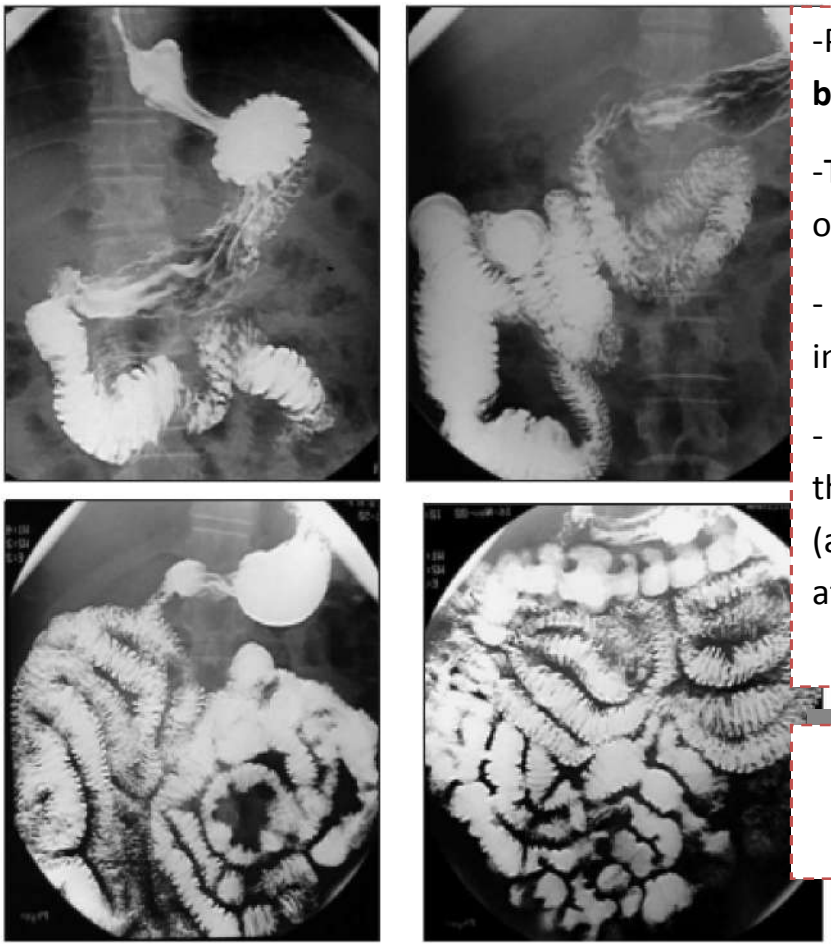
Duodenal ulcer with scarring and marked deformity of the base of the duodenal bulb after healing of a duodenal ulcer.



**Chronic duodenal ulcer:** Barium meal showing the classic trefoil deformity of the duodenal cap due to fibrosis resulting from healed ulcer

# Small intestine abnormalities

## Barium meal follow through



-Patient drinks **200-300 ml barium**.

-The barium flow is observed

- films are taken at regular intervals

- until the barium reaches the ascending colon (average time is 2-3 hours after barium intake).

**Normal**

**Small Intestinal series**

### Corhn's disease

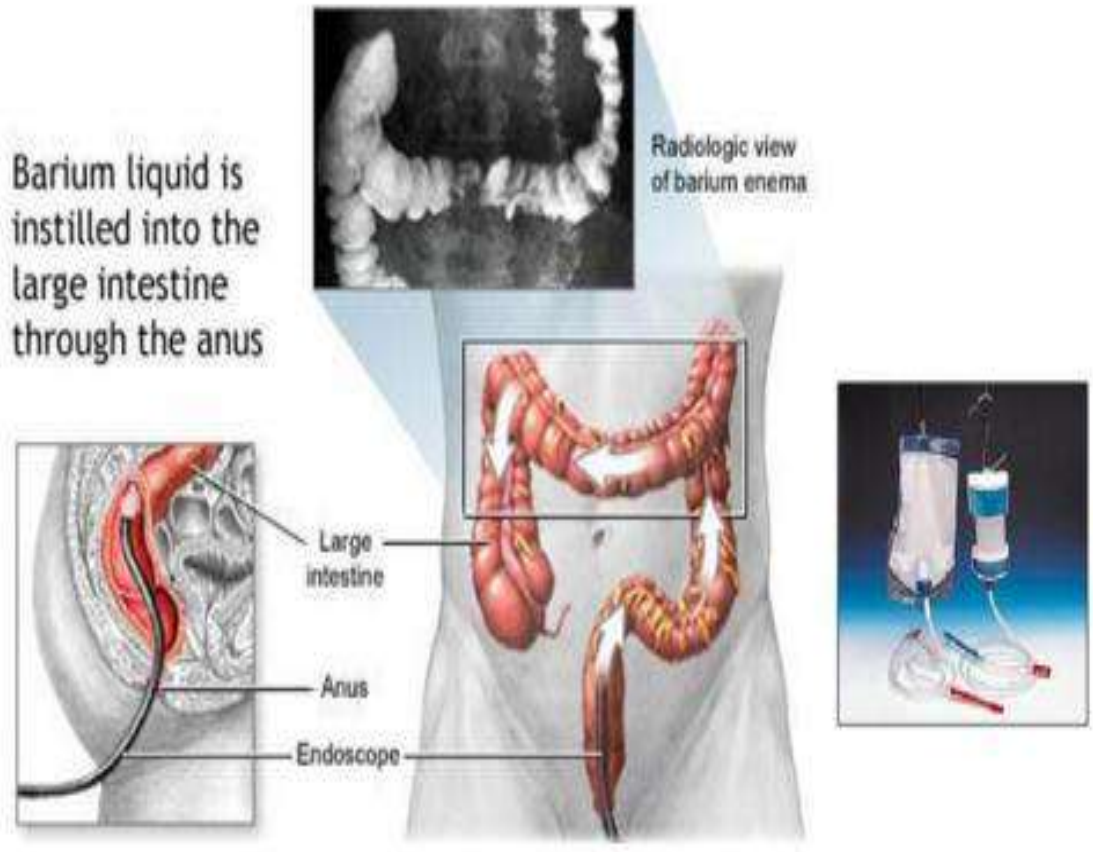
Sub mucosal lymphoid tissue hyperplasia → thickening and rigidity of the affected segment → luminal narrowing = Stricture

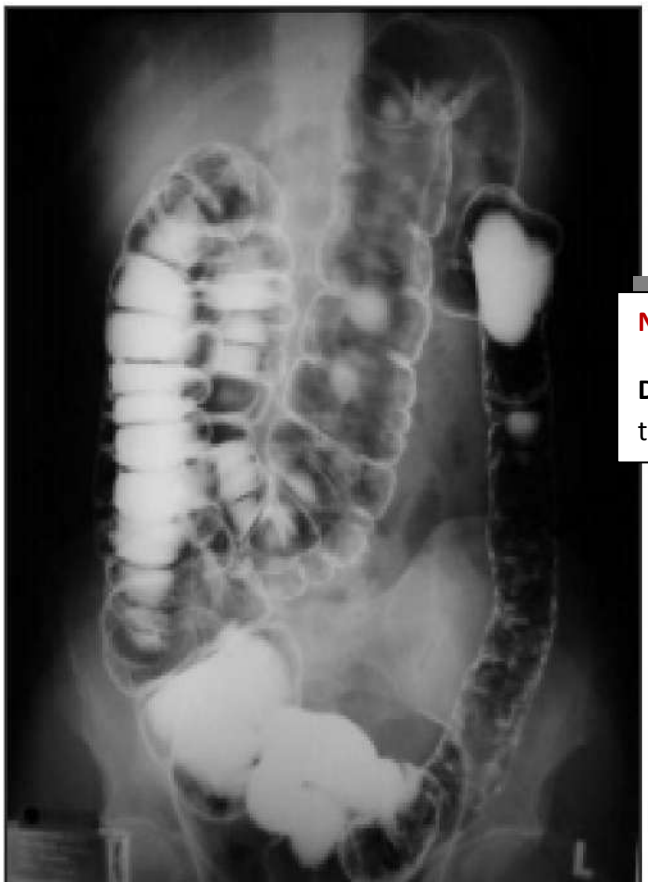
**Crohn's disease :** Spot view from a small-bowel follow-through study showing irregular luminal narrowing of the terminal ileum with ***rose thorn*** appearance due to linear longitudinal and transverse ulcerations Also note the displacement of the involved loop away from the normal small bowel secondary to mesenteric inflammation and fibro fatty proliferation

## Large Intestine (Barium Enema)

**Barium enema**

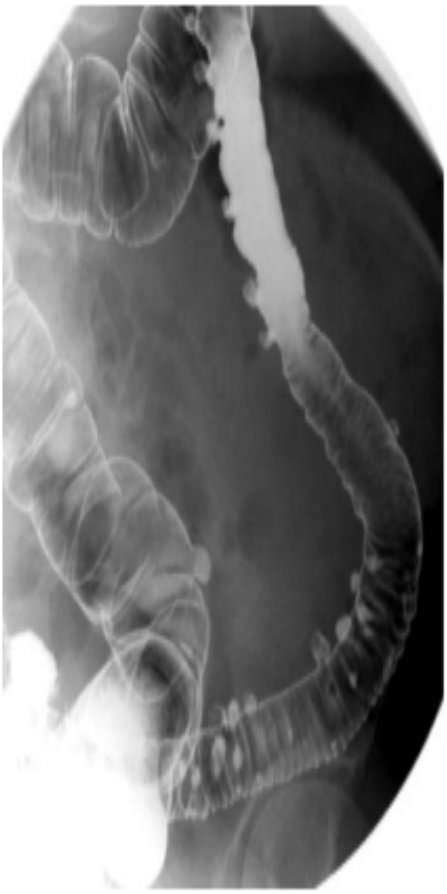
- ✓ is a valuable diagnostic tool
- ✓ It helps detect abnormalities in the large intestine .
- ✓ Barium enema, along with colonoscopy, remains standard in the diagnosis of colon cancer, ulcerative colitis, and other diseases of the colon.
- ✓ **Colonoscopy** allows both therapeutic resection of mucosal lesions as well as diagnostic biopsy.





**Normal barium enema**:

**Double contrast** enema showing the normal appearance



**Colonic diverticular disease:** Barium enema examination showing few colonic diverticulae mainly affecting the sigmoid and descending colon with no evidence of complications

**Ulcerative colitis:** Double contrast barium enema shows a featureless descending and sigmoid colon, lacking normal haustral marking. No evidence of stenoses , masses or fistula formation. Normal ascending and transverse colon appear normal.

**Sigmoid carcinoma**
Barium enema study demonstrating an "apple core" lesion most consistent with carcinoma of the bowel.

**Cancer colon:** Barium enema examination showed malignant stricture with typical apple core configuration seen involving the distal part of the transverse colon [arrow ]

**Don't Forget:**

- ✓ Barium studies are **contraindicated** in intestinal obstruction & suspected perforated gut.
- ✓ Barium is a highly irritant chemical material, if contact peritoneum → **sever chemical peritonitis**.
- ✓ **Abdominal US** , is the basic & initial modality for assessment of most of GIT abnormality.
- ✓ **Consult radiologist to chose the most suitable modality for the case.**

# Basics of UT Imaging

# Urinary Tract Imaging Modalities

- **Ultrasonography ( US )**
- **Plain kidney, ureters and bladder ( KUB / PUT )**
- **Intravenous urogram ( IVU )**
- **Cystography and ureathrography**
- **Computed tomography ( CT ) scan**
- **Magnetic resonance imaging ( MRI ) scan**
- **Nuclear medicine**
- **More invasive tests**

## Ultrasonography ( US )

- ✓ Non-invasive
- ✓ Real time imaging
- ✓ No radiation hazards
- ✓ No contrast media

Normal renal sonogram

® **Diagnostic value**

- ✓ **Parenchymal changes** assessment
- ✓ **UT calculi** (Stones) detection
- ✓ UT **obstruction**
- ✓ Renal & bladder **masses** or Cysts
- ✓ **Congenital anomalies**
- ✓ Doppler assessment of the **renal vessels**

## Plain UT (PUT)

**Diagnostic value**

- ✓ Radioopaque calculi
- ✓ Calcifications
- ✓ Gas pattern
- ✓ Bony abnormalities

**Normal PUT**

## Intravenous urography (IVU)

### Requirements:

- ✓ Fasting **4-6 hours** , good hydration is essential
- ✓ Adequate bowel preparation
- ✓ Renal function tests [ serum creatinine level below 3 ]
- ✓ Non ionic contrast media are used
- ✓ to guard against contrast nephropathy

### Diagnostic value:

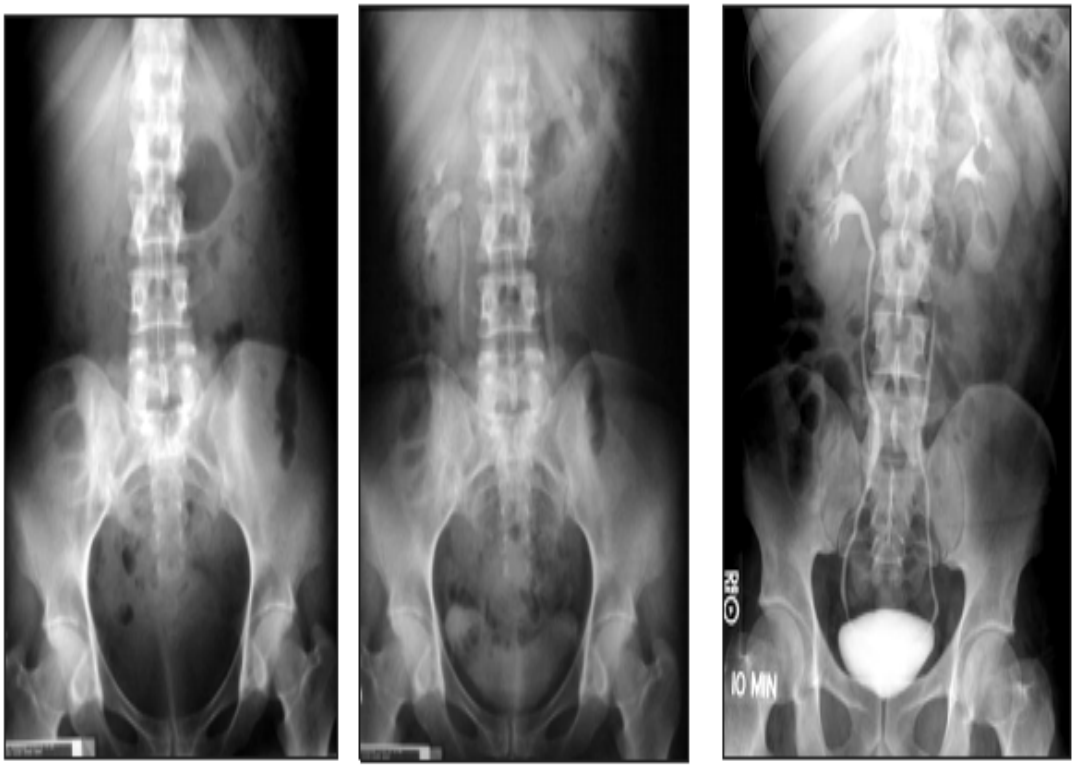
- ✓ Show the renal function
- ✓ UT obstruction
- ✓ Renal an bladder masses
- ✓ Congenital anomalies

### Contraindications:

- × Renal impairment
- × Hypersensitivity to contrast media

Normal IVU

## IVP series




**PUT showing no radiopaque calculi**: IVP showing normal renal function with normal appearance of both pelvicalyceal systems, ureters and urinary bladder

## Computed tomography ( CT )

### Advantages:

✓ More sensitive

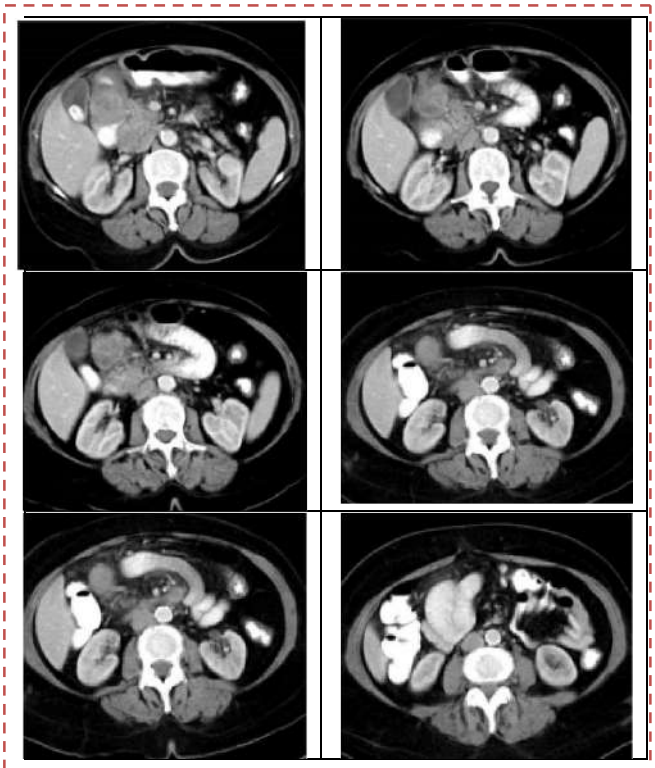
### Requirements:

✓ Fasting 4-6 hours

✓ May need bowel preparation

✓ May use contrast media

**Don't Forget :** radiation hazards



**Enhanced CT** , showing

normal renal configuration and function

### Diagnostic value

✓ Accurate Detection of UT calculi

✓ UT obstruction

✓ Renal an bladder masses

✓ Differentiates masses cystic/solid

✓ Congenital anomalies

✓ CT angiography

## Magnetic resonance imaging ( MRI )

- ✓ Functional & Morphological imaging

### Indications :

- ✓ Risk of contrast nephropathy
- ✓ Allergy to contrast agents

### Requirements :

- ✓ Fasting 4-6 hours
- ✓ No bowel preparation
- ✓ May use contrast media
- ✓ No radiation hazards

MR urography **without** IV contrast injections

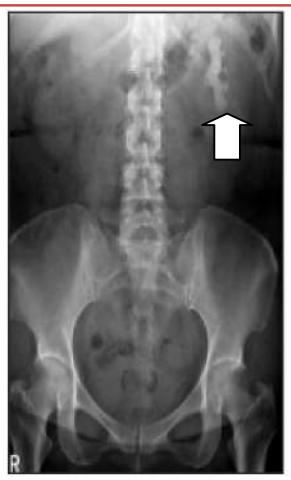
## × UT Pathologies

**Diagnosis of UT pathology**

- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions
  - Congenital lesions
  - Vesico – ureteric reflux
  - Urethral lesions
  - Reno-vascular hypertension

## Renal Stones:

- ✓ **Radioapque** → Seen in US / PUT
- ✓ **Radiolucent** → Seen in US / IVU (Obstructive effect)



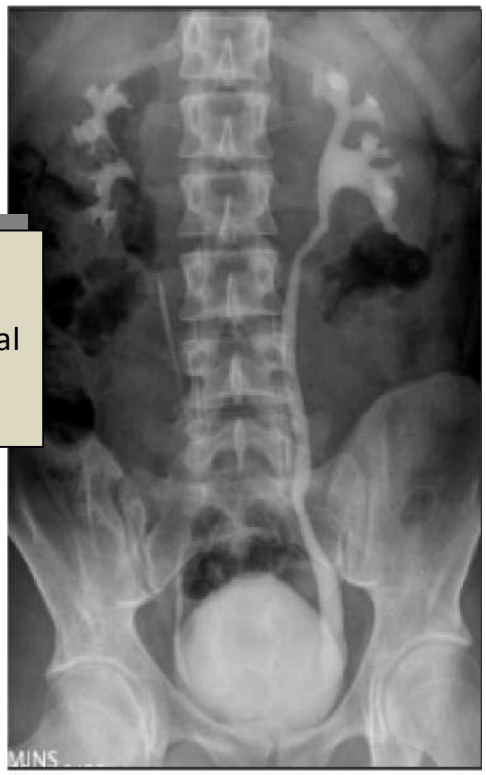
Large stage- horn left renal stone

Small left renal stone

Multiple large urinary bladder calculi

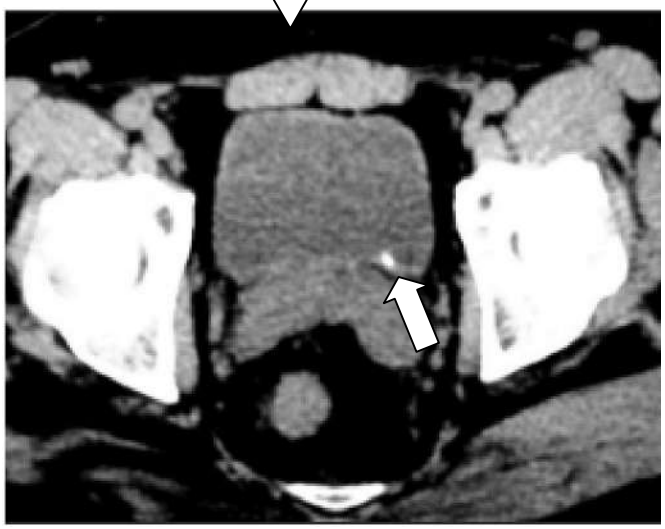
**Radiolucent left renal stone** seen

occupying the renal pelvis with no back pressure effect



**IVP** showing

Distended left pelvicalyceal system and ureter proximal to a **suspected distal ureteric stone**

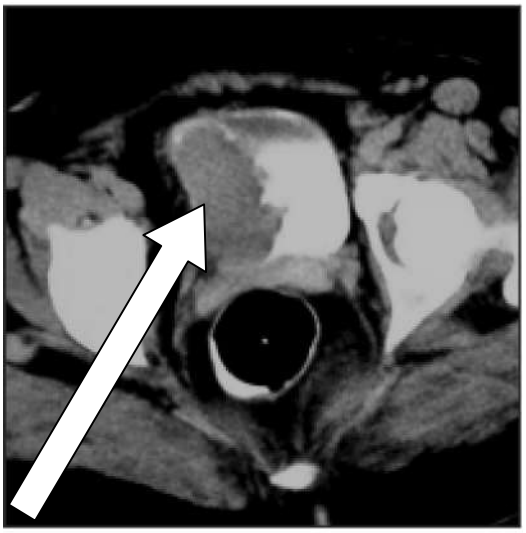


**CTU: distal ureteric stone** Confirmed

# Renal Neoplasm:

## Bladder carcinoma

IVU of a patient with hematuria clearly shows a large, irregular filling defect within the bladder caused by a tumor, compared to the normal bladder seen in the right image

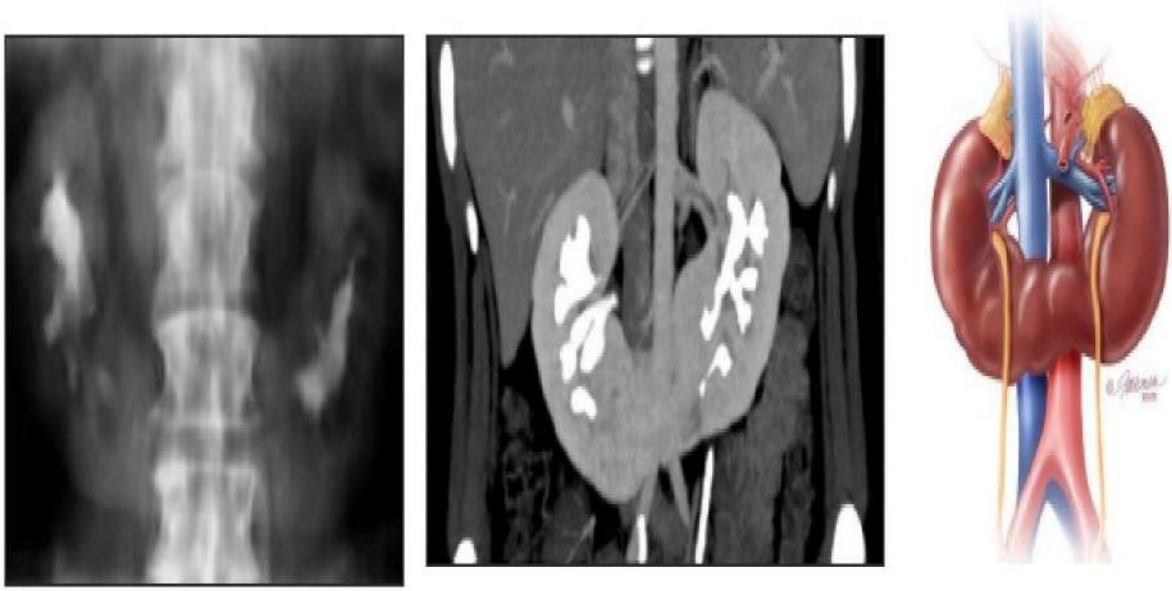


**Pelvic CT scan** showing a **large tumor mas**s involving

the right side of the urinary bladder representing vesical

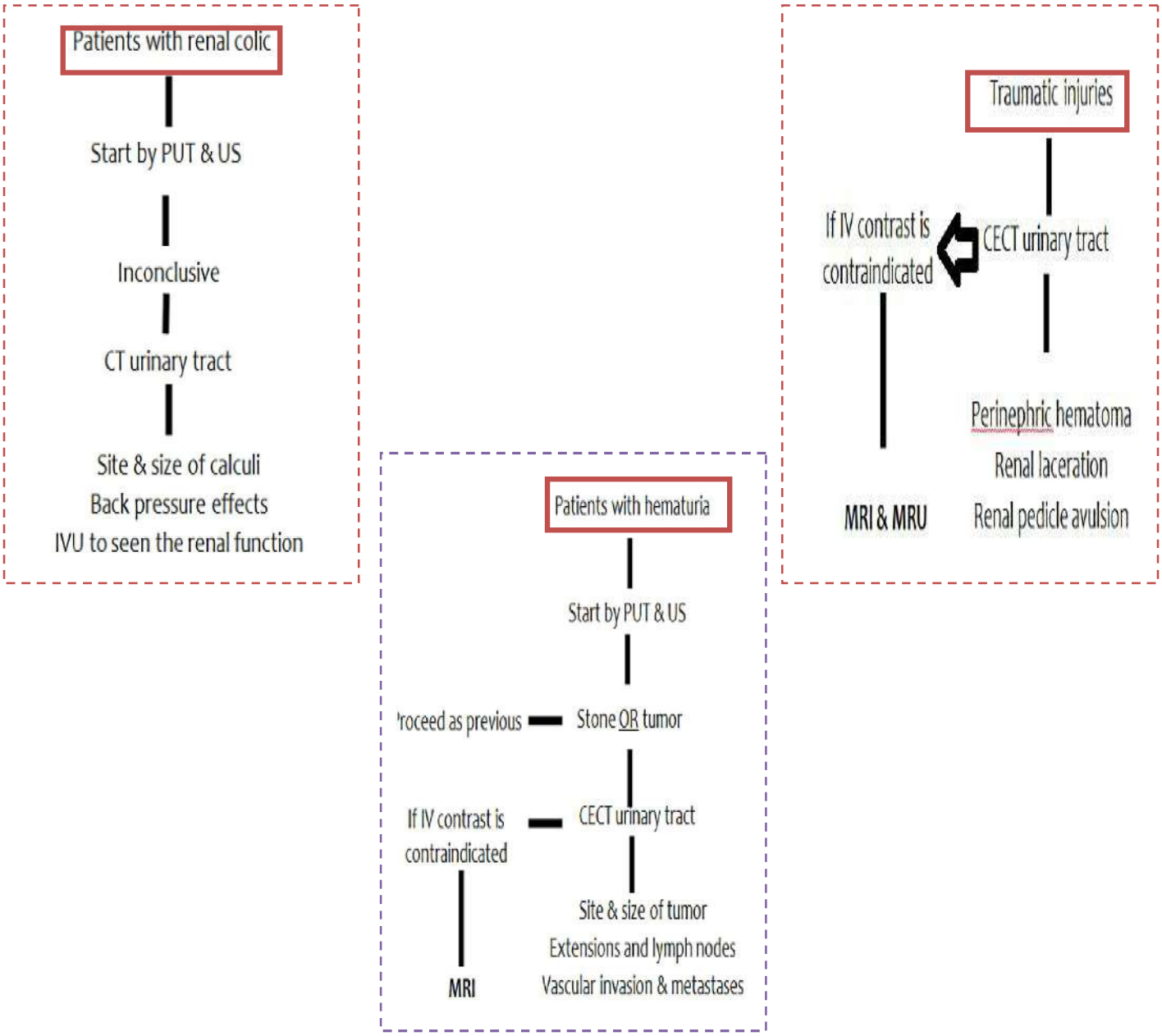
## Congenital lesions

- Absent & hypo plastic kidney
- Duplex kidney and ureter
- Ectopic kidney
- Horseshoe kidney
- PUJ obstruction
- Uretroceles
- Bladder diverticulum



IVP and coronal reconstructed CT image showing horse- shoe kidney

# How to choose Modality for UT Cases



# Basics of Emergency Imaging

# Emergency

Serious, unexpected, and often dangerous situation requiring immediate action.

## ✍ Emergency Imaging :

- **Ultrasonography ( US )**
- **Plain X ray**
- **Computed tomography ( CT ) scan**
- **Magnetic resonance imaging ( MRI ) scan**
- **Nuclear medicine**
- **More invasive tests**

## ✍ Emergency cases need imaging assessment may be :

- **Traumatic :** Fractures, organ injury , bleeding
- **Inflammatory:** as meningitis, Abscess, Peritonitis, Appendicitis ….etc.
- **Obstructive :** as Hydrocephalus , intestinal obstruction, hydroneprosis, ischemic …… etc
- **Hemorrhagic :** internal hemorrhage

**…….. & others.**

# TRAUMA IMAGING

## Fracture: bone break

**Imaging:**

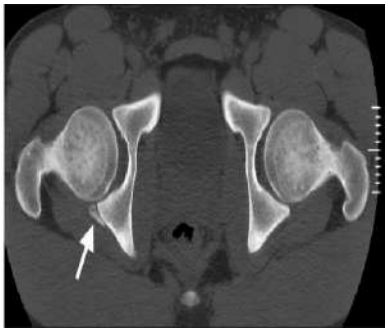
- **X ray :** basic & initial
- **CT :**

For detailed assessment

& classification

On **bone window**

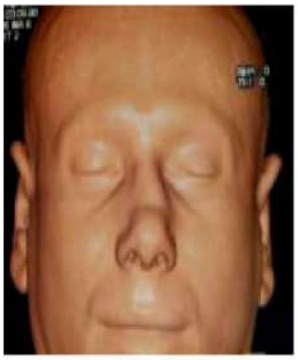
& **3d reformate**



CT showing fractures difficult to seen in X ray

## Maxillo –facial trauma

- Fracture lines [ Extent, Comminutions, displacement ]
- Soft tissue injuries (orbit )
- Intracranial complications



## Maxillo –facial trauma Why urgent ?!

- To remove bone fragments in vital areas [ orbit , brain ]
- To reduce fracture before adhesions
- To release muscles before fibrosis
- To seal skull floor defects before meningitis
- To ensure patent air way
- To remove FBs before infection

# Abdominal Trauma

## ® Ultrasound:

- ✓ Portable,
- ✓ rapid,
- ✓ non invasive
- ✓ Inexpensive
- ✓ No oral or IV contrast
- ✓ Serial examinations are possible

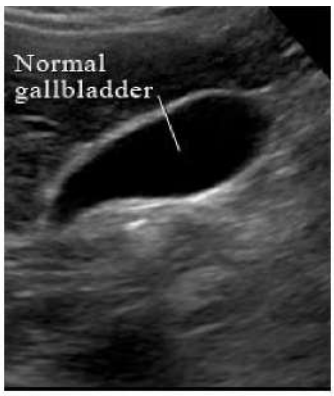
## ® CT :

- **Oral contrast** (water soluble material) → For suspected perforation
- **IV contrast** (non ionic material) :
  - Maximize the difference between the **enhancing parenchyma** and the **non enhancing hematoma** or **laceration**
  - Detect **urine extravasation**
  - Detect the **site of active bleeding**

# Abdominal Pain

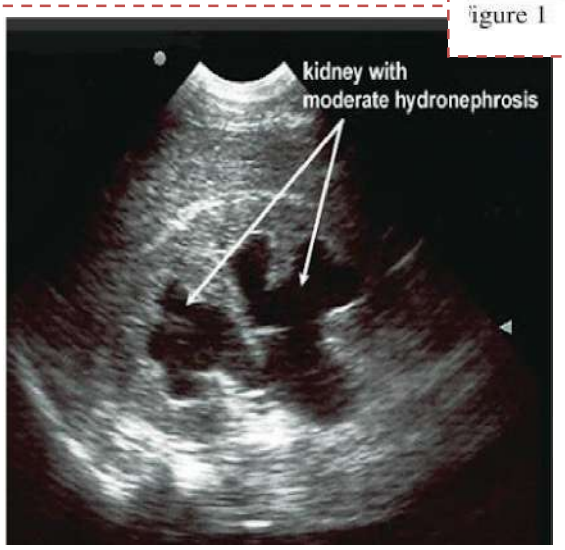
## ✓ Abdominal US:

- Initial & basic …..1st modality to use
- Can diagnose many causes as :
  - Renal or billiary obstruction
  - Intestinal obstruction & Perforation
  - Inflamatory conditions : as Acute appendicitis & its complications , Abscess
  - Organ Injury & collections




igure 1


Figure 2



## X ray Abdomen:

- **Diagnose Finding as :**
  - **Perforated gut**

    **→ Pneumo-peritonium**
  - **Intestinal obstruction**

    **→ Multiple Air-fluid levels**

- ✓ **CT Abdomen :** +Oral / IV Contrast

  When X ray & US

  Are not enough for diagnosis

# Chest Trauma

## ® X ray

**For initial Assessment**

## ® CT

**For further & detailed assessment of**

- Chest wall : Hematoma , rib fractures , surgical emphysema
- Pleura : pneumothorax
- Lung : Contusion , laceration

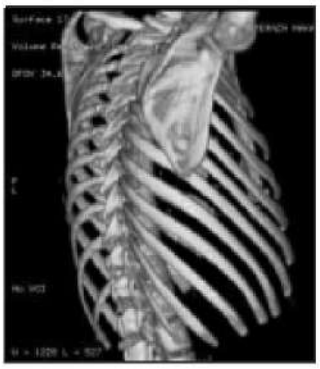
**Rt Pneumothorax**

**In X ray & CT**

## CT Reformate 3 D Images:

### Chest wall

- Fractures
- Deformities
- Neoplasms
- FB location



## Vascular Emergency

| Coronary vessels | Aorta & Mesenteric V | Limb vessels |
|---|---|---|
| • Occlusion<br>• Stenosis<br>• Anomalies<br>• Grafts<br>• Stents | • Occlusion<br>• Stenosis<br>• Aneurysms<br>• Dissection<br>• Leakage<br>• Anomalies<br>• Grafts<br>• Stents | • Occlusion<br>• Stenosis<br>• False aneurysms<br>• Dissection<br>• Leakage |
|  |  |  |

# Basics of Radiology

# Interventional Techniques

**Radiological Interventional procedures:** minimally invasive procedures guided by imaging modalities either for diagnostic or therapeutic purposes.

## Methods of guiding Interventional techniques:

- ✓ US
- ✓ Fluoroscopy (Life X ray )
- ✓ CT

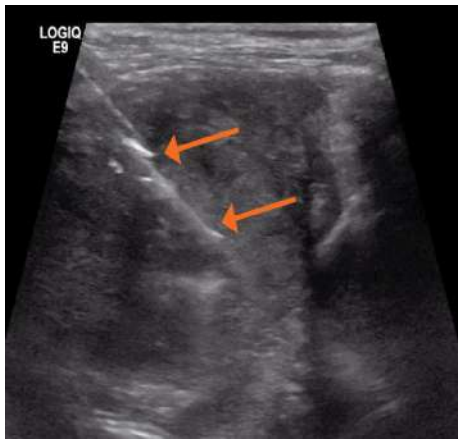
## Examples of Interventional techniques:

⇨ **Diagnostic :** as

- Biopsy ( US ot CT guided )
- Coronary Angiography

⇨ **Therapeutic :** as

- Abscess Drainage
- Tumor ablation
- Chemoembolization
- Varicosities sclerosing Therapy
- Stenting (vessels, …..etc)
- Vena Cava filters
- Vertebroplasty

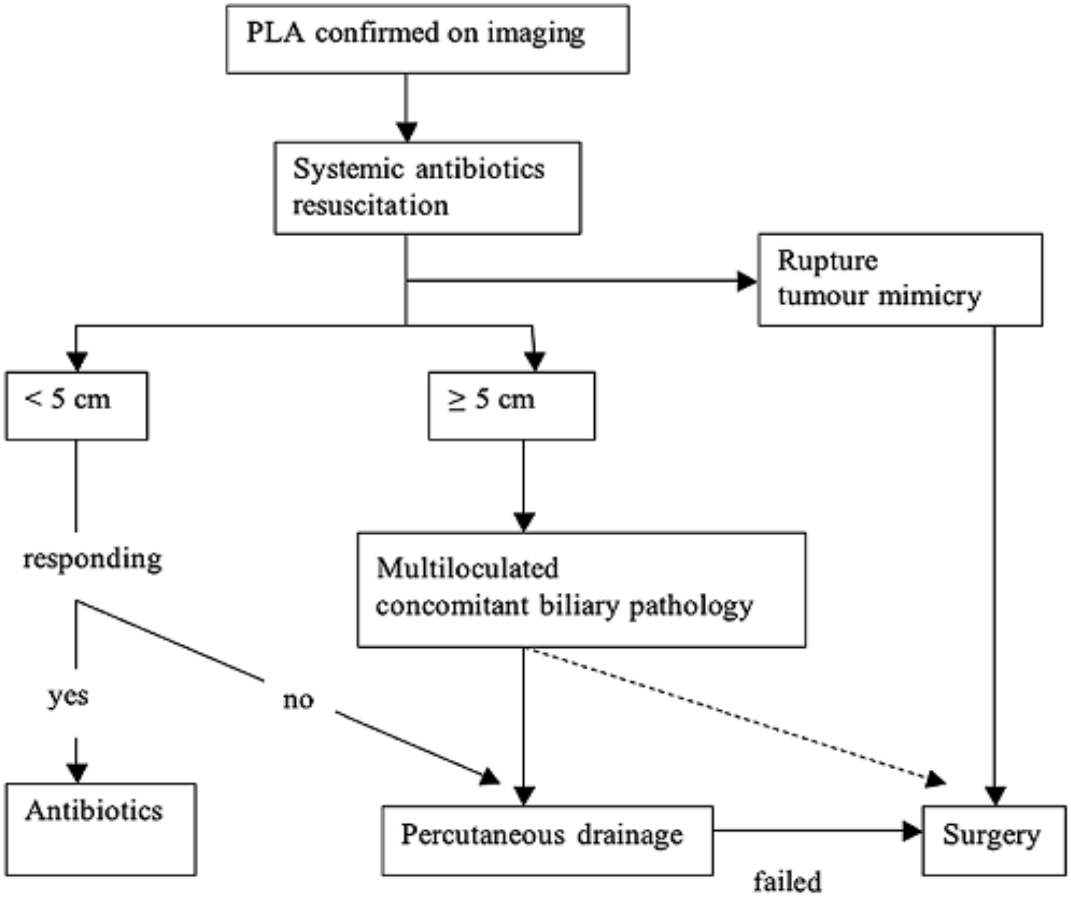



**US Guided Liver Biopsy , needle is seen (Arrows)**

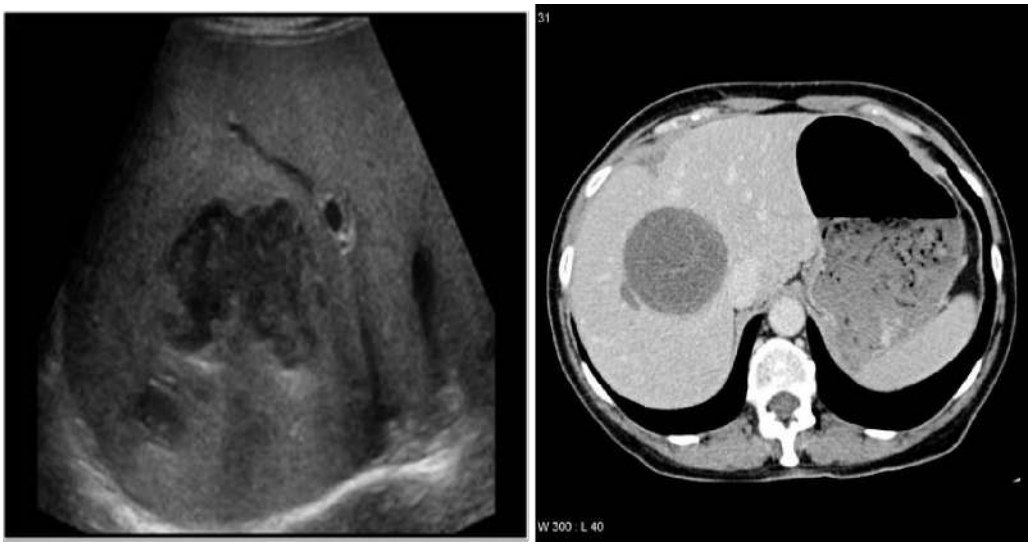
**Don't Forget:**

**Every Interventional Technique has its pre procedure preparation & related complications**

# Abscess Drainage




Schedule of Treating **P**yogenic **L**iver **A**bscess



**Liver Abscess in US & CT**

# CHEMOEMBOLIZATION

Or **TACE** = **T**rans **A**rterial **C**hemo **E**mbplization

- **Definition:** A combination of local delivery of chemotherapy and embolization to treat malignant lesions, most often of the liver.
- **Role:**

Deliver a local and concentrated dose of chemotherapeutic agents directly into the arterial feeding vessels of the tumor ……**with** or **followed by** Embolization using either **permanent** or **temporary** particulate materials.

The normal liver blood supply about **75 %** through the **portal vein** and only **25 %** through the hepatic artery. ***But Hepatic Tumor receives almost all of its blood supply from the hepatic artery.***

## Indications:

1 - Hepatocellular carcinoma (primary liver cancer)

2 – Hepatic Metastasis from:

- Colon cancer
- Breast cancer
- Sarcomas
- pancreatic Islet cell tumors
- ocular melanoma
- carcinoid tumors and other neuroendocrine tumors

3 - Other vascular primary tumors in the body

## Contraindications :

1. Impaired liver function

**N.B.** **HCC when small** with good liver functions is best treated with **resection.**

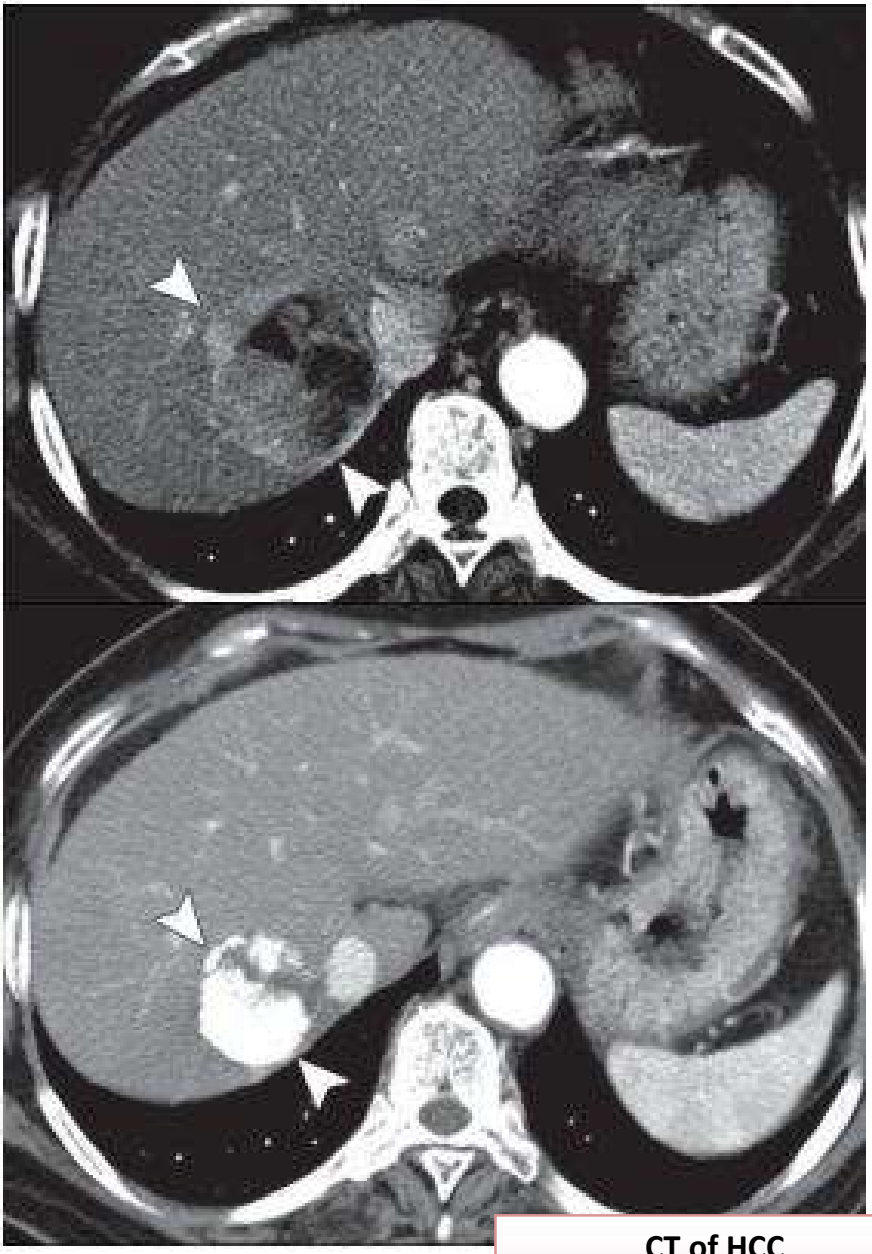
**Liver transplantation** can eliminate the tumor and also the underlying disease.

**TACE** has been shown to have survival benefits in patients with **unresectable HCC.**

للاطلاع فقط


A 62-year-old man with cirrhosis and hepatocellular carcinoma (HCC) presents for transarterial chemoembolization (TACE)

**Different Phases or steps of TACE Process**



**CT of HCC**

Before & After TACE

# Percutaneous Transhepatic Cholangiogram

## PTC & PTD

## Role:

✓ PTC allows visualization of the bile ducts , if they are partially or completely blocked

## Indications: Evaluation of

✓ **Biliary obstruction**.

✓ **Jaundice** , which may be due to :

- Calcular Obstructive: CBD Stones.
- Malignant Obstructive: Cancer Pancreas, Duodenum, and Liver.

✓ **Bile Leakage**

## Contraindications:

× Bleeding Tendency.
× Biliary tract sepsis
× Hydatid disease

**Large gallstone trapped in the duct**

# Vascular Embolization

## Definition:

Catheter embolization is the technique of occluding a blood vessel to obtain a therapeutic effect.

## GOALS

Embolization may have 3 therapeutic goals:

1. **Adjunctive goal** (eg, preoperative, adjunct to chemotherapy or radiation therapy)

2. **A curative goal** (eg, cases of aneurysms, arteriovenous fistulae [AVFs], arteriovenous malformations [AVMs], and traumatic bleeding)

3. **A palliative goal** (eg, relieving symptoms, such as large AVM, which cannot be cured by using embolotherapy alone)

## Indication

- It may use Alone or Combined with surgery or radiation.

1. **Active Bleeding**
2. **Tumors Embolization**
3. **Fibroid Embolization**

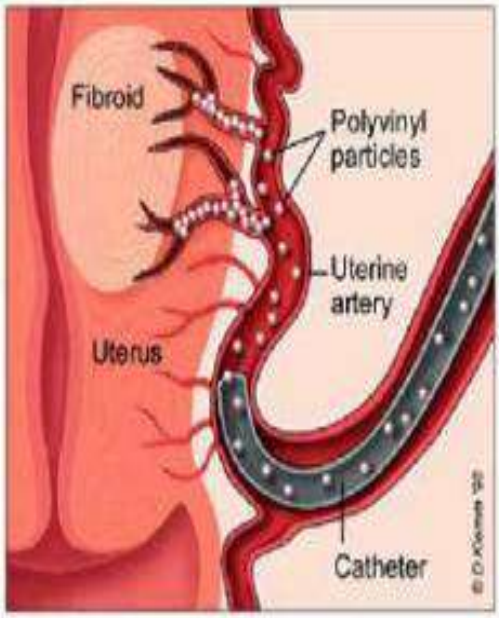
**Advantages:** *Embolization is less invasive than surgery, this lead to:*

- ✓ **Fewer complications.**
- ✓ **Shorter hospitalization**

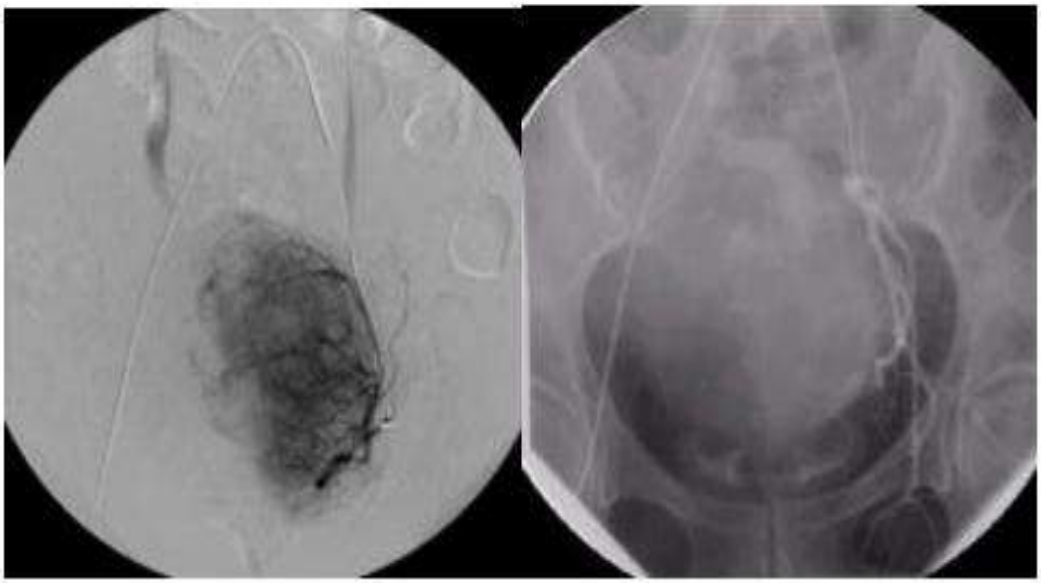
Uterine Fibroid, is not malignant, but may cause noisy symptoms as:

- Menorrhagia. - Pelvis or back Pain.
- Pressure on the bladder or bowel.

4. **Vascular Malformations**
5. **Aneurysms**
6. **Varicocele**







Uterine Fibroid: Pre & Post embolization

# Vertebroplasty

## HISTORY:

The procedure was originally developed in France in 1984 and has been further refined in the US since 1995.

## Definition:

Minimally invasive procedure, in which injection of cement (methyl - ethacrylate) into a fractured vertebral body as a means of treating pain.

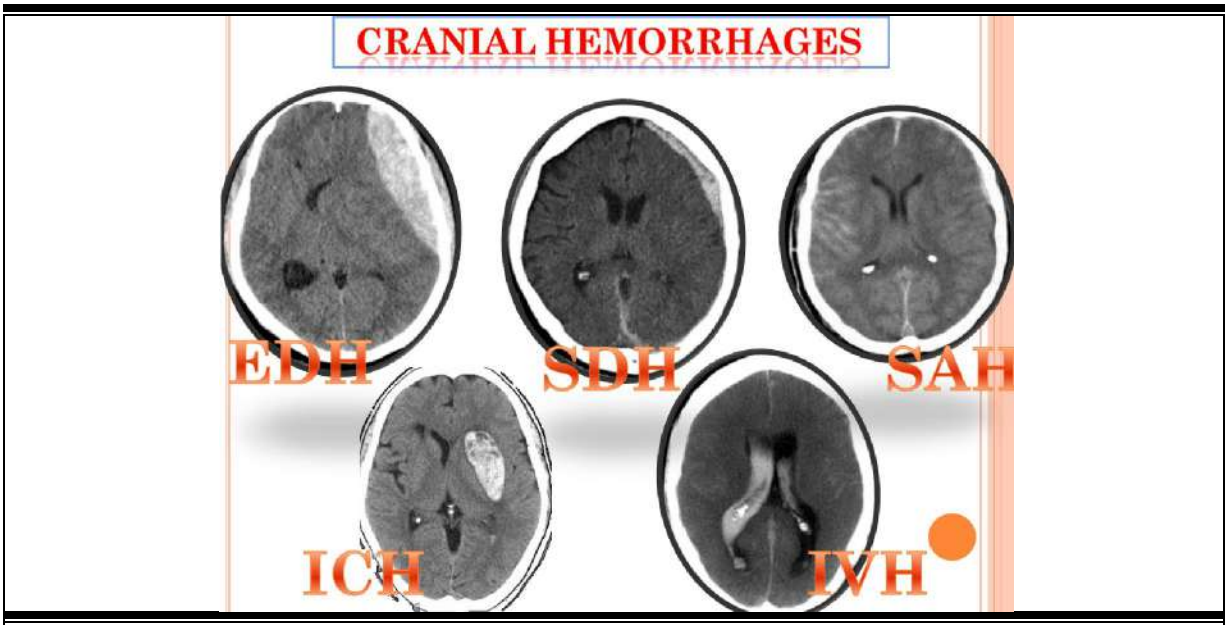
## Aim:

To relieve pain in this patients who have not responded to conservative measures.

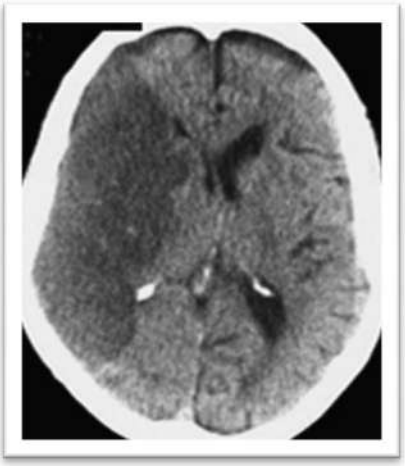
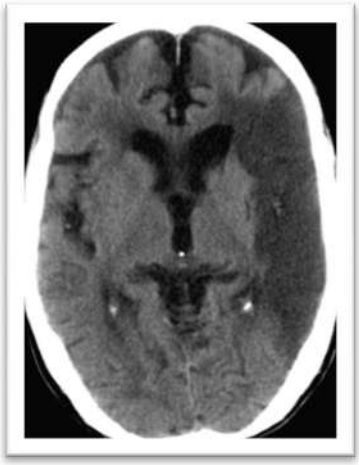
## Pathology:

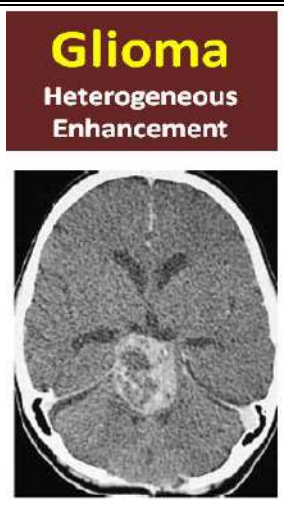
- ✓ Vertebral body fractures → Vertebral compression → pain.
- ✓ Common result of osteoporosis.

# Spot Cases Atlas



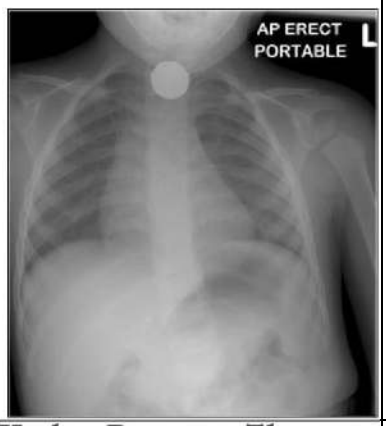

## Cerebral Infarction

| **Acute** (Days)<br>+ Mass effect of edema | **Sub Acute** (Weeks)<br>+ No mass effect | **Chronic** (months)<br>+ Evacu dilatation of adjacent ventricles |
|---|---|---|
|  |  |  |

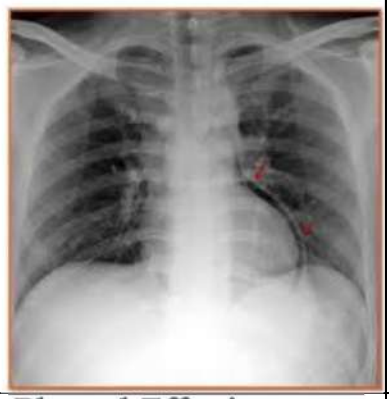




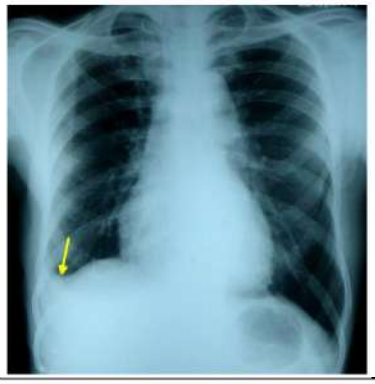

F.B. Inhalation



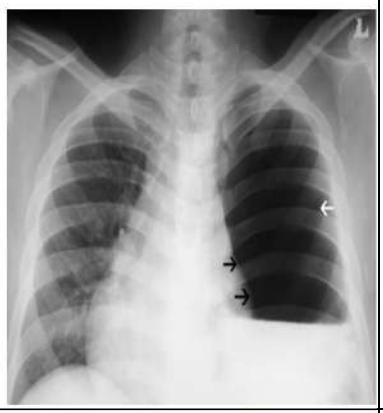

Pneumo-pericardium



Minimal
Rt pleural Effusion



Hydro-Pneumo Thorax



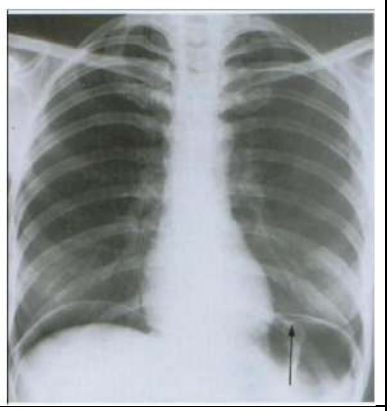
Pleural Effusion

Lung Mass

Mediastinal Mass

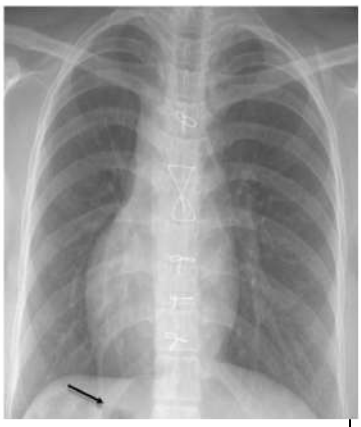
Lung Abscess

Pneumo
peritoneum

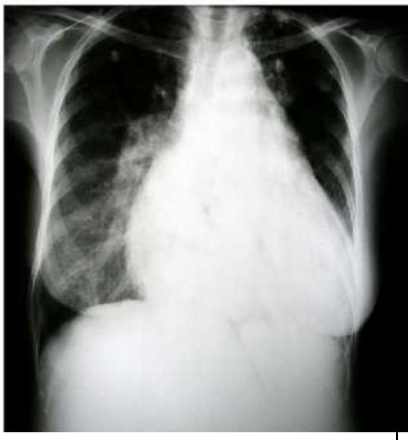


Dextrocardia

Situs Inversus Totali



Cardiomegally



Pneumo peritoneum

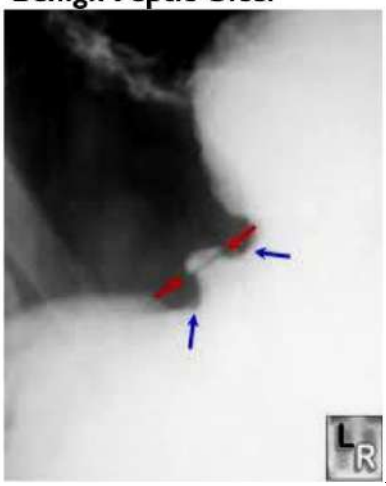
Tension Pneumothorax & lung collapse


Middle zone pneumonia & Pleural effusion

Intestinal Obstruction


Diverticular disease

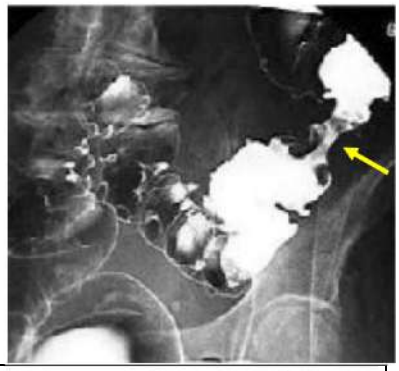
Hampton line sign
Benign Peptic Ulcer



Ulcerative Colitis

Colonic malignant Stricture (Apple Core sign)

Malignant Stricture of the colon



Esophageal Malignant Stricture

Hirschsprung disease

Imperforate Anus


Rt Ureteric Stone

Lt Ureteric Stone

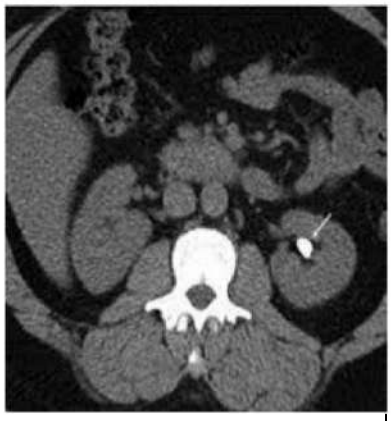
Lt Hydronephrosis & Hydroureter

Bilateral Stag horn stone

Lt Double Ureter

U.B. Mass

Lt renal stone



Rickets

Silver beaten sign

Green Stick Fracture


Hair on end sign

Rickets

# Sources & References

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