(A) GENERAL RADIOLOGY
(B) CHEST RADIOLOGY
(C) GENITOURINARY SYSTEM
(D) GASTROINTESTINAL SYSTEM
(E) CARDIAC RADIOLOGY
(F) MUSCULOSKELETAL SYSTEM
(G) RADIOTHERAPY

RADIOLOGY 2020

(A) GENERAL RADIOLOGY &RADIO PHYSICS

HISTORICAL ASPECTS

• **J.J. Thompson**	Discovered electrons
• **W.K. Roentgen**	Discovered X-rays in 1895
• **Henry Becquerel**	Discovered **radioactivity** in 1896
• **Madam Marie Curie**	Discovered radioactive substances radium, Uranium, etc.
• **Rutherford**	Discovered nucleus, α-rays and β-rays
• **Chadwick**	Discovered neutron
• **Maxwell**	Discovered electromagnetic waves (invented by Hertz)

VARIOUS MODALITIES FOR IMAGING :

1. Conventional Radiography
2. Computed / Digital radiography
3. Contrast radiography
4. Mammography
5. Ultrasonography (USG)
6. Computed Tomography (CT)
7. Magnetic Resonance Imaging (MRI)
8. Thermography (Outdated)
9. Xeroradiography (Outdated)
10. Radionuclide Imaging/ Scintigraphy/ Nuclear scan
11. Emission tomography (SPECT and PET)

(1) CONVENTIONAL RADIOGRAPHY :

X-RAY PRODUCTION :

X-rays are produced mechanically, by making electrons strike a target, which causes the electrons to give up their kinetic energy as x-rays **(X-rays are produced extranuclearly)**.

Gamma rays are produced by nuclear disintegration of radioactive isotopes **(Gamma rays are produced intranuclearly)**.

- X-rays are electrically neutral, produce fluorescence, highly penetrating, invisible rays.

X-RAY TUBE :

1.	X-Rays are produced by	:	*A stream of fast moving electrons that rapidly decelerate*
2.	X-Rays are produced in	:	*Thermionic vacuum tube called **hot filament** or **Coolidge X-ray tube***
3.	The X-Ray tube, a thermionic diode consists of	:	• *A tungsten filament cathode* • *A tungsten target anode* • *Pyrex glass (evacuated glass tube enclosure)*

- X-rays are produced whenever a stream of fast-moving electrons undergo rapid deceleration and these conditions prevail during operation of special thermionic vacuum tube called as **hot filament or Coolidge X-ray tube**.
- A typical X-ray tube is a thermionic diode consisting of a tungsten filament cathode, a tungsten target anode, an evacuated glass tube enclosure (**Pyrex glass**) and 2 circuits to heat the filament and to drive the space charge electrons to anode.

The underlying *principles* include:

1. A hot metal filament (cathode) gives off electrons by the process of thermionic emission.
2. If no kilovoltage is applied, the emitted electrons remain near filament as an electron cloud or space charge.
3. If kilovoltage is applied between the filament and target so as to place a negative charge on filament (cathode) and a positive charge on target (anode), space charge electrons are driven over to anode at high speed by the large potential difference. The electron stream crossing the gap between cathode and anode constitute the tube current, measured in milliamperes (mA).
4. The wavelength of the characteristic radiations produced by the target of X ray tube is not changed by the potential difference (kVp) applied.
5. **Intensity is proportional to $(kVp)^2$**.
6. The quantity of **X-rays produced depends on atomic number of target material, kVp and mA, while the quality depends on kVp only**.

1.	The stem, which connects the tungsten target to the remainder of anode assembly is made up of	:	*Molybdenum, which has high melting point and is a poor conductor of heat.*
2.	If X-ray were emitted from a point source, the magnification could be determined by ration of target-film distance to the target-object distance, which is called	:	***Geometric magnification***.
3.	In reality, X-rays are emitted from an area, the focal spot, hence the magnification that results with X-rays from focal spot, is called	:	***True magnification***
4.	Under usual radiographic situations, magnification of the image should be kept to a minimum. Two rules apply for this purpose	:	○ *Keep the object as close to the film as possible and* ○ *Keep the focus-film (X-ray machine to photographic plate) distance as large as possible.*
5.	X-Ray filters	:	*Sheets of metal placed in the path of X-Ray beam near X-Ray tube to absorb low*

energy radiation

6. X-Ray filters are usually made of : *Aluminium*

7. X-Ray filters : *Reduce skin exposure by 80%*

8. Diagnostic X-Ray beams of energy > 70 KVP : *Requires an equivalent of 2.5 mm of aluminium permanent filtration*

9. An **X-ray beam restrictor** is a device that is attached to the opening in the X-ray tube housing to regulate the size and shape of an X-ray beam

10. Types of X-Ray beam restrictors :
- *Aperture diaphragms*
- *Cones and cylinders*
- *Collimators*

11. Closely collimated beams have 2 advantages over larger beams :
1. *Less scattered radiation and thus improved film quality.*
2. *Smaller area of patient exposed and hence decreased patient exposure.*

12. Aperture diaphragms, cones, cylinders : *Restrict the number of available field sixes so not used.*

13. Collimators are best general-purpose restrictors

14. Advantages of collimators :
- Light beam shows the centre and exact configuration of the X-ray field.
- Accurate localization of the patient due to X-ray field illumination is permitted.
- It provides an infinite variety of rectangular X-ray fields.

15. **Grid**, a device invented by Dr. Gustave Bucky in 1913 is the most effective way of removing scatter radiation from large radiographic fields.
- Radiographic grid consists of lead foil strips separated by X-ray transparent spacers.
- They are used to absorb scatter radiation (and not primary radiation) and to improve radiographic image contrast.
- There are 2 types of grids, stationary and moving grids.
- Chief advantage of moving grids is elimination of image of the lead strips from the film, but they require a little greater exposure factors.
- Air gap technique is an alternative method of eliminating scatter radiation with large radiographic fields.

16. **THE FIVE BASIC WAYS THAT AN X-RAY PHOTON CAN INTERACT WITH ATOM/MATTER ARE:**
1. Photoelectric effect
2. Coherent scattering
3. Compton scattering
4. Pair production
5. Photodisintegration

17. The photoelectric effect is the predominant interaction with low energy radiation and with high atomic number absorbers.

18. It generates no significant scatter radiation and produces high contrast in the image, but exposes the patient to great deal of radiation.

19. The photoelectric effect is inversely proportional to cube of energy of incident photon and directly proportional to cube of atomic number of interaction material.

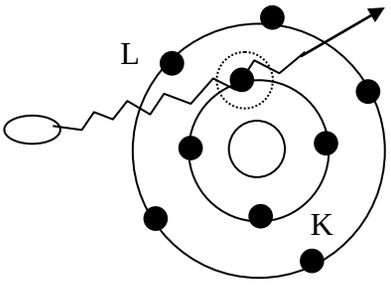
Element	Atomic number	K edge (kev)

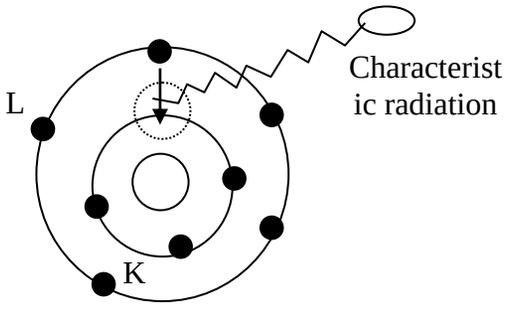
1.	Hydrogen	1	0.013
2.	Carbon	6	0.28
3.	Copper	29	9.0
4.	Lead	82	88.0

Photoelectric interaction :

It predominates in diagnostic radiology. The atom consists of a central nucleus and orbital electrons. The positively charged nucleus holds the negatively charged electrons in specific orbits, or shell. The innermost shell is called K shell, and the more peripheral shells are named consecutively L, M, N, and so forth. These shells have limited electron capacity and specific binding energy. The K-shell can hold only two electrons. When an incident photon, with little more energy than the binding energy of K-shell electron, encounters one of these electrons, it ejects it from orbit and the photon disappears, giving up all its energy to electron. This electron now flies into space and is absorbed. Thus the atom is now left with an electron void on the K shell, which is filled up soon by as a electron from adjacent shell drops into K shell, giving up energy in the form of X-ray photon. This is photoelectric effect.

- X-rays are ionizing electromagnetic radiations, essentially produced when a stream of K shell electrons of an atom accelerated by a high voltage applied between the filament (cathode) and the target (anode), strikes the target and the electrons give up their energy producing **characteristic radiations** i.e., the X-rays.





- Linear attenuation co-efficient is equal to CT number for CT scanning and attenuation of X-rays depends on it.

- **Primary radiation**: It goes from cathode to anode of X-ray tube. It comes directs from of X-ray tube. Except for the useful beam, the bulk of this radiation is absorbed in the tube housing.

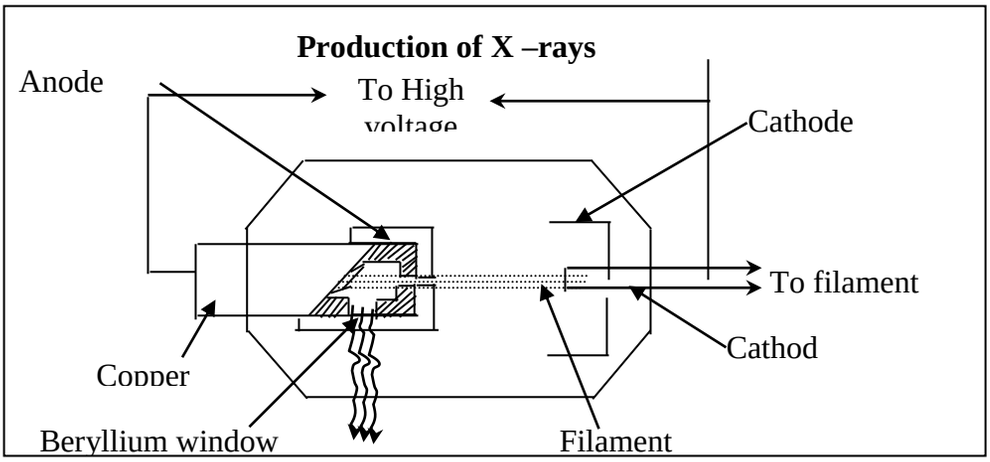
- **Secondary radiation**: It is radiation other than primary and is emitted by any matter irradiated with X-rays,

which are often loosely called scattered radiation.

- **Scattered radiation**: Radiation, which during passage through a substance has been deviated in direction. It may also have been modified by an increase in wavelength (Compton effect). It is one form of secondary radiation.

- **Stray radiation**: includes secondary radiation and any radiation other than the useful beam coming from within X-ray tube housing (such as item radiation). This is the radiation against which special protection is needed. Useful beam is that part of primary radiation which passes through aperture, cone or other device for collimating X-ray beam.

- Penetrating power of X-ray increases with decreased wavelength and increased frequency.

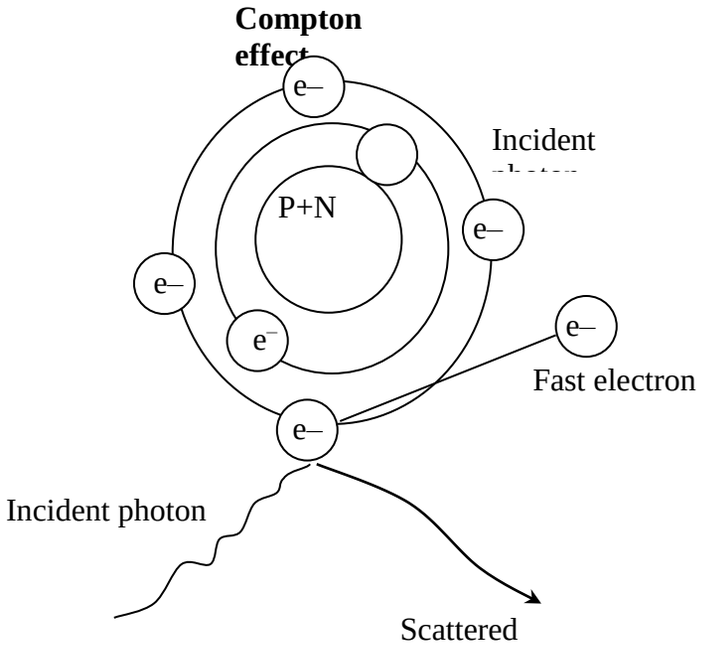


- **mAs controls film density, while kVP controls image contrast and penetration of X-ray.**

- **To increase contrast reduce kV; to reduce contrast increase kV (a well known rule).**

Compton scattering :

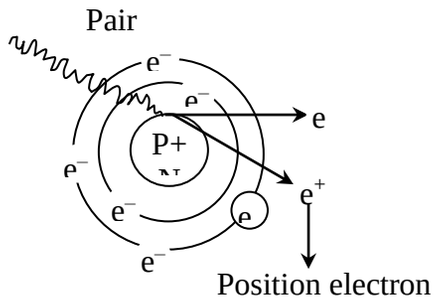
- When incident photon has enough energy to dislodge a loosely bound electron, the emerging photon, undergoes a change in direction- and it is called scattered photon.
- Thus, frequency and energy of the scattered photon is less than that of incident photon.
- These are responsible for **scatter radiation**, which constitute film fog, impairing image contrast.
- Therapeutic radiation acts by Compton effect.



Coherent or unmodified scattering/Elastic scattering

When energy of incident photons is less then the binding energy of the electrons, it causes the electrons to vibrate, causing release of an electromagnetic wave identical in energy to that of incident photon, but differing in direction.
Not useful in clinical radiography.

Tomography (PET) is based on pair production.



X-RAY FILM

√ **There are following layers in an X-ray film :**
- Supportive Base made up of Polyester plastic.
- Adhesive or subbing layer for proper binding of the emulsion to the base.
- Emulsion containing silver halide (most commonly used is silver bromide). crystals suspended in gelatin **(photosensitive layer) –** *the key component of a X-ray film.*
- Protective anti-abrasive supercoat of pure gelatin.
- Non-curl backing (only in single coated film) to prevent curling of the film.
- Antihalation layer of dye added to non-curl backing or to the base to prevent reflection and unsharpness.

- The behaviour of X-ray film (silver bromide emulsion) with respect to light spectrum (VBGYOR) is known as its spectral response.
- An x-ray film is far more sensitive to blue, violet and ultraviolet light than to the rest of the spectrum (monochromatic).
- An *x-ray film is least sensitive to red light* and if sensitizers are added to x-ray film, the spectral response can be extended in to green (up to 570 nm), known as orthochromatic emulsion, or even as far as the red (up to 700 nm) in polychromatic emulsion.

Films used in medical imaging :

1. **Double emulsion/coated(duplitized) films:** Have emulsion, applied to both sides of the plastic base in order to increase sensitivity.

E.g. a. Direct-exposure (non-screen type) films

- Intra-oral **dental films**
- Kidney surgery films
- Radiation monitoring films

b. Screen type films (Most commonly used type in **routine X-ray filming** and used with two intensifying screens)

2. Single emulsion/coated films: have emulsion applied only to one side of its base. Their main advantage is high quality images. To identify the emulsion side of single-coated film a **small notch is provided** into one edge of each film. The emulsion side is facing if the film is held with the notch in the top right-hand corner.

E.g. a. Screen type film (used with single intensifying screen)
b. Photofluorographic film
c. Cathode-ray tube (CRT) photography
d. Duplication film
e. Subtraction film
f. Laser imaging film
g. Mammography film
h. Computed tomography (CT) film
i. Radionuclide imaging film
j. Diagnostic ultrasound film
k. Computed radiography (CR system) film

Chemical processing of a X-ray film

X-rays film exposed to radiation → Develops —Rinse→
Fixer → washed

Developer – major constituent – mixture of phenidone & hydroquinone

Fixer – major constituent – sodium thiosulfate/ ammonium thiosulfate.

2.DIGITAL OR COMPUTED OR FILMLESS RADIOGRAPHY OR PHOSPHOR PLATE TECHNOLOGY

It is one of the most modern imaging method in which selective window settings of some image enhance visualization of lung fields, mediastinum or bones as desired.
Optic drum scanners/laser scanners can digitize conventional film radiographs.

Types:
1. Phosphor plate CR (e.g. europium activated barium fluoride)
2. Selenium detection CR → Excellent quantum efficiency considerable dose reduction possible.
3. Large area, thin film transistor detector CR→ Rapid image, excellent resolution.

Although it is most mature radiographic technology and uses conventional radiographic equipment but employs reusable ***photostimulable phosphor*** or selenium plate (europium- doped barium fluorohalide) instead of convocational film cassette.

Mechanism:
The phosphor plate stores energy of incident X-ray as latent image.

↓

On scanning the plate with LASER beams the stored energy is emitted as light, which is detected by a photomultiplier.

↓

And converted to digital signal by digitizer.

↓

This digital information is then manipulated, displayed and stored in whatever format desired on computer.

The phosphor plate can be reused once latent image has been erased by exposure to whole light.

MAJOR ADVANTAGES OF CRS :

- Linear photoluminescence dose response, which is much greater than that of conventional film.
- Hide altitude.
- Post processing of images possible.
- Advantage of image archiving and transmission.
- Excellent resolution

PLAIN RADIOGRAPHY

1.	Direct digital radiography apparatus uses	:	*Amorphous silicon*
2.	Viewing of digital images with clinical details and report on monitor and accessibility of same on computerized electron network is called	:	*PACS (Picture Archiving and communication system)*
3.	The magnification factors in macro radiography	:	*1.5 X, 2 X*
4.	Cineradiography is useful for studying	:	*Disorders of swallowing*
		:	*Coronary angiography*
		:	*Angiocardiography*
5.	Roentgen is the unit of radiation	:	*Exposure in air*
6.	Xeroradiography is used in mammography for the demonstration of	:	*Breast tumors*
7.	Most widely used heavy metal in radiology is	:	*Barium*
8.	Hypocylcoidal tomography is used for viewing	:	*Petrous bones*
9.	Most radiosensitive tissue of body	:	*Bone marrow*
	Least radiosensitive tissue of body	:	*Nervous tissue*
10.	Highest dose of irradiation of gonads is received during examination of	:	*Hip*
11.	In xeroradiography, an aluminium plate is coated with a thin layer of	:	*Selenium*
12.	CT scanning was discovered by	:	*Godfrey Hounsfield in 1972*
13.	Movement blur should be minimal to get	:	*Maximum sharpness of image*
14.	Exposure time of radiation can be minimized by use	:	*Fast screens*

of

15. The gas used for pneumography : *Carbon dioxide*

16. Radio protection shields are made up of : *Lead*

17. IVP in pregnancy should be postponed till : *10 - 12 weeks after delivery*
18. Photosensitive material used in X-ray is : *Silver bromide*
19. Radiological investigations in women should be done within : 10 days following menstruation
20. Standard optimum distance for radiological examination : *90 - 100 cm*

X-rays films

• Expiratory film is required in	Pneumothorax (erect, frontal, expiratory) & FB
• Inspiratory film is required	For PA view CXR
• Renal scan	Done in prone position
• Barium-meal in hiatal disorders	Done in Trendelenburg's position

Some important views

X-RAY VIEWS FOR BEST VISUALIZATION OF VARIOUS STRUCTURES

STRUCTURE VISUALIZED	X-RAY VIEW
Skull trauma (sella turcica) (pituitary fossa)	Lat view
Pneumothorax	PA view on expiration
Internal auditory canal (both sides)	Stenver's view
Lt. atrial eniargement	Rt. Anterior oblique
Orbital roof, orbital floor fracture	Waters' view (occipitomental view)
Orbital lesions	Cardwell view (15° occipitofrontal)
Optical foramen	Rhese view
Mastoid process	Lat oblique (Schuller's view)
Paranasal sinuses (PNS)	Water's view
Sphenoid sinuses	Lat view
Minimal pleural effusion with barium swallow-perforation of abdominal organs	Lat decubitus view (left) AP view in erect posture
Cephalopelvic disproportion	Lat view
Gallbladder	Rt anterior, oblique
Congenital D/L of hip	Von Rosen view (CDH)
Fracture scaphoid	Oblique
Spondylolisthesis intervertebral foramina	Posterior, oblique Oblique
For apex, **L**ingular lobe (rt middle lobe) of lung	**L**ordotic
To detect interlobar effusion	Reverse lordotic

# patella	Skyline
Recurrent Subluxation/dislocation of shoulder	Stryker's view

BONE DENSITY

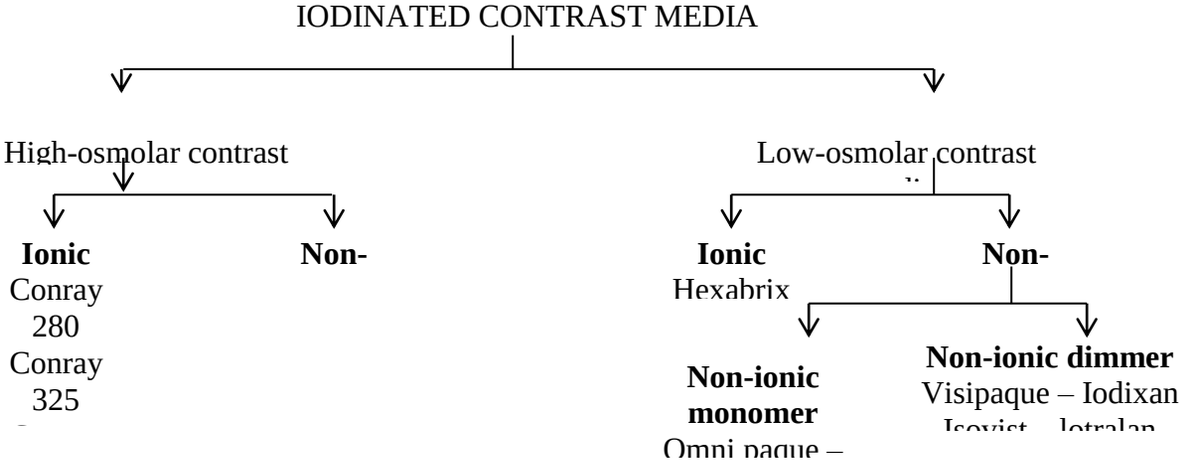
1. DXA – Dual – energy X-ray absorptiometry is a highly accurate X-ray technique that has become the standard for measuring bone density in most centres.
* CT – used in spine, forearm, tibia
: *Mainly done in lumbar spine & hip*

: *Hip is the preferred site of measurement*

2. Gold standard investigation for osteoporosis : *DEXA (Dual Energy X-Ray absorptiometry)*

(3)

INTRAVASCULAR IODINATED CONTRAST MEDIA



1. In general, Non-Ionic LOCM are move commonly used nowadays

2. The average daily physiological turnover of iodine is – : *0.0001 g*

3. The total iodine content in the body is – : *0.01 g*

4. The requirement for a 2-, 3- or 4 vessel angiogram may be – : *70 g iodine*

5. Conventional X-ray Cerebral angiography is the gold standard for identifying and quantifying atherosclerotic stenoses of cerebral arteries and for identifying, and characterizing other pathologies, including aneurysm, vasospasm, intraluminal thrombi, fibromuscular dysplasia, arteriovenous fistula, vasculitis & collateral channel of blood flow

Adverse Reactions to Radiological Contrast Media

i. Idiosyncratic reactions are the most feared and the most frequent serious and fatal complications of radiological contrast media
ii. Reactions are more common in asthmatics and patients with history of allergy or previous reaction
iii. Non-idiosyncratic reaction are dose dependent

GUIDELINES FOR PREMEDICATION OF PATIENTS WITH PRIOR CONTRAST ALLERGY

12 h prior to examination	Prednisone, 40 mg PO or methyl prednisone 32 mg PO
2 h prior to examination	Prednisone, 40 mg PO or methyl prednisone 32 mg PO And Cimetidine 300 mg PO or ranitidine 150 mg PO
Immediately Prior to examination	Benadryl, 50 mg IV (alternatively can be given PO 2 hours prior to examination)

1. Two types of contrast agents are commonly used : *1) Barium sulphate*
2) Water soluble iodinated contrast agent

2. Barium sulphate is : *Inert*

3. Barium sulphate is contraindicated in :
- *Tracheoesophageal fistula*
- *Bowel perforation*

4. Aqueous contrast : *Is rapidly absorbed from peritoneal cavity and interstitial spaces*
Useful in fistula and bowel perforation
:

DYES USED IN VARIOUS PREPARATIONS

Investigations	Dye used
Angiography	Urograffin
Myelography	Metrizamide (myodil)
Bronchography (esophageal atresia)	Dianosil
Lymphangiography	Methylene blue and lipiodol
Chromocystoscopy	Indigocarmine
Sialography	Neohydiol
CT-scan	Metrizamide (water soluble I_2)
IV pyelography (IVP)	Urogragffin, Conray 420 (Na detrizoate)
Fetography	Ethiodol
Intestinal obstruction	Gastrograffin
Hysterosalpingography	Conray-280 (meglumine iothalamatedone on 14^{th} day of menstrual cycle)
IV Cholangiography	Billigraffin (meglumine ioglycamide)
MRI	GDPA (gadolinium)
Esophagography	Barium swallow
Oral cholecystography (Graham Cole test)	Iopanoic acid (Telepaque)
Percutaneous transhepatic cholengioggraphy (PTC	Conray-280 (meglumine iothalamate)

Spleennoportography	Na metozamide (75%)
Urethrography	Umbradil viscous
Venography	45-65% hypaque
Ventriculography	Metrizamide
Pneumography	CO_2 gas

Myelography

1. Radiographic investigation of the spinal canal

2. Contrast material injected into : *Subarachnoid space*

3. Contrast agents :
- *Negative contrast – Air or oxygen*
- *Positive non-ionic, water soluble, low osmolar, organic iodine compound*

4. Oily preparations (iophendylate) causes : *Chronic adhesive Arachnoiditis*

5. Metrizamide (Amipaque) :
- Isotonic and freely miscible with CSF
- Flows along SA spaces along the nerve roots
- Absorbed from SA space within 48 hours
- Low viscosity, so narrow bore needle can be used, less post spinal complications

6. Iohexol (Omnipaque) : *Most commonly used non-ionic iodinated contrast agent*
Less SA toxicity

7. Most dangerous complication of myelography : *Arachnoiditis*

EXCRETORY UROGRAPHY (INTRAVENOUS UROGRAPHY, IVU, IVP)

- Primary modality for imaging the urinary tract.
- The renal margins and parenchyma (*nephrogram*), as well as the entire collecting system (pyelo*gram*), including the ureters and bladder,7y7 can be visualized diagnostically.
- The quality of the urogram depends on good pelvicalyceal concentration of contrast media as well as sufficient distension of the collecting system.
- **Indications** :
  - Trauma
  - Acute genitourinary pain
  - Hematuria
  - Infections
  - Suspected neoplasm
  - Renal transplantation
  - Neurogenic bladder
  - Congenital anomalies
  - Complications following surgery

- Hypertensive urogram :
  - Bolus injection of contrast followed by rapid sequence films at 1, 2 and 3 minutes post injection.

- Radiological criteria for renovascular hypertension
  - Delayed visualization of contrast in the collecting system on the affected side
  - Decreased renal size
  - Delayed wash out of contrast on later films
  - Notching of proximal ureter on involved side due to collateral flow via the periureteral plexus

- Contraindications :
  - Combined renal and liver failure
  - Multiple myeloma
  - Pregnancy
  - Previous reaction to contrast / allergy
  - Infants
  - Thyroid disease
  - Diabetes mellitus
- Both plain film & urogram should be exposed at 66 kVp – 70 kVp

- Contrast : Low osmolar water soluble non ionic iodinated contrast (iohexol).

URETHROGRAPHY :

Retrograde Urethrography/ Ascending urethrography :

- Examination of the male urethra by this technique is frequently done to evaluate urethral trauma or obstruction secondary to inflammatory disease or neoplasm.
- Opacification of the male urethra in retrograde fashion allows visualization of the anterior urethra but is usually accompanied by *relatively poor filling of the posterior urethra* because of the resistance encountered at the external sphincter.
- The appropriate contrast material should be water soluble. Methylglucamine diatrizoate or iothalamate is used.

Voiding Cystourethrography / Micturating Cystourethrography / Descending urethrography ;

- The primary indications for cystourethrography are to evaluate the presence of vesicoureteral reflux and to investigate abnormalities of the bladder neck and the posterior urethra.
- Functional assessment of bladder contractility and micturition is also possible using this technique.
- Current infection of the lower urinary tract is a contraindication to the procedure.
- **Indications :**
  To demonstrate the various abnormalities in the neck of bladder and urethra
  - Recurrent UTI especially in children
  - For complete assessment of cases of bladder diverticuli
  - For demonstration of VUR
  - For demonstration of bladder contractions and the control of micturition
- An MCU is indicated in all boys less than 1 year of age with UTI.
- Any child who requires imaging of kidneys & or urinary tract for whatever reason, with the exception of trauma cases, should undergo a USG examination as the first investigation.
- It is necessary in all boys to assess by MCU when there is any suspicion of urethral pathology.

HYSTEROSALPINGOGRAPHY (HSG) :

Definition: Visualization of the uterine cavity and Fallopian tubes by using negative contrast media (normal

saline in hydrosalpingosonography) or positive contrast media (Echovist in sonosalpingography and the iodinated nonionic low-osmolar contrast agent in HSG).

Ideal time to perform HSG: Between 7th and 10th day of menstrual cycle, for following reasons:
1) No risk of early pregnancy
2) Isthmus is most easily distensible
3) Tubal filling occurs readily.

Indications for HSG:
1) Infertility
2) Recurrent miscarriage
3) Congenital abnormalities
4) Post-uterine and/or tubal surgery
5) Abnormal uterine bleeding
6) Evaluation after major pelvic trauma and/or surgery
7) Prior to artificial insemination and *in vitro* fertilization, for tubal patency (other tubal patency tests are laparoscopic chromopertubation, CO_2 insufflation and hydrosonosalphingography - Sion test).

Contraindications for HSG:
1) Pregnancy
2) Bleeding
3) Immediate pre and postmenstrual phases
4) Recent untreated pelvic infection
5) Tubal or uterine surgery within last 6 weeks
6) Contrast medium sensitivity
7) Recent D and C procedure
8) Severe renal or cardiac disease
9) Migrated IUCD.

(4) MAMOGRAPHY :

- It's a special radiographic technique for imaging of Breasts, basically used for screening purpose.
- It has replaced Xeroradiography because apart the effect of greater depth dose due to the use of higher x-ray tube kilovoltage, the average glandular dose in xeromammography is about three to six times greater than in screen-film mammography.
- The required image should have high contrast, high spatial resolution, and low noise.
- It differs from routine radiographic technique in that *instead of tungsten filament* ***molybdenum*** is used as *target material. Rhodium and rhenium* can also be used. This is because, ***molybdenum*** produces low energy X-ray beam after bombardment with electrons, which are must in mammography as it is used as a screening tool for breast lesions and its repeated use is likely and one of the predisposing factor for carcinoma breast is radiation itself.
- It requires high soft tissue resolution (aim is to image breast tissues), ***low radiation*** *dose* (aim is to avoid radiation hazard to breast**)**, special compression views (mediolateral view is the most important one) and equal radiation exposure to all parts of breasts.
- Mammography X-ray tubes are *Low kV-high mA output* tube, operated in the 22- to 35-kVp range, commonly have a rotating anode to achieve currents of the order of 100 mA, and usually have a molybdenum target, a thin beryllium window (less than 1 mm), as opposed to the more absorbing Pyrex

glass used on routine X-ray tubes, and a molybdenum filter of about 0.03 mm thickness. Focal spots of 0.3 mm are required.

- Overall detection rate of carcinoma breast by mammography is 58-69% and 8% only, if the lesion < 1cm in size. Hence mammography is a screening modality and not the best diagnostic measure.
- Thus, mammography is a very specialized radiographic examination whose main purpose is to aid in the diagnosis of breast cancer. The indicators being searched for within the matrix of adipose and glandular tissue of the breast are subtle, soft-tissue density lesions with spiculated margins and clusters of small calcifications, each less than 0.5 mm in diameter, often referred to as "microcalcifications" (hallmark).
- MC frequency used: 7.5MHz

Indications for Mammography include :

1. Before breast surgery, as it may avert an unnecessary biopsy demonstrating that the palpable mass has a characteristically benign appearance.
2. Follow up of breast cancer patients.
3. Work up a patient with metastases from an unknown primary.
4. Mammographic Screening is best screening method for carcinoma breast**.**

(5) ULTRASONOGRAPHY/ULTRASOUND STUDY/USG

- Ultrasound is sound with a frequency greater than **20,000 cycles/sec** (Hertz, Hz).
- Thus, sounds with a frequency above 20 kiloHertz (20 kHz) are called ultrasonic (beyond the range of human hearing).
- The sounds used for sonar are well into the ultrasonic range, with frequencies of 1 - 20 megaHertz (MHz).
- Medical sonography employs frequencies between 1MHz and 20 MHz.
- It does not involve use of ionizing radiation (the greatest advantage).
- Subjecting a special ceramic material, a piezoelectric crystal, to a short-voltage electric spike, produces these high frequencies.
- The piezoelectric crystals in the ultrasound probe are nothing but innumerable dipoles arranged in geometric pattern and electric field causes sudden change in their physical dimensions (shape) by realigning them, thereby starting a series of vibrations that produce sound waves.
- Thus, by the virtue of **piezoelectric effect** in the ultrasound probe one form of energy (electric energy) is converted in to another form (sound energy) the body /organs parts are imaged.
- It works on pulse echo principle and B-mode is used for transmission during all routine including abdominal ultrasonography.
- **Real-time B-scans** allow body structures which are moving to be investigated. The simplest type of scanner is just a speeded up version of the 2-D B-scan, allowing a rapid series of still pictures to be built up into a video of the movement. More sophisticated systems have an array of transducers rather than just one pair of transmitter and detector, and the current image is combined by computer with a recently stored image to improve the overall quality.
  - The probe or the transducer is any device that converts one form of energy to another. In case of ultrasound, the transducer converts electric energy to mechanical energy and vice versa.
  - The ultrasound transducer uses the **principle or property of piezoelectricity** which occur naturally in some materials whereby an applied electric field produces a change in linear dimensions.
  - **Quartz, natural ceramic** is a naturally occurring piezoelectric material having the unique ability to respond to the action of an electric field by changing shape and to the change in polarity of voltage applied by generating small potentials and thus producing an ultrasound image.
  - Currently **Lead zirconate titanate (PZT), synthetic ceramic** is the most widely used material in the ultrasound sound transducers/probes replacing the firstly discovered Barium titanate. Although

some naturally occurring materials possess piezoelectric properties (e.g., quartz) but most crystals used in medical ultrasound are man made with artificial ones, known as Ferroelectrics.

In most diagnostic applications, frequencies in the range 1–20 MHz are commonly used.

The various frequencies used for various body parts are as follows:

1. **1.5 to 2.5 MHz**—abdomen in obese patients and transcranial studies.
2. **3 to 7 MHz**—abdomen, heart and obstetric USG (2nd and 3rd trimester).
3. **7 to 15 MHz**—Superficial tissues like thyroid, breast and scrotum, orbital, transrectal, transvaginal and transesophageal or endoscopic ultrasonography.
4. **> 20 MHz**—eye, skin and intravascular USG (IVUS).

- More the dense a tissue is, more will be the acoustic impedance, reflection of the ultrasound beam will be more, producing more acoustic shadow.
- The acoustic impedance of bone is maximum in our body (7.8 Rayls); hence it produces dense/maximum acoustic shadow.
- Calculus also produces acoustic shadow.
- Clear liquids allow ultrasound to pass directly through without much alteration, so that echoes that come from tissue behind liquid are usually enhanced (brighter). This is known as **"acoustic enhancement"**.
- Dense materials such as bones or calculi cast shadows on the structures behind them, as the ultrasound waves do not go through them. This is known as **"acoustic shadowing" (*Postacoustic shadow*)**.
- Postacoustic shadow is of immense importance in detecting gallbladder and renal calculi.
- **WES triad** (Wall Echo Shadow) is diagnostic sign of gallstones on ultrasonography, where wall of gallbladder, echo of calculus, and postacoustic shadow of the calculus seen together is diagnostic of cholelithiasis.

TRUS (Transrectal ultrasonography)

- Transabdominal Ultrasound does not have the spatial resolution needed for identifying intraprostatic disease, for which transrectal or transurethral approach is necessary.
- TRUS is an **excellent** adjuvant to physical examination, it does not serve as a screening investigation. However, the combination of Digital Rectal examination (DRE) & serum PSA level is more sensitive then TRUS.
- But once suspected, prostatic carcinoma is most effectively confirmed by TRUS-guided needle biopsy.
- The staging accuracy of TRUS does not match the accuracies attainable by MRI, especially **Endorectal coil MR** (ERMR).
- CT is not recommended for routine tumor staging as it is insensitive & non specific. **CT** is useful in advanced cancer for evaluation of adenopathy & metastases.
- **Major role of MRI** is in local staging of Disease.
- In rectal carcinoma the depth of penetration can be best achieved with TRUS, while the involvement of perirectal nodes can be better assessed by MRI.

1.	**Ultrasound in obstetrics can induce changes in cell migrating at an early developmental stage**		
2.	For IVUS (Intravascular ultrasound) frequency used is	:	*20 MHz*
3.	Absolute barrier to USG	:	*Air*
4.	The ultrasound waves travel in human tissue at a velocity of	:	*1540 m/s*

5.	The substance that is most widely used as transducer in medical ultrasonics is	:	*Lead zirconate titanate (PZT)*
6.	Activity of transducers of USG are based on the principle of	:	*Piezoelectric effect*
7.	The A scan in USG represents	:	*Amplitude mode (used for all linear measurements)*
8.	In diagnostic applications frequency used is	:	*2 – 20 MHz*
9.	Frequency mostly employed for Doppler studies is	:	*3 – 6 MHz* *3 - 7.5 MHz*

COLOR DOPPLER IMAGING/STUDY

- Based on Doppler Effect (change in the perceived frequency of sound emitted by a moving source measures blood flow). It provides both audio and video signals.
- Types
  - Continuous waves
  - Pulsed waves
- In Doppler imaging colour displays direction of blood flow. It is
  Red – when direction of flow is towards the transducer.
  Blue – if flow is away from transducer.
  Intensity of colour represents velocity of blood flow. Lighter shades represent higher velocity
- **Used for**
  Arterial stenosis (e.g. RAS, TAP, AV fistulas), carotid occlusion, PVD, Burger's disease.
  DVT, varicose veins to find perforator incompetence

It has become common practice to represent flow towards transducer as red and flow away as blue.

The **main advantages of Colour Doppler imaging** include:

a) Confirmation that a structure is a vessel or that a known vessel is patent. It shows vessels that are too small to be seen by 2D image.
b) Direction of flow can be easily confirmed, as important in the portal vein.
c) It also permits the assessment of number and distribution of vessels within a tissue volume which is important to second blood flow signals from vessels like renal accurate and uterine arteries and in assessment of vascularity in and around focal lesion.
d) Doppler frequency shift data also needed to measure blood flow velocity directly.

TRANS ESOPHAGEAL ECHOCARDIOGRAPHY (TEE)

Even in the hands of experienced echocardiographers, some portion of the adult population, *due to obesity, chronic obstructive lung disease, or abnormalities of thoracic musculoskeletal anatomy*, may not be amenable to transthoracic (i.e., precordial, apical, suprasternal, or subcostal) echocardiographic imaging. In these patients, the development of transesophageal methods has permitted superior visualization of certain portions of cardiac anatomy. In particular, *assessment of structures near the esophagus (left atrium, right atrium, inter atrial septum, atrio-ventricular valves, pulmonary veins, and aorta)* may be visualized from transesophageal windows.

- It is also a cardiovascular monitoring technique. it is the *most sensitive and practical technique* for detection of **myocardial ischemia** in the perioperative period.

6.COMPUTED TOMOGRAPHY (CT)

CT SCAN – COMPUTERIZED AXIAL TOMOGRAPHY

1.	In CT scan bone appears	:	White
2.	Absorption value for water in CT is	:	*Zero*
3.	The first investigative procedure to be done in sub-arachnoid haemorrhage	:	*CT*
4.	The tissue having highest attenuation coefficient value in CT	:	*Bone*
5.	The tissue having lowest atten-uation coefficient value in CT	:	*Fat*
6.	CT scanning was discovered by	:	*Godfrey Hounsfield in 1972*

Godfiery n. Hounsfield *(1973), while working with central research laboratories of EMI (electromusical instruments) limited Hayes, England first described an elaborate technique in which x – ray transmission readings were taken through the head at a multitude of angles. He got a Nobel prize of medicine in 1979 for describing this first effective scanning system, which was called EMI scanner.*

1. ***Generation I CT machineL EMI*** *scanner*
2. ***Generation II CT machine:*** *Scanners in which the x – ray tube and detectors are made to move in translate rotate type of mechanical motion.*
3. ***Generation III CT machine:*** *Scanners that employ a rotating motion in which the detectors and x –ray beam rotate around the object.*
4. ***Generation IV CT machine:*** *Scanners in which detectors are stationary and the x – ray source is moved around the object.*

CT image depends only on X-ray absorption

CT number/HU value:

Basic principle of CT is linear attenuation of X-rays.

- Incident X-rays are linearly attenuated by their interaction with orbital electrons of tissues. Measurement of attenuation of emerging / detected beam→ gives density of intervening tissues and this density forms basis of signal intensity variation obtained in X-ray tomograms.
- For unenhanced CT, there is an essentially linear relationship between voxel signal intensity (image brightness) and the X-ray linear attenuation coefficient, which is scaled relative to air and water and converted to an integer.
- This is expressed in Hounsfield units (HU), which range from –1000 to +4000.
- Actually the linear attenuation co-efficient of each pixel converted to a new number is called a "CT number" which allows computer to present the information gathered as picture/image with large gray scale.
- CT numbers are also called **Hounsfield units (HU)**.
  - Air has a value of –1000 HU
  - Fat of -120 to -200 HU
  - Water of 0 HU

- Soft tissues of 20–60 HU
- Blood of 50-60 HU
- Bone of + 1000 HU

Unenhanced/ Noncontrast (NCCT)/ Precontrast/ Plain CT is investigation of choice for :

1. Acute SAH (As the age of blood advances, its density decreases as it gets degraded into its degradation products i.e. oxyhemoglobin → deoxyhemoglobin → methemoglobin → hemosiderin, hence for chronic bleeds CT is not good)
2. Head injury
3. Fractures in Spine injury
4. Intracranial calcification
5. Fractures of pelvis
6. Minimal Pneumoperitonium
7. Ureteric calculi (most sensitive investigation for acute renal colic)
8. Detecting Calcification (e.g. as in retinoblastomas, ovarian dermoids, hydatid cysts, corpus callosal lipomas, neuroblastoma etc)

Contrast-enhanced/ CECT is investigation of choice for:

1. Meningitis (especially tubercular)
2. Lung carcinoma (Except Pancoast tumor)
3. Mediastinal tumors (Except Posterior mediastinal tumors, which are neurogenic)
4. Pancreatic lesions (Except neuroendocrine tumors of pancreas)
5. Staging of Renal cell carcinoma (Except for RCC with renal/IVC thrombosis)
6. Abdominal adenopathy
7. Small bowel tumors
8. Blunt trauma abdomen
9. Advanced Ca prostate (staging)

HIGH RESOLUTION COMPUTED TOMOGRAPHY/HRCT

BASIC PRINCIPLES:

Three factors which significantly improve the spatial resolution of CT such that it can be described as High Resolution Computed Tomography/HRCT and be used for studying the greater details of lung parenchyma/petrous temporal bone are:

1. High spatial reconstruction or edge enhancing or sharp or bone algorithm (for image reconstruction, as it reduces image smoothing and makes structure visibly sharper).
2. Narrow beam collimation(reduces volume averaging within the section and so increases spatial resolution causing marked effect on appearance of lungs, notably the vessels and bronchi)
3. Small field of view.

- This makes, HRCT a ideal modality for correct identification of subtle diffuse abnormalities of lung parenchyma even in very early stage and thus evaluating interstitial lung disease in the best manner. It is also helpful in imaging of temporal bone.
- Slice thickness of 1 mm is ideal for HRCT
- **Clinical Applications:**
  - Bronchiectasis

- Interstitial and Diffuse lung diseases
- Emphysema

- HRCT is of proven value in the diagnosis of diffuse lung disease (like interstitial lung diseases), particularly in the early stages when the chest radiograph is normal and for follow-up.
- HRCT clearly depicts distribution and higher definition of appearances of pulmonary parenchymal disease.
- Nowadays HRCT is used for detection of bronchiectasis, and surgery is undertaken without preoperative bronchography. Severity and extent of bronchiectasis is demonstrated.

Mediastinal or chest wall involvement by lung pathway may also be demonstrated.

Advantages of CT:

1. Less time of acquisition
2. High spatial and temporal resolution
3. Best to detect calcification

Disadvantages of CT:

1. Modality that gives highest radiation dose (Ionizing radiation hazard)
2. No multiplanar capability, only axial images possible (except for MD CT)
3. Contrast related toxicity.
4. Due to '*beam hardening'* artifact not good for posterior fossa tumors.

(7) MRI – MAGNETIC RESONANCE IMAGING

- It is a noninvasive method of mapping the internal structure of body by producing images by the virtue of gyromagnetic property of protons, with the greatest advantage of **not using ionizing radiation** for imaging.
- It employs radiofrequency (rf) or radiowaves waves/radiation in the presence of carefully controlled magnetic fields in order to produce high quality cross sectional images of body in any plane.
- It portrays the distribution of hydrogen nuclei and parameters relating to their motion in water and lipids.
- **Prucell**, pioneer of MRI, took the advantage of the fact that 60%our body is made up of water i.e. protons. Nuclei of certain atoms (protons or neutrons) when placed in a magnetic field, absorb and emit energy of a specific frequency.
- Almost all images produced to date have been by the virtue of **gyromagnetic property of protons and the nuclear magnetism of hydrogen nucleus (or proton)**, which is a particularly favourable nucleus from MRI standpoint, and is present in virtually all biological material.
- Because nuclei are spinning, they respond to magnetic couple like gyroscope to their axes, are tilted so that they come to rotate at exactly same frequency about the magnetic field; direction of movement is **known as 'precession'**.

Some Common Intensities on T1 & T2 Weighted MRI Sequence
Signal Intensity

Image	CSF	Fat	Brain	Edema
T1W	Low	High	Low	Low
T2W	High	Low	High	High

i. Fast flowing blood returns no signal (flow void) on routine T1W & T2W spin echo MR images.

ii. Slower flowing blood, as occurs in veins or distal to arterial stenoses, may appear high in signal.
iii. Diffusion – Weighted Imaging (DWI) assesses microscopic motion of H_2O, restriction of motion appear as relative high signal intensity on diffusion - weighted image.
iv. DWI is the most sensitive technique for detection of acute cerebral infarction of < 7 days duration and is also sensitive to encephalitis and abscess formation.

T1 & T2 Relaxation times

v. The rate of return to equilibrium of perturbed protons is called the relaxation rate.
vi. The relaxation rate varies among normal & pathologic tissues.
vii. The relaxation rate of a hydrogen proton in a tissue is influenced by local interactions with surrounding molecules and atomic neighbors.
viii. Two relaxation rates, T1 & T2 influence the signal intensity of the image
ix. The T1 relaxation time is the time, measured in milliseconds, for 63% of the hydrogen protons to return to their normal equilibrium state, while the T2 relaxation is the time for 63 % of the protons to become diphased owing to interaction among nearby proton.
x. The intensity of the signal within various tissues and image control can be modulated by altering acquisition parameters, such as the interval between Rf pulses (TR) and the time between the Rf pulse and the signal reception (TE)
xi. So called T1 weighted images are produced by Keeping the TR and TE relatively short.
xii. T2W images are produced by using longer TR and TE times.
xiii. Structures containing more water, such as CSF and edema, have long T1 and T2 relaxation rates, low signal intensity in T1W images & a high signal intensity on T2W images.
xiv. FLAIR – **Fl**uid-**a**ttenuated **i**nversion **r**ecovery is a useful pulse sequence that produces T2W images in which the normally high signal intensity of CSF is suppressed.
xv. FLAIR images are more sensitive than standard spine echo images for the detection of lesion within or adjacent to CSF.
xvi. Gradient echo imaging is most sensitive to magnetic susceptibility as seen with blood, calcium, and air, and is indicated in patients with traumatic brain injury.
xvii. Gadolinium is a pure magnetic substance, which means that it reduces the T1 & T2 relaxation times of nearby water photons, results in a high times of nearly water photons, resulting in a high signal on T1W images & low signal on T2W image signal on T1W images & low signal on T2W image Gadolinium does not cross BBB.

Advantages of MRI

- Non-ionizing radiation
- Images can be easily produced in any plane e.g., sagittal and coronal (good for spinal cord, aorta, vena cava)
- Visualization of posterior fossa and other areas prone to bony artifact on CT e.g., cranio-cervical junction.
- Precise staging of malignancy e.g., extending within the bone marrow and other areas occult to CT and other methods.

Disadvantages of MRI

- High cost
- Claustrophobia
- Long imaging time causes increased motion artifact
- Contraindicated in patients with metallic foreign body (pacemakers, cochlear implants), unable to

image calcium.

1.	Magnetic field strengths used for clinical imaging currently range from	:	*0. 2 Tesla (T) to 8 (T)*
2.	Gadolinium enhanced MRI is used for diagnosing	:	• *Small acoustic neuroma* • *Tumor recurrence* • *Distinguishing tumor from edema* • *Perfusion studies*
3.	MRI is unsuitable for patients with	:	*Cardiac pacemakers*
4.	MRI is superior to CT scan in that there is	:	*Absence of ionising radiation*
5.	MRI cannot image	:	*Calcium*

SOME RADIOLOGICAL PROCEDURES

- **Thermography**
  - IR rays are used & it reflects arterial blood supply
  - Used for – breast tumour, carotid insufficiency, placental localization

- **Lymphangiography**
  - Dye used is methylene blue/lipoidal ultra fluid
  - X-ray appearance of L~
    - Foamy/soap bubble appearance -- Hodgkin's disease
    - Irregular filling defect -- sec./metastatic LN-pathy
    - Marginal sun burst app -- reticulum cell sarcoma
    - Coarse nodular storage pattern-- lymphosarcoma
- **Esophagoscopy/graphy & Bronchography**

- Dye used is Dionosil

SPECIAL X-RAY PROCEDURES

Conventional Angiography

- DSA (Best diagnostic and therapeutic procedure at the same time)
- CTA
- MRA

Arteriography

- **Femoral artery is used (right preferred)** for catheterization.
- DSA is either intra-arterial (**IADSA-best)** or intra-venous (IVDSA).
- **Superselective angiography:** A smaller catheter may be passed through the larger one to reach the branch artery, supplying a small area of tissue or tumor.

CT Angiography

Uses

- Pulmonary embolism
- Kidney disorder-HTN, renal artery stenosis
- Aneurysm-aorta, brain
- Aortic dissection of its major branches
- After stenting in carotids
- Arterial disease screening
- Tumors-to see feeding arteries

Absolute C/I

- Anaphylaxis to dye
- Pregnancy
- Renal failure

MR Angiography

- **With contrast-** TOF, PCA
- **Without contrst-** Head ad neck

Aortography

Right femoral artery is preferred

PET AND SPECT

- CT and MRI image anatomy, and PET (Positron emission tomography) and SPECT (single proton emission computed tomography) image functions.
- PET measures metabolism (e.g. glucose)
- SPECT measures blood flow.
- Both PET and SPECT analyze gamma rays exiting the body.
- The source of gamma rays is a dose of radioisotopes injected into the patients.

- C^{11} is primarily used for PET
- TC^{99} is used for SPECT.
- Ideally the time between the injection and scan is 90 min.

PET IMAGING

- It suggests the disease before changes in anatomy are apparent.
- As the radioactivity is very short lived (2-3h), radiation exposure is low.

LIMITATIONS

- False results if chemical balances altered.
- The radioactive substance decays fast, so it must be produced in a labnear the PET scanner.

USES

- In neurological disease diagnosis like Alzheimer's disease
- In differentiating between Alzheimer's disease and other mental disorders like Parkinson's disease, Huntington's disease, and vascular dementia, etc.
- In epilepsy, localize foci of pileptic seizures and determin if surgery is required.
- Benign malignant tumors-helps in staging. Most accurate diagnostic procedure to differentiate tumor recurrences from radiation necrosis or post surgical changes.
- Determine effectiveness of chemotherapy and myocardial viability.

SPECT IMAGING

- Used in CVA (cerebrovascular accident) diagnosis.
- Direct therapy, assessment of therapy, and prognosis.
- Diagnosis of dementia-Huntington's disease, Alzheimer's disease
- Epilepsy –determine foci of seizures and its treatment.
- Trauma-Location and extent of the injury and prognosis.
- Neoplasm (Tumor)-determine causes of treatment.
- SPECT is best functional scan of brain.
- SPECT is IOC in postoperative changes and residual recurrent tumor differentiation.

Radionuclide	Physical t1/2 life
O^2	2 min
C^{11}	20 min
N^{13}	10 min
F^{18}	110 min

(B) CHEST RADIOLOGY (RESPIRATORY SYSTEM)

SPECIAL CHEST RADIOGRAPHIC VIEWS

- **Good** visualization of the apices of lung require projection of clavicles upward, as in the ***apical view*** **(apicogram)** with the X-ray tube angled up 50-60^0, or downward, as in the ***lordotic view*** with the patient in lordotic PA position in which a middle lobe collapse is seen clearly as a well-defined triangular opacity. A lordotic view is useful to detect lesions of middle lobe (like collapse) and collection on in fissure and subtle infiltrates in Uzs.
- ***Oblique views*** are taken usually to demonstrate the retrocardiac space, the posterior CP angles and the chest wall, with pleural plaques being clearly demonstrated.
- ***Decubitus view*** shows small amount of pleural fluid, which is not seen on PA view.
- ***Paired inspiratory and expiratory views*** are important in demonstrating air trapping, small pneumothorax, interstitial shadowing, diaphragm movements, and inhaled foreign body in children.

- Retrosternal space is best seen in **lateral view** while the retrocardiac space is seen well on **oblique view**.
- Films exposed ***in expiration*** are invaluable in the investigation of air trapping, particularly in paediatric practice for any patient suspected of having inhaled a foreign body. It may also enhance the demonstration of a small pneumothorax and interstitial shadowing.
- Paired views (inspiratory and expiratory films) are very important children with a possible diagnosis of an inhaled foreign body.

Normal chest radiograph (CXR)

- If the film is well centered the medial ends of the clavicles are equidistant from the vertebral spinous processes at the T4/5 level.
- With low kV film the vertebral bodies and the disc spaces should be just visible down to the T8/9 level through the cardiac shadow.
- Trachea is midline in its upper part, and then deviates slightly to the right around aortic knuckle.
- Central dense shadow seen on the PA chest film comprises the mediastinum, heart, spine and sternum.
- With good centering 2/3rds of the cardiac shadow lies to the left of midline and 1/3rd to the right.

- In 97% of subjects the left hilum is higher than the right and in 3% they are at the same level. The normal hila should be of equal density and similar size with clearly defined concave lateral borders.
- Of all the structures in the hilum only the pulmonary arteries and upper lobar veins contribute significantly to hilar shadows on plain radiographs.
- The horizontal fissure is seen on PA view running from the hilum to the region of 6^{th} rib in axillary line. Both oblique fissure commence posteriorly at the level of T4 or T5, passing through hilum and the left is steeper and finishes 5 cm behind the anterior CP angle, whereas the right ends just behind the angle.
- In most patients the right hemidiaphragm is higher than the left. This is due to the heart depressing the left sided and not to the liver pushing up the right dome. A difference greater than 3 cm in height of the two domes is considered significant.
- The bronchial vessels are normally not visualized on the plain chest film. The peripheral lung markings are mainly vascular, veins and arteries having no distinguishing characteristic.

Hila

Theses are composed of:

- **L**ymph nodes
- **P**ulmonary arteries and their main branches
- **U**pper lobar pulmonary veins and
- The major **b**ronchi

The lower lobe pulmonary veins do not cross the hila in their course to left atrium and hence do not contribute to hilar shadow.

Mediastinal outline

- The SVC and innominate vessels form the right superior mediastinal shadow; a dilated aorta may contribute to this border.
- The SVC and the right atrium usually form the right inferior mediastinal i.e. the right heart border.
- On left side the superior mediastinal border is less sharp and formed by the subclavian artery above the aortic knuckle.
- The main pulmonary artery (pulmonary conus) and the left ventricle form the left inferior mediastinal i.e. the left heart border.
- The area between the main pulmonary artery and the left ventricle is occupied by additional structures if they are slightly enlarged, namely left atrial appendage and the right ventricular outflow tract.

Trachea

- Trachea is a straight tube which starts at C6 vertebral level as continuation of larynx, passes downward and backward in the midline and ends at carina, i.e., T4–T5 vertebral level which also corresponds to sternal angle of Luis, by dividing into right and left bronchi.
- Tracheal length is 6–9 cm.
- The upper limits of normal for its coronal and sagittal diameters in ducts on plain chest radiograph are 21 and 23 mm, respectively, for women, and 25 and 27 for men.
- Normal *subcarinal angle* is 60–75^{o}
- In children, the angles of division symmetrical, but in adults the right main stem bronchus has a steeper angle (40^{0}) than the left (25^{0}).
- The carinal angle is widened in left atrial enlargement due to elevation of left main stem bronchus.
- It starts at the level of C6 vertebra and ends at T4, having 6–9 cm length.
- It divides at carina into two main bronchi.

- Tracheal bifurcation is known as known as carina. It is not visible on lateral view. It is seen well on left anterior oblique view.

1.	Detection of free intraperitoneal air	:	Lateral decubitus abdominal film
2.	Causes of elevated hemidiaphragm	:	• *Pulmonary collapse* • *Phrenic nerve paralysis* • *Intestinal distension* • *Abdominal organomegaly (Hepatomegaly, Splenomegaly)* • *Abdominal mass (subphrenic abscess, tumor)* • Eventration of diaphragm Scoliosis
3.	A powerful tool in the detection and localization of pulmonary disease	:	*'Silhouette sign'*
4.	On lateral radiograph a pneumonia is confirmed by	:	*'Spine sign'*
5.	Expansive consolidation is most commonly associated with	:	• *Penumococcal and Klebsiella pneumoniae* • Neoplasms
6.	The commonest cause of air bronchogram	:	*Consolidation*
7.	Causes of acinar opacifications	:	• *Transudate* • *Exudate (e.g. pneumonia)* • *Alveolar proteinosis* • *Extrinsic allergic alveolitis* • *Hemorrhage* • *Malignancy* • *Aspiration pneumonitis*
8.	'Finger in glove' appearance on plain film is seen in	:	*Bronchiectasis due to Allergic Broncho-pulmonary Aspergillosis*
9.	The commonest benign chest wall tumor is	:	*Lipoma*
10.	To differentiate between pleural thickening and pleural effusion	:	*Decubitus film (X-ray view of choice)*
11.	Inter lobar fissure effusion are well visualized by	:	*Lateral view (X-ray view)*
12.	For middle lobe collapse	:	*Lordotic view*
13.	For mediastinal structures	:	*High KVP technique*
14.	Presence of a cold thyroid nodule in a child indicates high possibility of malignancy		
15.	Best view for small pneumothorax	:	*P-A view on expiration (expiration compresses lung parenchyma and expands pleural space)*
16.	In suspected case of fractured ribs, view of choice is	:	*Oblique view*
17.	Investigation of choice for demonstration of movements of diaphragm	:	*Fluoroscopy*
18.	The main use of CT scan in the chest is	:	*Assessing mediastinal disease* *Staging lung cancer*
		:	
19.	HRCT (High resolution CT) is invaluable in	:	*Interstitial pulmonary disease*

20.	Ventilation/ Perfusion scanning done in	:	*Suspected pulmonary embolism*
21.	Ventilation scan done by	:	*Inhalation of radioactive xenon or krypton*
22.	Perfusion scan done by	:	Injecting IV Tc99 m labelled macroaggregates
23.	Pulmonary angiography is mainly used to confirm	:	*Pulmonary embolus, A-v fistula, Pulmonary artery hypoplasia.*
24.	Best investigation for Aortic dissection	:	*MRI*
25.	Myocardial infarction is best detected by using	:	*MTC pyrophosphate*

26. Radiographic features of pulmonary embolism

(a) **Without infarction**

(i) Westermark's sign – Reduction of vasculature distal to obstructing embolus

(ii) Fleischner sign – Dilatation of individual pulmonary artery due to peripheral embolus

(b) **With infarction**

Hampton's hump – Pulmonary infarct appearing as shallow hump shaped lesion with base at pleural surface.

27.	Minimum quantity of pleural fluid required to be seen in erect PA view	:	*250 ml*
28.	Minimum quantity of pleural fluid seen in ultrasonography/ lateral film	:	*50 ml*
29.	Bronchography is largely replaced by	:	*Fibre optic bronchoscopy*
30.	Aorta is well shown on	:	*T1* weighted spin-echo imaging with ECG gating
31.	Aortic dissections are now usually described by	:	*Stan Ford classification*

CHEST

1.	A lateral decubitus x ray detects effusion only when amount of fluid is	:	*50 – 100 ml*
2.	Expiratory films are needed for better demonstration	:	*Foreign body, pneumothorax*
3.	Absence of thymic shadow on day 1 is abnormal		
4.	Commonest ectopic hormone produced by a thymoma is	:	*ACTH*
5.	30 – 40 % of patient with thymomas have myasthenia gravis, while 10% of patient with M. gravis have thymomas		
6.	Air bronchogram is seen in	:	*Non obstructive collapse* *Lymphoma* *PMF* *Alveolar cell carcinoma*
7.	Right sided pleural effusions are due to	:	*Meig's syndrome* *CCF* *Ascites* *Amoebic liver abscess*
8.	Left sided pleural effusions are due to	:	*Pancreatitis* *Aortic rupture* *Oesophageal rupture*

9. CT angiography is rapidly becoming the examination of choice in patients with suspected pulmonary embolus

10. Paradoxical movement is seen in : *Diaphragmatic palsy*

11. In a bronchopleural fistula, link to the pleural space is via the airways, in pneumothorax via the air spaces (alveoli)

Silhouette sign is used mainly for localizing intrathoracic lesion.

Sign	Lesion of
Obscured right heart border	Right middle lobe (ant. Segment) lesion.
Obscured left heart border	Lingular lobe / left lower lobe
Hemidiaphragm	Relative lower lobe
Aortic knuckle	Apico-posterior segment of left upper lobe
Ascending aorta	Ant. Segment of right upper lobe
Descending aorta	Sup. & posterobasal segment of left lower lobe

Hilum overlap sign -

- **Differentiates b/w anterior mediastinal mass and cardiac enlargement/Pericardial effusion.**
- **In ant. Mediastinal mass, mass will often overlap the main pulmonary artery.**

Cervicothoracic sign –

Used in localizing superior mediastinal lesion in CXR PA view

- **Ant. Mediastinal lesion – projects below the clavicle**
- **Post. Mediastinal lesion – projects above the clavicle.**

Hilar Shadow –

Formed by lower lobe branch of pulmonary a. + Upper lobe veins

KERLEY LINES

A Lines	Thin non-branching lines radiating from the hilum, 2-6 cm long. Thickened deep interlobular septa.
B Lines	Transverse non-branching thin lines at the lung bases perpendicular to the pleura, 1-3 cm long. Thickened interlobular septa.
C lines	Subpleural lymphatics not seen on radiographs

STAPHYLOCOCCAL PNEUMONIA

- Infection with *S. aureus* is most commonly seen in infancy or in older immunocompromised child.
- Most commonly seen in infancy or in older immunocompromised child.
- Pyoderma, caused by Staphylococcus can disseminate or be associated with lung infection.
- In acute phase → necrotic, cavitating pneumonias with associated pleural-effusion.
  - Often multifocal and bilateral

- No lobar predilection
- Bronchopneumonia
- Air bronchogram is unusual

- Characteristic Pneumatoceles (thin walled cavities secondary to localized pulmonary destruction)
- Even after clinical resolution of acute illness **ghost cavities** (Pneumatocele) may persist for months on radiograph.

Klebsiella Pneumonia

- Caused by **Friedlander's bacillus**.
- Typically affects elderly debilitated men.
- Usually causes lobar consolidation, more often right sided, and frequently upper lobar.
- The volume of affected lung may be increased due to copious exudation of fluid producing typical **"Bulging fissure" or "Bow fissure" sign**.
- Cavitation is also known.

PULMONARY TUBERCULOSIS

Mycobacterium tuberculosis infection

Primary TB:	*Secondary TB (Post primary TB)*:
○ Ghon's complex ○ Pleural/pericardial involvement ○ Tuberculoma ○ Regional adenopathy ○ Milliary TB ○ Extrapulmonary TB	○ Acinar consolidation ○ Tuberculoma (caseation) ○ Cavitation ○ Endobronchial spread ○ Milliary TB • **Ghon's focus** (primary focus of TB) → often present in mid zone of lung, located peripherally in subpleural region and right side is affected more than left. Associated hilar adenopathy common. • **Simon's focus** → during early bacteremia, seeding may occur in lung apex. • **Puhl's lesion** → the commonest site of isolated lesion of chronic pulmonary TB is apex of the lung because the blood flow is sluggish at the apex and diffusion is poor. • **Ashman's focus** → Infraclavicular lesion of chronic pulmonary TB

	Primary pulmonary TB	**Secondary/post primary reactivation/reinfection/adult TB**
Inactive	Normal radiograph	Normal radiograph
	Scarring (any site)	Scarring (restricted

	+ sequelae	site) + sequelae
	Calcification (nodes, lung)	Calcification (nodes, lung and pleura)
Active	Consolidation (any site)	Consolidation (restricted ite)
	Adenopathy + sequelae	Endobronchial lesion+ sequelae
	Effusion (pleural, pericardial)	Effusion (pleural, pericardial)
	Miliary TB	Miliary TB
	Other (e.g., bone)	Other (e.g., bone)
Indeterminate activity	Tuberculoma	Tuberculoma

Restricted site = Apical and posterior segment of upper lobes and superior segment of lower lobes.

Characterization of mediastinal node in various diseases:

Mediastinal or hilar nodes enlargement > 2 cm in their short axis diameter is likely to be due to metastatic carcinoma, malignant lymphoma, sarcoidosis, tuberculosis or fungal infection. Lesser degrees of enlargement can be due to lymph node hyperplasia and pneumoconiosis (e.g., silicosis). Widespread moderate mediastinal adenopathy is frequent accompaniment of chronic diffuse lung disease and bronchiectasis.

- **Sarcoidosis** the hilar nodes are enlarged in almost all cases. The important diagnostic feature of adenopathy in sarcoidosis is its symmetry.
- Lymph node enlargement due to **malignant lymphoma and leukemia** is *bilateral but asymmetrical*, hilar node enlargement is rare without accompanying mediastinal node enlargement, posterior mediastinal nodes are infrequently involved and paracardiac nodes are rarely involved but become vital as sites of recurrent disease.
- Lymph node enlargement due to **tuberculosis or fungal infection** may affect any of the nodal groups in hila or mediastinum. Dense calcification is frequent both in nodes that stay enlarged and in those that shrink. A low-density centre with rim-enhancement of the enlarged node is a useful pointer towards the diagnosis of TB.
- A rare cause of strikingly uniform contrast enhancement (lymphnodes bloom out on ECCT) is **Castleman's disease**.
- Sometimes there is a ring of calcification at the periphery of node—so-called **'eggshell calcification'** that is a particular feature of **sarcoidosis and silicosis**.

Mycobacterium avium intracellular complex (MAC) infection:

CXR

- Patchy unilateral/bilateral air-space consolidation
- Small or nodular lesions
- Bronchiectasis
- Cavitations (thick or thin walled)
- Middle lobe syndrome

Hydatid disease of lung

- Hydatid disease of lung is the most common site of secondary involvement in children.
- Lower lobes affected in 60% cases.
- Calcification of cyst wall is very rare and seen only in 0.7% cases.
- When in mediastinum, vertebral erosion in addition to rib erosion may occur with posterior mediastinum being affected in 65% cases. May be complicated by bacterial infection after cyst ruptures.

- **Radiological signs:**
  - **Meniscus/double arch/moon/crescent sign** due to thin radiolucent crescent in uppermost part of cyst.
  - **Combo sign** due to air fluid level inside endocyst and air between pericyst and endocyst.
  - Collapsed membranes inside the cyst outlined by air causing **'serpent' sign**.
  - Completely collapsed crumpled cyst membrane floating on the cyst fluid produces **"water Lilly" sign** of Camalotte.
  - **Cyst in cyst sign**

Allergic Bronchopulmonary Aspergillosis

Primary diagnostic criteria for ABPA:

1) Asthma (84–96%) (Episodes of bronchospasm)
2) Roentgenographic transient or fixed pulmonary infiltrates
3) Test for *Aspergillus fumigatus* positive (skin)
4) Eosinophilia (8–40%)
5) Precipitating antibodies to *Aspergillus fumigatus* (70%)
6) IgE in serum elevated
7) Central (perihilar) bronchiectasis (late manifestation that proves diagnosis)
8) Serum specific IgE and IgG *Aspergillus fumigatus* levels elevated.

Secondary diagnostic criteria (less common):

1) *Aspergillus fumigatus* mycelia in sputum
2) Expectoration of brown sputum plugs (54%)
3) Arthus reaction to *Aspergillus* antigen.
4) Fungal ball with 'air crescent' surrounding it (**Air crescent or Monads' sign**) is characteristic of aspergilloma.

1.	Normal chest X – ray in severe pneumonia can be seen in	:	*Neutropenic patients*
2.	Legionella pneumonia commonly has associated	:	*Pleural effusion*
3.	The characteristic features seen in Klebsiella and Hemophilus infection	:	*Bulging fissures*
4.	Pleural reaction is least commonly seen in	:	*Mycoplasma pneumonia*
5.	Empyema with sulphur discharging cutaneous sinuses seen in	:	*Actinomyces*
6.	Organism responsible for post biopsy hydropenumothorax are	:	*Staph. aureus Clostridium perfringens* Gram negative and anaerobic organisms

7. Cavitation, empyema and endobronchial spread of infection are seen in post primary TB

8. Lymphadenopathy is a feature of primary TB

9. Miliary TB is more common in post primary TB

10. The most common agent causing pulmonary infection in AIDS is bacterial

11. Commonest cause of lobar pneumonia : *Strep. pneumoniae*

12. Common causative agents of bronchopneumonia : *Staph. aureus*
Gram negative organisms

13. Commonest cause of pneumonia with pneumatocele formation : *Staph. aureus*

14. Commonest cause of pneumonia with bulging fissure : *Klebsiella pneumonia*

15. Multiple small calcified nodules in B/L lung field is seen in : *Histoplasmosis*
Chickenpox pneumonia
Miliary TB (Seldom)

16. Large air way obstruction can cause collapse (hypoinflation) emphysema (hyperinflation), bronchiectasis and bronchocele formation

17. Over expanded left lower lobe seen lateral to the hilum in LUL collapse is called : *Luft Sichel*

18. The 'comet tail' sign on HRCT seen in : *Blesowski's syndrome or*
Rounded atelectasis

19. In compensatory emphysema the expanded segments cloud normally on expiration while air trapping (i.e. no clouding on expiration) occurs in c/o obstructive emphysema

20. 'Meniscus sign' or "Mondred sign" in lung is commonly seen in : *Aspergillus fungus ball*

21. Post primary tuberculosis of lung has a predilection for : *Upper lobes & upper segments of lower lobes*

22. Commonest cause of visceral pleural calcification is : *Tuberculosis*

23. Ghon's complex refers to : *Ghon's focus with regional lymphadenopathy*

24. Ranke complex in tuberculosis refers to : *Calcified hilar nodes*

25. X-ray appearance of a solid mass within a cavity seen in : *Aspergillosis*
: *Blood clot in the cavity*
Breaking down neoplasm
Complicated hydatid cyst

26. Water lily sign is found in chest X-ray in : *Hydatid cyst*

27. Radiologic signs in ruptured hydatid cyst
(a) Air fluid level
(b) Floating membrane/ water-lily / camalote sign
(c) Double wall sign
(d) Rising sun sign/ serpent sign → dry cyst with crumpled membrane
(e) Empty cyst sign → when contents are expectorated

28. Bilateral symmetrical perihilar opacities in HIV patients : *PCP*

29. Bilateral upper lobe cysts in HIV patient : *PCP in a prior prophylactic administered aerosolized pentamidine*

30. Types of aspergillus infection in lung
(a) Aspergilloma
(b) Invasive aspergillosis
(c) Allergic bronchopulmonary aspergillosis

31. 'Round' pneumonia is : *Spherical pulmonary mass caused by pneumonia, usually pneumococcus*

CAUSES OF AIR BRONCHOGRAM

Common	Rare
1. Pneumonic consolidation	Lymphoma
2. Pulmonary edema	Sarcoidosis
3. Hyaline membrane disease	Alveolar proteinosis Alveolar cell carcinoma ARDS

INTERSTITIAL LUNG DISEASE / DIFFUSE LUNG DISEASE

Radiographic features of Bronchiectasis:

- 'Bunch of grapes' appearance
- 'Gloved fingered' appearance
- 'Ring' shadows
- 'Tram track' appearance

SILICOSIS

Silicosis occurs due to inhalation of SiO_2.
CXR:

- Multiple small (miliary) nodules in mid and upper zones
- Enlargement of hilar nodes with peripheral eggshell calcification
- Presence of nodal calcification may allow differentiating it from CWP
- Aggregation of nodules with formation of larger conglomerate areas of progressive massive fibrosis is hallmark of complicated silicosis
- *Snowstorm appearance* on CXR is characteristic of it

Asbestosis

It is characterized by specific pleural and parenchymal changes (thoracic changes) and some extrathoracic changes.

Pleural changes:

1) **Commonest radiological feature of asbestos** exposure is the pleural plaque, which is well-defined soft

tissue sheet originating on the parietal pleural. The lesions are usually bilateral, lying in middle and lower zones and over the diaphragm. When calcified they form a **'holly leaf' pattern** with sharp, often angulated outlines.

2) Diffuse pleural thickening
3) Pleural effusions
4) Malignant mesothelioma

Pulmonary changes:

- The radiological features are similar to those of fibrosing alveolitis.
- Pulmonary pseudotumor can be a feature, which characteristically shows distortion of pulmonary vasculature producing a 'Comet tail' appearance on plain x-ray, and CT.
- 'Comet tail' appearance is also seen in Round atelectesis.
- **Extrathoracic changes**: Peritoneal mesothelioma and laryngeal carcinoma.

Caplan's syndrome

- Pneumoconiosis with multiple lung nodules with rheumatoid arthritis in coalmine workers with the rheumatoid disease constitute Caplan's syndrome.
- Caplan's nodules, first described by Caplan in 1953, are pulmonary lesions most frequently in workers with cutaneous rheumatoid nodules but may precede the development of overt rheumatoid arthritis.
- Radiologically they are smaller (1–4 cm) and better defined. Crops of lesions tend to appear; they frequently occur in periphery of the lung and can involve any lobe.
- Radiographic appearances of silicosis include multiple small nodules seen predominantly in middle and upper zones (miliary nodular opacities), enlargement of the hilar lymph nodes with **"eggshell" calcifications** and Caplan nodules.

Wegener's granulomatosis

- Mean age of set is approximately 40 years.
- It is characterized by granulomatous vasculitis of upper and lower respiratory tracts (85-90% patients) with glomerulonephritis (77% cases).
- Characteristic cavitating lung nodules of varying size (mm to cm) occur without zonal predilection.
- The majority of patients with Wegener's granulomatosis develop nodules that are of varying size from few mm to several cm and have no zonal predilection.
- On CT, a feeding vessel leading to nodules and air bronchogram on it may be seen. Linear bands, spiculations and pleural tags may also be seen in the relation.
- Cavitation is characteristic of it.
- Consolidation and groundglass opacities are also recognized features.

Sjogren's syndrome

- It is chronic autoimmune inflammatory disease characterized by a triad of dry mouth, dry eyes and arthritis.
- It occurs (60%) in association with other collagen vascular disease, especially rheumatoid arthritis; however, in contrast to latter, there is marked female predominance of pulmonary manifestations.
- Interstitial fibrosis similar to Cryptogenic fibrosing alveolitis mainly affecting lower zones and occurrence of lymphocytic interstitial pneumonitis is seen.
- Skin nodules are not seen.

Sarcoidosis

Staging of Sarcoidosis according to it's appearance on CXR:
Stage I: Lymphadenopathy

Stage II: Lymphadenopathy with parenchyma opacity
Stage III: Parenchymal opacity alone.
Lymphadenopathy

- 70-80% of patients show it.
- Bilateral, symmetrical hilar and paratracheal.
- Tracheobronchial and bronchopulmonary nodes also affected.
- AP windows node enlargement also common.
- Only in 1-5% Lymphadenopathy is asymmetrical.
- 'Eggshell' calcification can occur.
- In 90% cases lymphadenopathy disappears within 6-12 months.

***Differential diagnosis* of "Eggshell nodal" calcification:**
Common causes: Sarcoidosis, silicosis
Uncommon causes: Histoplasmosis, lymphoma (post irradiation), blastomycosis, amyloidosis.

HRCT features:

- 1-5mm nodules in perilymphatic fashion predominantly along bronchovascular bundles subpleurally.
- Airspace consolidation
- Airway wall thickening
- Patchy ground-glass opacities
- UZ, MZ fibrosis.
- Pleural effusions and thickening are unusual. The prevalence of effusions in only about 2% and their presence should raise doubts about diagnosis of Sarcoidosis.
- Bronchial stenosis and airflow obstruction can rarely occur.

In sarcoidosis granulomas in lung are without necrosis.

Causes of nonsarcoid granulomas, i.e., granulomas with necrotic area are:

- TB
- Gumma
- Cryptococcosis
- Histoplasmosis
- Coccidioidomycosis
- Nocardiasis
- Foreign body granulomas
- Histiocytosis
- Vasculitides
- Chronic granulomatous disease
- Extrinsic allergic alveolitis

1.	Silicosis is due to the inhalation of small particles of	:	*Silicon dioxide*
2.	Linear diaphragmatic pleural calcification is a frequent finding in	:	*Asbestosis*
3.	All Pneumoconial disorders produce nodular shadows except	:	*Asbestosis, produces linear shadows*
4.	Radiological feature similar to fibrosing alveolitis seen in	:	*Pulmonary asbestosis*

5. Pulmonary findings in asbestosis
(a) Subpleural bands
(b) Progressive massive fibrosis
(c) Round atelectasis (pulmonary pseudotumour)
(d) Bronchial Ca.

6. ILO has given radiological classification for : *Pnenumoconioses*

7. Mendelson's syndrome is : *Bilateral diffuse alveolar opacities caused due to aspiration of acid gastric contents after anaesthesia, alcohol abuse, drug overdose, epilepsy*

8. Radiological findings in SLE in chest are :
(a) Pulmonary fibrosis
(b) Air esophagogram
(c) Aspiration pneumonia
(d) Bronchiolar carcinoma

9. X ray picture in 'Fibrosing alveolitis' : *B/L Diffuse nodular or reticulonodular shadows favouring lung bases, Honeycombing appears later on in advanced stage of disease*

10. Egg shell calcification seen in :
Silicosis
Sarcoidosis
Histoplasmosis
Blastomycosis
Scleroderma
Amyloidosis

Calcification in Lungs & Pleura

• **Calcification in lungs**	**Pleural calcification**
• B/L in TB • B/L Histoplasma • B/L coccidiomycosis	• Old empyema/hemothorax • Talc exposure • Asbestosis, silicosis

CAUSES OF HONEY COMB SHADOWS

Common	Rare	Similar Appearance
Histiocytosis X	Tuberous sclerosis	Bronchiectasis
Scleroderma	Amyloidosis	
Rheumatoid	Gaucher's disease	Cystic

disease		fibrosis
Fibrosing alveolitis	Neurofibromatosis	
Pneumoconiosis	Chronic interstitial pneumonia	
Sarcoidosis	Lymphangiomyomatosis	

NEOPLASMS

1. Lung is affected by disease at presentation in : *10 – 15 % cases of lymphoma*
2. Parenchymal involvement is more common in : *Hodgkin's lymphoma*
3. Pleural effusions in lymphoma are most commonly secondary to : *Adenopathy*
4. Lymphocytic interstitial pneumonia (LIP) is seen in : *HIV*
5. Lymphadenopathy with LIP is s/o lymphomatous change
6. Bronchial carcinoids more commonly cause : *Cushing's syndrome than carcinoid syndrome (0 – 31%)*
7. Bronchogenic carcinomas having less than 90° angle of contact with aorta are considered resectable (the converse however is not true)
8. Pancoast's tumor is best imaged by : *MRI*
9. Adeno and large cell carcinoma's manifest as peripheral nodules
10. Small and squamous cell as are usually central, associated with cigarette smoking
11. Most frequent lymph nodes involved in Hodgkin's disease : *Anterior mediastinal lymph nodes*
12. Most frequent type of lymphoma to affect the mediastinum : *Hodgkin's disease*
13. Positive 'sail sign' in mediastinal mass is suggestive of : *Thymic enlargement (this sign* (Wavy border sign is also used to identify the thymic shadow) *is seen in normal infants and children & helps to identify the thymic border)*
14. Pop corn calcification in chest X-ray is seen in : *Hamartoma*
15. Cannon Ball deposits in lungs is seen in ::: *Osteogenic Sarcoma*
Seminoma of testis
Hypernephroma
16. 'Golden S' sign in x ray chest is seen due to : *Mass causing lobar collapse in which fissure takes 'S' shape. Obstructing hilar mass should be suspected*
17. Superior sulcus tumour is also known as : *Pancoast tumour*
18. Kaposi's sarcoma in lung is seen in : *HIV positive*
19. Bronchial carcinoid secretes : *ACTH*
20. Carney's triad consists of : *Pulmonary chondromas*
: *Extraadrenal paragangliomas*
: *Gastric epitheloid leiomyosarcomas*
21. Tumours showing air bronchogram : *Bronchoalveolar Ca*

: *Lymphoma*
: *Pseudolymphoma*

22. Calcification pattern involved with benign lesion : *Diffuse calcification in nodule*
Central calcification
Laminar calcification
Popcorn calcification

23. Calcification if at all in malignant lesion : *Speculated with halo*

24. Pancoast's tumors cause brachial neuropathy
25. Carcinoma lung presents most commonly as either *pneumonia (clinical) or nodule (Radiological)*
26. Pulmonary metastasis are multiple, > 1 cm, seen in lower lobes and better seen by high KV technique
27. Hemoptysis is a rare manifestation of pulmonary haemorrhage
28. Lymphangiomas are most common in : *Upper anterior mediastinum*

Metastasis in Lung

Calcifying lung metastasis	Cavitating lung metastasis	Hemorrhagic lung +metastasis with ill defined nodules
• Breast	• SqCC, Sarcoma	
• Osteosarcoma/chondroma	• Colon	1. RCC
• Thyroid (papillary)		2. Melanoma
• Mucinous adeno Ca. + Lung metasta-sis following RT/CT	• Transitional cell	3. Thyroid Ca
• Testicular, Ovarian	• Cx under CT (Chemotherapy)	

MEDIASTINUM

Pneumomediastinum

It is characterized by presence of gas in mediastinal tissues outside the esophagus and tracheobronchial tree.

Signs of Pneumomediastinum on CXR include:

1. **The "Continuous diaphragms" sign:** describes the presence of radiographically visible mediastinal air between the heart and the diaphragm. The air trapped in mediastinum posterior to pericardium (on frontal view).
2. **"Ring around artery" sign:** air surrounding intra-mediastinal segment of right pulmonary artery (Lateral

view)

3. **"Tabular artery sign":** air adjacent to major aortic branches.
4. **"Streaky lucencies"** of air in mediastinum.
5. **"Double bronchial wall" sign**: clear depiction of bronchial wall by an air next to and within bronchus.
6. **"V sign of Naclerio" or extra-pleural sign** is mediastinal air extending laterally between mediastinal pleura, lower thoracic aorta and diaphragm.
7. **"Spinnaker sail" or "thymic sail" sign** is seen in children are the mediastinal air outlines the thymus.
   - Oesophageal perforation is most common cause of pneumomediastinum.
   - Hamman's sign (mediastinal crunch) is *clinical sign* of pneumomediastinum noted on auscultation.
   - In **Pneumopericardium** the air is limited to distribution of pericardial reflection and the thick shaggy soft-tissue destiny of fibrous pericardium is separated by air from cardiac density.
   - Air-fluid level is seen in both pericardial effusion and pleural effusion.

Causes of solitary pulmonary nodule

Bronchial carcinoma	Bronchocele	
Bronchial carcinoid		Fungal ball
Granuloma (Tuberculoma)		Massive fibrosis
Hamartoma	Bronchogenic cyst	
Metastasis	Sequestration	
Abscess	A- V malformation	
Hydatid cyst	Pulmonary infarct	
Pulmonary hematoma	Round atelectasis	

* Thymoma is best demonstrated using : CT scan

COPD

1. Emphysema which cannot be recognized radiologically : *Centrilobular emphysema*

2. Barrel Shaped Deformity of chest and flattened diaphragm are seen in : *Emphysema*

3. Uncomplicated acute or chronic bronchitis does not produce any radiological sings

PLEURAL DISEASES

Pleural effusion

- A small amount of free fluid may be undetectable on an erect PA chest film, as it tends initially to collect under the lower lobes of lung. Such small subpulmonary effusions can be demonstrated on lateral decubitus chest radiograph.
- This view with affected side dependent provides a sensitive means of detecting small quantities of pleural fluid (50–100 mL).
- The posterior and then the lateral costophrenic angles become blunted as the amount of effusion increases, by which time a 200—500 mL effusion is present.
- First 300 mL of pleural fluid collection is not visualized on PA view (collected in subpulmonic region first, then spill into posterior costophrenic recess).
- Lateral decubitus views may demonstrate small amount of pleural fluid (as small as 25 mL).

Etiology of Pleural effusion

Causes of left-sided pleural effusion:

Spontaneous esophageal perforation
Dissecting aneurysm of aorta
Traumatic rupture of aorta distal to left subclavian artery
Transection of distal thoracic duct
Pancreatic and gastric neoplasm
Pancreatitis (left sided (68%), right sided (10%), and bilateral (22%))

Causes of right-sided pleural effusion:

Congestive heart failure
Transection of proximal thoracic duct

Loculated pleural effusion

- Fissural interlobar loculation is seen particularly in heart failure and may produce the so-called **phantom tumor/vanishing tumor**.
- On lateral view it is sharply marginated and biconvex and has a tail passing along fissure. A common problem is to differentiate encysted fluid in lower right oblique fissure from middle lobe collapse.
- Extrapleural sign is positive i.e. the opacity is pleural based with obtuse angle between the medial margin and chest wall on PA CXR.

Pneumothorax

Spontaneous pneumothorax is most common, and it occurs most commonly due to rupture of *subpleural blebs*.

CXR:

- Sharp white visceral pleural line
- Radiolucent pleural space devoid of lung markings
- Underlying collapse of lung
- A large pneumothorax may sometime lead to complete relaxation and retraction of the lung, with some mediastinal shift towards the normal side, which increases on inspiration.

Tension pneumothorax:

- Massive displacement of mediastinum
- Kinking of the great vessels
- Ipsilateral lung squashed against the mediastinum, or herniated across the midline
- Depressed or inverted ipsilateral dome of diaphragm

1.	Pneumothorax requiring emergency treatment	:	*Tension pneumothorax*
2.	Diaphragmatic pleural calcification is virtually pathognomic of	:	*Asbestosis*
3.	Minimum quantity of fluid which can be seen on PA view (erect)	:	*250 ml.*
4.	Signs suggesting pneumothorax in supine film	:	*Ipsilateral translucency*
		:	*Deep sulcus laterally*
		:	*Double diaphragm sign*

5.	Meig's syndrome consists of	:	*Ascites*
		:	*Pleural effusion*
		:	*A benign ovarian tumour (Most commonly fibroma 80%)*
		:	*Resolution of ascites and pleural effusion after removal of tumor*
6.	Fluid accumulation between the lung and visceral pleura, a finding in heart failure	:	*Lamellar effusion*
7.	Fissural interlobular loculation seen particularly in heart failure on lateral view	:	*Phantom tumour*
8.	In opaque hemithorax the initial examination of choice	:	*US – ultrasonography*
9.	Split pleura sign is seen in	:	*Empyema*

Causes of unilateral hyperlucency

Normal: Increased density of contralateral lung
Eg. pleural effusion
Thickening
Consolidation
Technical: Rotation, Scoliosis
Soft tissue: Mastectomy
Congenital absence of pectoralis major, poliomyelitis
Emphysema: Compensatory – lobar collapse, lobectomy
Obstructive - foreign body, tumor, Mcleod's syndrome, congenital lobar emphysema
Bullous
Vascular: Absent.hypoplastic pulmonary artery, obstructed pulmonary artery eg. by tumour, embolus
Mcleod's syndrome

Cavitating pulmonary lesions

Infections: Staphylococcus, Klebsiella, TB, histoplasmosis, Amoebic, Hydatid, Paragonimiasis, Fungal.
Malignant: Primary, Secondary, Lymphoma
Abscess: Blood borne, Aspiration
Pulmonary infarct:
Pulmonary hematoma:
Pneumoconiosis: PMF, Caplan syndrome
Collagen diseases: Rheumatoid nodules, Wegener's granulomatosis
Developmental: Sequestered segment, Bronchogenic cyst, congenital cystic adenoid malformation
Sarcoidosis: Bullae, Blebs, Pneumatocele, Traumatic

OTHERS

1.	Tracheobronchomegaly is seen in	:	*Mounien Kuhn syndrome*
			Ehler Danlos syndrome
			Lung fibrosis

			Prior Mechanical Ventilation
2.	Tracheobronchomalacia is seen in	:	*Prolonged intubation* *Relapsing polychondritis* *Diffuse tracheal disease* COPD
3.	Hyperinflation is a common indirect sign of airway disease Secondary Spontaneous pneumothorax seen in	:	*Histocytosis X* *Lymphangioleiomyomatosis*
4.	Kerley's B lines are	:	*Thickened interlobular septae*
5.	Best view to demonstrate small pleural effusions	:	*Lateral decubitus film*
6.	Inversion of hemidiaphragm is seen in	:	*Tension pneumothorax*
7.	Most common content of diaphragmatic hernia in infants	:	*Bowel*
8.	The glands involved in sarcoidosis are	:	*Bilateral hilar and right para tracheal*
9.	Ribbon ribs are found in	:	*Neurofibromatosis*
10.	Paradoxical movement of diaphragm in fluoroscopy is seen in	:	*Phrenic nerve palsy (this constitutes a positive sniff test)*
11.	Air Bronchogram is seen in	:	*Pneumonic consolidation* *Pulmonary oedema*
		:	*Hyaline membrane disease (H.M.D.)*
		:	*Bronchio alveolar carcinoma (this carcinoma presents as an area of consolidation on X-ray)*
12.	Most common site of sequestration in lung	:	*Lower lobes (particularly left lung)*
13.	Mismatching of V & Q Scan is virtually diagnostic of	:	*Pulmonary* emboli

CAUSES OF SUPERIOR MARGINAL RIB DEFECTS
SITES OF PORTA-SYSTEMIC ANASTOMOSES

Normal	Isolated defects Projected artifacts (due to lordosis)
Neurological	Paralytic poliomyelitis Quadriparesis
Collagen vascular disease	Rheumatoid arthritis SLE Systemic sclerosis
Local pressure	Chest drainage tube Osteochondroma Neural tumor Coarctation of aorta
Hyperparathyroidism Miscellaneous	Osteogenesis imperfecta Marfan's syndrome

Flared, wide, gracile or ribbon like ribs are seen in : *Neurofibromatosis – I*

Osteogenesis imperfecta
Mucopolysaccharidoses
Thalassaemia
Basal cell naevus syndrome
Sprengel's deformity

CALCIFICATION ON THE CHEST RADIOGRAPH

Intrapulmonary	Granuloma, infections: Tuberculosis, Histoplasmosis, Chickenpox, Coccidioidomycosis, Actinomycosis, Hydatid cyst
	Chronic abscess Tumors Metastases: Osteogenic sarcoma, Chondrosarcoma, Cystadenocarcinoma Arteriovenous malformation Hamartoma, carcinoid Hematoma Infarct Mitral valve disease Broncholith-tuberculosis Idiopathic Rare Metabolic-hypercalcemia Silicosis, sarcoidosis Rheumatoid arthritis Amyloid Osteopathia racemosa
Lymph nodes	Tuberculosis Histoplasmosis Sarcoidosis Silicosis Lymphoma after irradiation
Pleural	Tuberculosis Asbestosis, talcosis Old hemothorax, empyema
Mediastinal	Cardiac Valvular Infarcted muscle Tumors Pericardial Ventricular aneurysms Vascular Tumors
Pulmonary artery	Pulmonary hypertension Aneurysm Thrombus

Chest wall	Costal cartilage Bone tumors, callus Breast: tumors, fat necrosis Soft tissue: parasites, tumors, etc.

OTHER PATHOLOGIES

1. The most common manifestation of Rheumatoid disease in thorax : *Pleural effusion*

2. Scleroderma causes basal fibrosis associated with air esophagogram, calcinosis and aspiration pneumonia

3. Lung disease cause by Coal Worker's Pneumoconiosis causes little fibrosis, that cause by silica causes significant fibrosis

4. Crocidolite produces more significant changes in the lungs than chrysolite

5. Holly leaf pleural plaque and diaphragmatic calcification are typical of Asbestosis

6. Garland's triad is seen in : *Sarcoidosis (1 – 2 – 3 sign) Bilateral hilar and right paratracheal; adenopathy*

7. Sarcoidosis is characterized by peribroncho vascular nodules; consolidation with peripheral nodularity is called the sarcoid galaxy sign

8. Tuberous sclerosis causes lymphagio leiomyomatosis in the lungs and is seen in females of reproductive age group

9. Fractures of the 1st 2 ribs indicates severe trauma

10. Fractures of the lower ribs is associated with splenic and renal injury

11. The XRC is (N) in 10 – 15% patients with pulmonary thromboembolism

12. Aortic trauma is common at the isthmus (area between left SCA and ligamentum arteriosum) and ascending aorta

13. Techno gas is : *Carbon particles labelled with* Tc^{99th}

14. In pulmonary : Tc^{99m} *and*

thromboembolism, V/Q scanning in done using *Krypton*

15. Large speculated nodular masses (1 – 10 cm) are seen in
16. Presence of effusion with sarcoidosis is rare and should suggest another diagnosis
17. Eosinophilic granuloma affects lungs in male smokers
18. Signs of pulmonary thrombo embolism include Westermark's sign, Fleischner's sign, Hampton's hump and pleural effusion

PAEDIATRIC CHEST

Transient tachypnea of the newborn (TTN or neonatal wet Lung disease):

- Most common cause of respiratory distress in term newborn
- CXR:
  - Linear opacities
  - Perivascular haze
  - Thickened fissures
  - Interlobular septal thickening (interstitial edema)
  - Symmetric perihilar radiating congestion
  - Mild hyperaeration
  - Small amount of pleural fluid

Respiratory distress syndrome (Hyaline membrane disease/HMD)

- Predisposing factors: Prematurity, LSCS, diabetic mother.
- M:F=1.8: 1.
- CXR:
  - Diffuse granularity of reticulogranular pattern ("groundglass" appearance)
  - Prominent airbronchogram
  - Hypoaeration with volume loss
  - Bilateral symmetrical distribution

Pulmonary sequestration

- Sequestrated lung is **defined as** "a congenital mass of aberrant pulmonary tissue that has no normal connection with the bronchial tree or with the pulmonary arteries.
- It is **usually located** in one of the basal segments of lower lobe. In 98% cases intralobar sequestration involves medial parts of left lower lobe. 98% of extralobar sequestrations are left sided.
- **Two varieties** of pulmonary sequestration are known: Intra and Extralobar type.
- **Extralobar (ELS) →** it is most common variety in neonates and infants, is located between the lower lobe and diaphragm, has its own pleural covering, and other anomalies are common (65%) in ELS (like pulmonary hypoplasia, horseshoe lung, CCAM, bronchogenic cysts, diaphragmatic hernia and cardiac anomalies).
- **Intralobar sequestration (ILS) →** diagnosed after adolescence, contained within lung with no separate pleural covering and is intimately connected to adjacent lung.
- It is usually supplied by an anomalous artery arising from aorta and its venous drainage is via the azygos

system, the pulmonary vein, or IVC. Hence angiography is **useful for confirmation of the diagnosis**, which shows one or more systemic vessel entering the mass, usually arising from aorta at or below diaphragm.

- Bronchography shows normal bronchi draping around the sequestration.
- The **imaging modality of choice for pulmonary sequestration is ultrasonography**. Doppler ultrasound readily demonstrates the vascular connection to the sequestration.

Congenital diaphragmatic hernia

- It is most common intrathoracic fetal anomaly due to absence of closure of pleuroperitoneal canal by 9th week of gestation

- CXR:
  - Bowel loops in chest.
  - Contralateral mediastinal shift.
  - Complete/partial absence of diaphragm.
  - Absence of stomach/small bowel in abdomen.
- The neonatal radiograph shows a left sided large intrathoracic mass of soft tissue density and the more characteristic pattern of intrathoracic air-filled loops developing after several hours.
- The differential diagnosis of other cystic appearing intrathoracic masses in newborn is lobar emphysema, CALD, pulmonary sequestration, bronchogenic cyst etc.
- The diagnosis is frequently now made prenatally at ANC USG or MRI and involves left pleuroperitoneal canal in 75% cases.
- On USG, congenital diaphragmatic hernia can be detected as early as at 17th week of gestation.
- Small intestine in 88%, stomach in 60%, colon in 56%, spleen in 45%, liver in 51% and kidney is in 22% chances of herniation into chest in Bochdalek hernia.
- Mediastinal deviation is often seen first and is the **most obvious USG sign** of CDH.
- **Absolute diagnostic ultrasonographic sign** is visualization of peristalsis in chest and paradoxical motion of the abdominal contents on fetal inspiration.
- Supportive signs include mediastinal shift, heart displaced to the side opposite to herniation with only sometimes heart axis being changed, stomach in chest, abdominal circumference lower than fifth percentile for gestational age and polyhydramnios.
- In **Morgagni hernia,** omentum and colon are the most frequent hernial contents. It is known to be associated with trisomy syndromes.

Congenital cystic adenomatoid lung malformation (CCAM/CALD)

- It is congenital cystic abnormality of lung characterized by a interlobar mass of disorganized pulmonary tissue
- Equal frequency in all lobes seen
- Three types are known: microcystic, macrocystic and mixed type.
- CXR :
  - Unilateral expansile mass with well-defined margins (80%)
  - Multiple air/occasionally fluid-filled
  - Compression of adjacent lung cysts
  - Contralateral mediastinal shift (87%)
  - Hypoplastic ipsilateral lung
  - Proper position of abdominal viscera
  - Spontaneous pneumothorax (late sign)

Macleod's (Swyer James) Syndrome/ Unilateral Hyperlucent Lung Syndrome

- Obliterative Bronchiolitis resulting from childhood viral infection may occasionally affect one lung and present in adult life as Swyer-James syndrome.
- CXR may show pulmonary hyperinflation, and decreased vascularity in unilateral lung field.
- HRCT is characterized by unilateral lung hypoattenuation, bronchiectasis, and air trapping.

Bronchogenic cysts and esophageal duplication cysts:

- Bronchogenic cysts often narrow and displace the trachea and can cause life-threatening airway obstruction. They are usually found beside the trachea or between the trachea and the esophagus.
- An occasional clue to the diagnosis of broncho-pulmonary foregut malformation is the presence of a butterfly vertebra or some other spinal anomaly in the chest or lower neck.
- Esophagography is sometimes able to demonstrate the intramural nature of esophageal duplications.
- MR imaging shows these cysts well.
- **Esophageal duplication cyst** is round or tubular lesion occurring in the lower posterior mediastinum, which often distort esophagus but only rarely communicate with the esophageal lumen.

Foreign body aspiration

- Due to straighter, broader and short right bronchus with only 25^0 angle of bifurcation, foreign body aspiration is common on right side.
- Aspiration pneumonitis or aspiration of foreign body **in supine position** usually affects posterior segment of right upper lobe or the foreign body will be lodged into posterior segment bronchus of right upper lobe.
- The foreign body aspirated in upright position will be lodged into superior or apical segment of right lower lobe (gravity dependent areas usually affected).
- Specific affection almost invariably in **pulmonary sequestration** includes posterobasal segment of left lower lobe.

1. Scimitar syndrome also known as Pulmonary venolobar syndrome, hallmark feature : *Hypoplasia of involved lung*

2. Multiple lung cysts in children are caused by :
CLE
Pulmonary Interstitial emphysema
Sequestration
CDH
CCAM

3. An aberrant left main pulmonary artery arising from the right pulmonary artery is called as pulmonary artery sling and causes compression of the right main bronchus

4. Thymic enlargement after a period of stress is called thymic rebound

5. The thymic signs include wave sign, notch sign and sail sign

6. Pneumatoceles occur in the resolving phase of a pneumonia and indicate resolution

7. Most common causes of focal, non inflammatory airway obstruction : *Inhaled foreign body*

8. In children an inhaled foreign body may go into either lung since angles are the same

9. Most frequently aspirated object : *Non radio – opaque vegetable item such as peanut*

10. Air trapping and mediastinal shift are seen best on expiratory films

11. 'Shaggy heart' is classic radiographic finding in : *Pertusis*

(C) GENITOURINARY SYSTEM

(1) IMAGING TECHNIQUES

Importance findings on IVU (intravenous urogram / excretory urography)

Indication	Finding
1. Hydronephrosis	Clubbing of calyces
2. Congenital anomalies - Horse shoe kidney - Ureterocele - PKD - Retrocaval ureter - Ectopic ureter	 Flower vase appearance Adder / cobra head appearance Spider leg appearance Reverse 'J' sign with hydronephrosis Dropping flower appearance
3. RCC	Irregular filling defect; spider leg appearance

Intravenous urography

The main current indications:

- For assessment of function of the kidney (although scintigraphy is the best)
- Persistent or frank hematuria
- Renal and ureteric calculi (particularly prior to endourological procedures)
- Ureteric fistula
- Ureteric strictures
- Complex urinary tract infection (especially tuberculosis)
- Some urogenital congenital anomalies

The sequence of taking film is:

- Plain KUB film → Nephrographic phase and a 5 minutes after injection of contrast → full-length 15 minutes film → 30/45 minutes prone full length film and lastly the post-void film.

The stereotypical appearance of normal IVU:
In first minute of IVU healthy kidneys show diffuse enhancement. This is referred to as **nephrogram** → of this it takes 12-20 s for contrast to reach renal arteries after its intravenous injection → and hence in first half minute, contrast in vascular compartment dominates and therefore the cortex is more enhanced than medulla and in 2nd half minute, contrast escaped from vascular compartment reaches into extravascular compartment, undergoes glomerular filtration and enter renal tubule to and thus contrast increases in tubules causing more diffuse enhancement of kidneys → Contrast begins to appear in the calyces from around 1 minute and in good quality films, the contrast may also be seen in collecting tubules as fine linear opacities running along medullary pyramids toward calyces. This is referred to as **pyelotubular stasis or medullary or pyramidal blush** → contrast in normal calyces will begin to drain immediately into pelvis and ureter. This phase is referred as **pyelogram**→ with or without compression PCS distends and is visualized optimally around 12-15 minutes → release of compression allows transient visualization of ureters in more clear way → bladder filled well with contrast is seen at 30-45 minutes and then **post void film** should be taken.

The main contraindications:
- Liver failure with renal failure
- Myelomatosis
- Pregnancy
- Previous history of reaction to contrast
- Severally dehydrated patient

Modifications in IVU/IVP/ Excretory urography

- **Rapid sequence IVU:** Done in patients with suspected renovascular **hypertension**. Films taken at 1, 2 and 4 minutes after injection of contrast medium in addition to the routine filming sequence.
- **Infusion urography:** Done in patients with **compromised renal function**. 40–50 grams of iodine (as against 16 grams in usual procedure) is injected into 200–500 cc of glucose and given as infusion.
- **Diuretic urography:** Done in patients with **PUJ obstruction**. The patient is not dehydrated prior to procedure. IV frusemide is injected immediately following contrast, which causes copious contrast secretion, thus dilating the renal pelvis to greater extent and demonstrating the pathology nicely.

1. Definitive diagnosis of patency of renal arteries : Contrast angiography

2. In Renal failure, normal kidney size suggests acute rather than chronic process

3.	Chronic Renal Disease associated with normal kidney size are	:	*i. Polycystic kidney disease* *ii. Amyloidosis* *iii. Diabetes* iv. HIV associated. renal disease
4.	Investigation of bladder – neck obstruction in male is done by	:	*Cystourethrography*
5.	Investigation of choice after acute renal trauma is	:	*CT*
6.	Vesico-ureteric reflux is best demonstrated by	:	*Micturating Cystogram*
7.	The dye used for IVP	:	*40 ml. Of Conray 420*
8.	Isotopes used for scanning kidney	:	*Tc (99m) DMSA/DTPA* *(DTPA – for GFR, DMSA – for cortex)*
9.	Rapid sequence IVP is done in	:	Renovascular Hypertension
10.	Cobra head or Adder head deformity is seen on IVP in	:	*Ureterocele*
11.	Whitaker's test is done to know	:	Ureteropelvic junction obstruction.
12.	Maximum dose of contrast medium administered is	:	*600 mg of Iodine/ kg body weight in a well hydrated patient.*
13.	Choke urethrogram is done for	:	*Demonstration of anatomy of urethral stricture.*
14.	Internal spermatic venography is an extremely accurate method of demonstrating the location of	:	*Undescended testis*
15.	The most accurate method of measuring GFR is by	:	*99mTc DTPA*
16.	Renal scarring is best shown by DMSA scans		
17.	In pregnancy the ureter above the pelvic brim gets dilated, right more than left, this dilation persists for a month after delivery and predisposes to infection		
18.	Combined synchronous video cystometrography (VCMG)	:	*Indications :* *1) Symptoms of outflow obstruction in men below 35 years* *2) Urinary incontinence < 35 years age* *3) Possible outflow obstruction in females* *4) Problems following pelvic or plastic surgery* *5) Some neuropathic bladder problems*
19.	Initial Screening test for Renal artery Stenosis / Ischemic Renal Disease	:	*Doppler Ultrasonography*
20.	Most sensitive and specific test for diagnosis of RAS	:	*MRA*
21.	Most definitive diagnostic procedure is	:	Contrast enhanced arteriography

(2) INFECTIONS

RENAL TB

Pathognomonic features of renal TB:

1) Lobar caseation
2) Lobar calcification
3) Focal caliectasis
4) Hiked-up pelvis
5) Thimble bladder
6) Undermined ulcer in bladder

1. An IVP aids in diagnosis of Genitourinary tuberculosis

2. A classical appearance in renal papillary necrosis : *Egg in cup appearance*

3. Failure of both kidneys to ascend from the pelvis is referred to as : *Pancake kidney – Under congenital*

4. 'Wind in the sail appearance' is seen in PU valves on : *MCU – Under imaging*

5. A calyceal cyst or bladder diverticulum requires for imaging : *IVU – Under imaging*

6. Mathe's sign is seen in : Perinephric abscess

7. Single most important radiological findings of schistosomiasis : *Bladder wall calcification*

8. Ring shadow around renal papilla is found in : *Renal medullary necrosis*

9. Pencil like curvilinear calcification in bladder wall is seen in : *Biharziasis*

10. Autonephrectomy occurs in : Tuberculosis

11. Xanthogranulomatous pyelo-nephritis is associated with : Proteus infection with calculus disease

12. Lobar pattern and ureteric calcification are diagnostic of TB

13. Mnemonic to remember causes of papillary necrosis is : ***(RAPID)***

- *Renal vein thrombosis*
- Analgesic abuse
- *Diabetes Mellitus*
- *Infant in shock*
- *Pyelonephritis*

Obstruction
Sickle cell disease
Ethanol

14. Scarred calculus, kinked up pelvis, thimble bladder and golf hole ureteric orifices are seen in TB

15. Saw toothed, beaded or pipe stem ureter seen in : *TB*

16. Reflux nephropathy causes maximum damage at the poles

17. As upmark kidney develops secondary to sterile reflux

18. In Schistosomiasis infection the bladder calcification occurs in the sub mucosa and does not interfere with bladder size and function

(3) CALCULI & OBSTRUCTION

1. Anatomical causes of calculi are : *Horseshoe kidney*
Calyceal cysts

Medullary sponge kidney
Ureterocele

2. Ground – glass appearance of a calculi is seen in : *Cystine stones*

3. Cortical nephrocalcinosis is seen in : *1. Acute cortical necrosis*
2. Nephrotic syndrome

4. The normal parenchymal thickness ranges from 2.5cm in the mid portion to 2 – 5 cm at the poles

5. End stage obstructive atrophy features of IVU : *'Soap bubble nephrogram'*
Shell or rim nephrogram

6. Accumulation of more than 1 litre of fluid in kidney : *'Giant hydronephrosis'*

7. Investigation of choice in acute ureteric colic is spiral non enhanced CT

8. Rim sign, Ball sign and crescent sign are seen in renal obstruction

9. Yo –Yo peristalsis in seen in renal duplication

10. Most common cause of bladder outlet obstruction in infant male is PU valves, infant female is ectopic ureterocele

11. Congenital bladder diverticuli are called 'Hutch" diverticuli

12. Intra uterine obstruction of lower urinary tract causes Potter's triad

13. High ano-rectal malformations are associated with fistulas with bladder

14. Fish hook appearance or J shaped ureters are seen in : *BPH*

15. Radiological female prostate on cystography is caused by hypertrophied levator ani muscle

16. Urethral and bladder trauma are associated with pelvic fractures

17. Swiss cheese nephrogram and spider leg appearance on IVU are seen with PKD

18. Flower vase ureters with inversion of renal axis in seen in horse shoe kidney

19. Simple cysts show the beak sign

20. X-ray view to differentiate between Gall-stone and Rt. Renal stone is : *Lateral view*

21. Commonest site of ureteric calculi : *Ureterovesical junction*

22. A persistent Nephrogram suggest : *Ureteric obstruction*

23. 'Rim sign' in nephrogram is seen in : *Severe hydronephrosis*

24. Increasingly dense nephrogram is a sign of : *Acute obstruction of urinary tract.*

25. Most common cause of acute ureteral obstruction is : *Impacted ureteric stone.*

26. Localised edema causing rounded filling defect in the bladder on contrast studies due to impacted calculus in the UV junction is called as : *Edling's sign*

27. Idiopathic retroperitoneal fibrosis is also called as : *Ormond's disease*
Radiological picture is characteristic with ureters pulled medially and narrowed by focal extrinsic compression at L4 – 5 levels.

28. Uric acid stones are : *Radiolucent*

29. Magnesium ammonium phosphate are called as : *Triple phosphate stone / Struvite calculi*

30. Persistence of radioactivity within a dilated system for more than 20 minutes after giving a diuretic is indicative of obstruction. Normally, washout occurs in < 10 minutes

(4) URINARY TRACT TUMORS

WILMS' TUMOR (Nephroblastomas)

- Wilms' tumor is the third most common malignancy in children following leukemia and brain tumors.
- It is the most common pediatric abdominal and renal malignancy.
- The mean age at presentation is 3 years; however, it tends to present at a younger age when bilateral or associated with syndromes.
- The incidence is equal in males and females.

Radiological Features :

- Plain radiographs – Mass effect with displacement of bowel.
- Excretory urography – Distorted collecting system and evidence of obstruction
- USG – Large mass of mixed echogenicity with hypoechoic areas that represent hemorrhage or necrosis. Good for assessment of vascular extension into renal vein, IVC and right atrium.
- CT – Mass lesion less dense than normal parenchyma. Curvilinear or amorphous calcifications in 10% can assess involvement of lymph nodes, contracted kidney, vasculature, local extension, distant metastasis.
- MR_1 – Nonspecific decreased signal intensity on T_1 weighed images and increased signal intensity on T_2 weighted images. Excellent for assessing intravascular extension.
- Angiography – helps in delineation of vascular anatomy in the setting of bilateral tumors and proposed segmental resections.

1.	Renal cell cancer is also called	:	*Internists tumor, Gravity tumor or hypernephroma*
2.	Bone metastases from renal cell carcinoma are typically	:	*Lytic and highly vascular*
3.	Individuals with predisposition for developing renal cell carcinoma	:	*Patients on dialysis* *Von Hippel Lindau syndrome*
4.	Patient presents with repeated episodes of flushing, hypertension and syncope while voiding likely diagnosis	:	*Pheochromocytoma of bladder*
5.	Multiple renal angiomyolipomas, with mental retardation and skin lesion seen in	:	*Tuberous sclerosis*
6.	Multiple small filling defects in the pelvis or ureter is seen in	:	*Malakoplakia*
7.	The commonest form of renal cystic disease is	:	*Simple renal cyst*
8.	Angiomyolipoma is best diagnosed by	:	*CT scan*
9.	The presence of fat in a renal mass is suggestive of	:	*Angiomyolipoma*
10.	Onion layer appearance on ultrasonography is suggestive of	:	*Angiomyolipoma*
11.	'Spoke – Wheel' appearance on angiography is more commonly seen with	:	*Oncocytoma*
12.	'Stipple Sign' on retrograde pyelography is seen in	:	*Transitional cell carcinoma*
13.	Beak sign in renal arteriogram is seen in	:	*Renal cyst (s/o benign lesion)*
14.	Pear shaped bladder is seen in radiology in	:	*Pelvic lipomatosis*
15.	Commonest renal tumour in tuberous sclerosis	:	*Angiomyolipoma*
16.	Candida renal infection occurs most commonly as a fungal ball in diabetics		
17.	Central calcification in a renal mass is s/o malignancy, while peripheral calcification indicates a benign lesion		
18.	Schistosomiasis and stone disease predispose to squamous cell carcinoma		

19. Adenocarcinoma develops in urachal remnant, ectopia vesicae and secondary to cystitis glandularis proliferans

(5) VASCULAR

Renal artery stenosis

- **Color Doppler** evaluation of the main renal arteries has limited practical applications as a screening technique.
- **Conventional CT** does not always show the renal arteries. However, the development of helical (spiral) CT and now multidetector CT allows volumetric acquisitions to be obtained during and single breath hold respectively.
- **Radionuclide imaging:** Although, IVP and renal scans have been abandoned as screening tests for renovascular hypertension due to their low sensitivity and specificity respectively, recently *captopril renography or captopril enhanced radionuclide renal scan* has been demonstrated to have a very high sensitivity (91%) and specificity (93%) for diagnosing it. However, no anatomic detail other than renal size is provided by the captopril renogram.
- **Magnetic Resonance Angiography (MRA)** of renal arteries motion Contrast and/or time of flight MRA can be, used for detecting stenosis of renal artery. In screening for stenosis of the main renal arteries and differentiation from fibromuscular dysplasia, the use of 3D CEMRA provides optimum method for its detection and allows the demonstration of small accessory renal arteries and segmental branches. Thus, MRA with gadolinium enhancement (CEMRA) has a sensitivity of 100% and a specificity of 93–97% for detection of proximal renal artery stenosis.
- **Angiography: "String of beads" appearance** of FMD is classically seen on angiography.

1.	Dilated right ovarian vein pressing upon the ureter and causing pain is called the	:	*Ovarian vein syndrome*
2.	Ureteral notching is found in	:	*Renal artery stenosis (due to collateral formation)*
3.	Renal artery stenosis can now be treated by	:	*Percutaneous dilatation with a* ***Gruntzig balloon – catheter***
4.	Renal scintigraphy in renovascular hypertension is enhanced by	:	*Captopril*

(6) CONGENITAL

Multicystic dysplastic kidney (MCDK)

In MCDK there is no normal overall structural pattern to kidney with loss of lobular organization although small islands of renal tissue are seen microscopically.

MCDK is nonfunctioning and characterized by an atretic ureter without increased incidence of VUR.

MCDK is usually unilateral and if bilateral, it is incompatible with life.
On US, seen as a small single cyst to large mass containing multiple cysts with largest situated peripherally.

Medullary cystic disease or Nephronophthisis is salt wasting nephropathy causing CRF in adolescents and young adults. Salt wasting, polyuria, hyposthenuria, polydipsia, severe anaemia, failure to thrive and growth retardation are characteristic features. Bilateral normal or small kidneys with smooth contour and thin cortex are seen on USG with increased parenchymal echogenicity and loss of CM differentiation.

Medullary cystic disease and Juvenile nephronopthisis are two different terms for conditions, which differ in inheritance but have similar renal morphology and are radiologically indistinguishable. Both present with slowly progressive renal failure. MCD is autosomal dominant disease and presents up to 4th decade.

USG reveal two normal sized kidneys with globally hyper-reflective appearance. Cysts are not a feature until late in disease and are then typically corticomedullary.

IVU is of little help in diagnosis if it is suspected on US. The 99mTc-DMSA scan may even fail to show the kidney. Ultimate diagnosis can only be made by rectal biopsy.

Medullary sponge kidney: 'Bunch of flowers' appearance i.e. thick dense streaks of contrast material radiating from pyramids peripherally ("papillary blush" in normal people).

Horseshoe kidneys

When the most medial subdivision of mesonephric bud meet and fuse and the ascent of the kidneys is arrested by the structures arising in the midline (inferior mesenteric artery), it results in a pair of ectopic kidneys that are usually fused at their lower poles, with their junction (isthmus) in front of the L_4 vertebra.
These kidneys are prone for infection, trauma and nephrolithiasis.
Other associations include anomalies of Gut, CVS, increased risk of Wilm's tumor, medullary sponge kidneys, Turner's syndrome and Ellis-van Creveld syndrome.
IVU appearance is characteristic:

- Kidneys are low lying with their upper poles directing superolaterally
- Lower pole calyces on both sides being directed inferomedially towards the midline
- PCS points anteriorly and rarely all or most of the calyces are reversed
- Ureters characteristically have **vase-like** curves ('flower vase' ureters).

ADPKD

- It is a bilateral renal cystic disorder which becomes manifest frequently after the 3rd decade of life.
- Gene is located on chromosome number 16 (in 90% cases) and 4.
- In ADPKD, there may be associated cysts in the liver (50% of cases), pancreas, spleen, lungs and testis. Other associations are berry aneurysms (which may cause SAH and severe headache), coarctation of aorta, valvular heart disease and colonic polyps. Congenital hepatic and periportal fibrosis is associated with ARPKD.
- IVU typically shows classical stretched appearance of calyces with some times spider leg appearance.
- USG typically reveals multiple bilateral (often asymmetrical) non-communicating cysts of varying sizes, generally scattered throughout the cortex and medulla with normal intervening parenchyma and bilateral enlarged kidneys.
- Ultrasound is 2nd most useful examination of urinary tract next to IVU in adult. When a renal mass/filling defect is found at IVU then an USG examination will easily and rapidly differentiate a tumor from cyst or calculus (radiolucent).
- Combining a IVU, with its ability to demonstrate the PC system in meticulous detail, and ultrasound, which will show abnormalities of renal outline, is probably the most efficient method of imaging the urinary tract accurately.
- CT is employed when urinary USG findings are inconclusive.

1. Adult polycystic kidney is associated with cysts in : *Liver, lung, kidney, pancreas & spleen. Berry aneursyms are seen in 10%.*

2. ASK UPMARK kidney is found in : *Segmental renal dysplasia*

3.	Potter's syndrome is otherwise called	:	*Renal-Facial dysplasia*
4.	Potter facies is associated with	:	*Bilateral renal agenesis (they cause oligohydramnios which causes multiple amputations & flat facies-called amniotic band syndrome or Potter's syndrome)*
5.	Bladder ears are found due to	:	*Transient hernia of bladder in normal infants, common in males*
6.	Hydronephrosis and polycystic kidneys are well demonstrated by	:	*Ultrasound*
7.	Spider leg calyces are seen in	:	*Polycystic kidney*
8.	Dromedary hump is a bulge in left kidney on its	:	*Outer border, due to splenic impression*
9.	Dwarf kidney is found in	:	*Simple renal hypoplasia*
10.	Spring onion appearance of ureter in excretory urogram is seen in	:	*Ureterocele*

11. Posterior urethral valves are classified according to Young's system and are best shown by MCU

12.	Inverse relationship between the site of insertion of the ureters and the position of renal segment they drain in duplication is referred to as	:	*Weigert – Meyer law*
13.	Commonest cause of neonatal abdominal mass is	:	*Hydronephrosis due to pelviureteric junction obstruction*
14.	Prune belly syndrome consists of	:	*Absent abdominal wall muscles undescended testis Renal dysplasia with grossly dilated collecting systemIt is also known as Eagle Barrette syndrome*

15. Most common cause of unilateral large kidney is duplex system

16. Duplex systems obey the Weigert-Mayer law the opening of the upper kidney is infero medial to the lower kidney

(7) BLADDER AND URETHRA

Bladder diverticuli

These are focal herniations of the urothelium and submucosa through weak sites in the bladder wall.

- Primary/ congenital/ idiopathic:
- Secondary diverticuli: e.g. pseudodiverticuli due to bladder outlet obstruction having constricted neck and are usually multiple. They result mostly due to chronic elevation in intravesical pressure and are frequently encountered in male patients above 60 years age. In early stages, multiple small protrusions of the bladder lumen appear between the trabeculae, called sacculations. As they enlarge above 2 cm they become defined as diverticuli. When large, they may produce classical symptom of **double micturition**.

Ureterocele

Ureterocele is cystic ectasia of subepithelial segment of intravesical part of ureter. MCU in children with Ureterocele shows a rounded or oval lucent defect near trigone which may however be effaced with increased bladder distension and eversion may be seen during micturition.

IVU shows early filling of bulbous terminal ureter **("cobra head" appearance**) and a radiolucent halo (ureteral wall + adjacent bladder urothelium) giving **"spring onion" appearance**.

Posterior urethral valves

Varying degree of chronic urethral obstruction due to fusion and prominence of plicae colliculi, normal concentric folds of urethra.

Usually located in posterior urethra just **distal to the level verumontanum**
It is the most common cause of severe obstructive uropathy in infants and children.
MCU is gold standard in diagnosis of PUV.

Prostate and Testes

Benign hypertrophy of prostate:

- 'Slit-like' elongated and compressed urethra
- Smooth filling defect/ indentation in bladder floor
- Periurethral and subvesical enlargement is very pronounced may produce rounded defect in floor mimicking Foley's balloon.
- Floor of bladder elevated and trigone pushed upwards, with distal ureteral 'J' or 'Fish Hook' deformity.
- Trabeculations and distension of bladder
- Bladder pseudodiverticuli and calculi
- Bilateral hydronephrosis and hydroureter may occur.

Carcinoma Prostate :

- Most common non-cutaneous cancer in American Men
- Life time risk of developing ca prostate is 18-19% and increases with age
- Location: Peripheral zone 70%, transition zone 20% and central 10%.
- **Spread**: hematogenous (bone osteoblastic metastasis) / **lymphatic**
- Most important factor affecting prognosis/choice of treatment is presence or absence of extracapsular extension.
- TRUS is most widely used imaging modality for local staging.
- 3D MR spectroscopy (increased choline and decreased citrate levels) +_ Endorectal MR imaging increase accuracy in detecting and staging of local and extracapsular extension of prostate carcinoma.
- Pathologically: adults (adenocarcinoma); Children (rhabdomyosarcoma)

(8) OTHERS

1. 'Pencil – line' or 'tram line' appearance of kidney is seen in : *Acute cortical necrosis*
2. Egg in a cup appearance : *Papillary necrosis*
3. Air pyelogram is seen in : *EmphysematousPyelonephritis (Diabetes)*
4. Most bladder ruptures are : *Extra peritoneal*
5. Intraperitoneal bladder ruptures is associated with blow to distended bladder
6. Most common abdominal mass is a neonate is a hydronephrotic kidney
7. Adrenal hemorrhage secondary to birth trauma occurs more on the right
8. True incontinence is caused by ectopic ureteric opening distal to external sphincter and VVF
9. Encephalocele, cardiac defects, renal cysts, polydactyly seen in : *Meckel's syndrome*

10. Ultrasonographic appearance of Renal transplant rejection is : *Enlarged hypoechoic kidney*

11. Fir tree appearance of bladder is a feature of : *Neurogenic bladder*

12. Fish hook appearance of ureters is seen in : *Prostatic enlargement.*

13. Tram track calcification in kidney is seen after : *Acute cortical necrosis*

14. Best radiological investigation for rupture of urinary bladder after pelvic fracture is : *Cystogram*

RADIOPHARMACEUTICAL AGENTS FOR UROLOGIC DIAGNOSIS

Radiopharmaceutical	Usual Dose (μ Cl.)	Radiation-Absorbed Dose (Rads) from Usual Doses		Usual Scintiphoto Exposure Time and Imaging Time Post Dose	Use
		Renal	Whole Body		
^{99m}Tc-Fe ascorbate DTPA ^{99m}Tc glucoheptonate ^{99m}Tc methylsuccinate	20,000	1.0	0.008	Serial: 4-s, photos at 0-30 s; static: 2-4 min. photos at 30 min.	Localized in renal cortex by deposition and retention in renal tubular cells. Uptake is proportionate to regional renal blood flow. Rapid serial photos show renal blood flow distribution
^{99m}Tc (Sn)-DTPA	20,000	0.1	0.030	Serial: 1- or 2 min. photos at 0-20 min. or longer. Also useful to image blood flow	Excreted solely by glomerular filtration. Useful for function imaging, but cortical definition vs. back-ground less than with other ^{99m}Tc agents.
^{99m}Tc (Sn)-DTPA	1000	0.03 (blad-der)	0.001	Static views during filling of bladder, 6-s images during voiding	Direct radionuclide cystography to detect and measure reflux
Sodium iodohippurate ^{121}	200	0.080	0.0042 (assumes normal clearance)	2-10 min. photos (depending on renal function) 0.30 min. for normal function to 1-2 hours for poor function	Excreted by tubular function (like paramino-hippurate); 70-80% extraction causes rapid clearance in normal tissue. Prolonged cortical transit time occurs in ischemic or other forms of tubular damage with increased water reabsorption

Sodium iodohippurate ^{123}	2000	0.01	0.005	Serial images for 30 min. or longer for poor function	Excreted by tubular function. Same uses as for ^{131} hippurate
Sodium iothalamate ^{125}	50	Negl i-gible	0.00015	Not useful for imaging	Glomerular filtration rate measurement

IMPORTANT CLUES

1. Investigation procedures in radiology

Ionizing	Non-Ionizing	Modalities which do not procedure radiation
– CT	– UV	– USG
- X-ray (radiography)	– Infrared radiation" (Thermography)	– MRI
– γ-ray	– Radiofrequency ablation	
– β-ray (electrons)	– Microwave radiation	
– Protons	– Phototherapy for jaundice (visible light)	
– Fluoroscopy, DSA		
– SPECT , PET		
– Nuclear scans		

Spect (Single proton emission computed tomography), **PET and MR** spectroscopy are some examples of functional imaging techniques.
MRI uses magnetic field to construct images.
Computed tomography uses radiation for constructing images.
Ultrasound is not mutagenic.

Doppler :

- Based on Doppler effect (change in the perceived frequency of sound emitted by a moving source measures blood flow). It provides both audio and video signals.
- **Types :**

- Continuous waves
- Pulsed waves

- In Doppler imaging colour displays direction of blood flow. It is

- Red – when direction of flow is towards the transducer.
- Blue – if flow is away from transducer.
- Intensity of colour represents velocity of blood flow, lighter shades represent higher velocity.

- **Used for**
  Arterial stenosis (e.g. RAS, taP, AV fistulas), carotid occlusion, PVD, Burger's disease. DVT, varicose veins to find perforator incompetence.

Some radiological procedures :

Thermography

- IR rays are used and it reflects arterial blood supply
- Used for – breast tumour, carotid insufficiency, placental localization.

Lymphangiography

- Dye used is Methylene blue/lipoidal ultra fluid
- **X-ray appearance of L~**
  - Foamy/soap bubble appearance ---------- Hodgkin's disease
  - Irregular filling defect ---------- Sec. Metastatic LN-pathy
  - Marginal sun burst app ---------- Reticulum cell sarcoma
  - Coarse nodular storage pattern ---------- Lymphosarcoma

PET :

Positron emitting radio nuclides are used : O_2 – **informs** O2 uptake CO_2 – informs blood flow, 18 FDG – inform glucose utilization and is most frequently used moiety.

Indications :

- To distinguish radiation necrosis from recurrent glioblastoma
- To evaluate degeneration of brain tumor from low grade to high grade
- To evaluate potential for recurrence of meningiomas
- To assess tumor viability and monitor treatment response
- To differentiate benign from malignant pulmonary nodules
- To evaluate staging, restaging, and response to therapy; local and distant metastasis; and response to treatment in patients with breast cancer
- For the diagnosis, staging and restaging of colorectal, esophageal, head and neck, breast and lung cancers and lymphoma and melanoma.
- For restaging of recurrent or residual thyroid cancers, of follicular cell origin.
- In stroke PET is useful to differentiate viable from non-viable tissue.

- Renal tuberculosis early stage - IVP
- Renal tuberculosis late stage - CT > IVP
- AVN - MRI
- Atypical cavernous hemangioma (mixed echogenicity) - MRI
- Evaluation of breast implant - MRI
- Chronic SAH - MRI
- Acute SAH - (Non contract CT)
- For staging pelvic malignancy - MRI
- Posterior fossa tumour - MRI
- Parameningeal rhabdomyosarcoma - MRI
- Acoustic vestibular neuroma - MRI
- Bronchiectasis - HRCT
- Solitary pulmonary nodule - CT
- (CT helps differentiating malignant from benign by detecting calcification in benign)
- Blunt abdominal trauma - CT Scan
- For localizing epileptogenic foci
- a. Structural imaging - MRI CT
- b. Functional imaging
  (done only when structural imaging fails) - PET, SPECT

- Aortic dissection, IOC - MRI
- Gold standard - CT
- Intraoperative monitoring - TEE
- Cardiac tamponade, pericardial effusion - 2-D ECHO
- Cardiac valvular disease - M. Mode ECHO
- Anterior urethra is best visualized by - Retrograde
- Posterior urethra best visualized by - MCU (Voiding cystogram)
- For entire urinary tract in emergency - Non contrast spiral CT (Helical CT)
- Pheochromocytoma - T_2 weighted MRI > CT
- Extra adrenal pheochromocytoma - ^{131} I-MIBG Scan
- Parathyroid adenoma - Tc -Th substraction scan
- Neuroendocrinal tumours (NENT) - SRS
- Except insulinoma for which - Endoscopic USG

View	Used for
• Lordotic	For apex, Lingular lobe (rt middle lobe) of lung
• Reverse lordotic	To detect interlobar effusion
• Stryker's view	Recurrent subluxation/dislocation of shoulder
• Lateral skull view	For sella turcica

- Silhoutte sign is used mainly for localizing intrathoracic lesion.

Sign	Lesion of
Obscured right heart border	Right middle lobe (ant. segment) lesion
Obscured left heart border	Lingular lobe/left lower lobe
Hemidiaphragm	Relative lower lobe
Aortic knuckle	Apico-posterior segment of left upper lobe
Ascending aorta	Ant. Segment of right upper lobe
Descending aorta	Sup. And posterobasal segment of left lower lobe

- Hilum overlap sign :
  - Differentiates between anterior mediastinal mass and cardiac enlargement/pericardial effusion.
  - In ant. Mediastinal mass, mass will often overlap the main pulmonary artery.
- Cervicothoracic sign :
  Used in localizing superior mediastinal lesion in CXR PA view
  Ant. Mediastinal lesion - projects below the calvicle
  Post. Mediastinal lesion – projects above the clavicle
- Hilar shadow
  Formed by lower lobe branch of pulmonary a + Upper lobe veins.

- **Respiratory** system
  - Air bronchogram – ARDS, HMO.

- Bulls eye lesion – granuloma
- Bat wing or butterfly appearance – pulmonary edema.
- Popcorn calcification – fibroadenoma.,.
- Egg shell curvilinear calcification – fat necrosis.
- Hyperlucent – emphysema, pneumothorax, Poland syndrome.
- Crescent or meniscus sign (in febrile neutropenic) – Aspergillus
- Minimal pleural effusion-lateral decubitus view same side.
- Pneumatocele – Staphylococcus, Klebsiella.
- Steeple sign – croup. .
- Shrinking lung syndrome – SLE.
- Vallecular sign – barium retention in Ca larynx.
- Sail sign – thymus.
- thumb sign – epiglottitis.
- Water Lilly sign – hydatid disease.
- Interlobar effusion – reverse lordotic view is best.
- Apex, lingual view – lordotic view is best.
- Egg shell calcification – silicosis (1st), pneumoconiosis, TB.
- Shaggy heart (loss of clearity), pleural plaques – asbestosis.
- Grape cluster pattern, honey combing, signet ring appearance, tam tack appearance – Bronchiectasis
- Kerley B. lines – pulmonary edema (pressure >16 cm)
- Retrocardiac air fluid level – hiatus hernia.

- **Renal system**
  - Rim sign, Soap bubble appearance – hydronephrosis.
  - Spider leg deformity – polycystic kidney.
  - Flower vase kidney – horse shoe kidney
  - Drooping flower app – ectopic ureter.
  - Cobra head app. – ureterocele
  - Thimble bladder – TB bladder
  - Sandy patches – schistosomiasis
  - Golf hole ureter – TB ureter

SOLVED MCQs

1. Which of the following imaging techniques gives maximum radiation exposure to the patient ?

(1) Chest X-ray (2) MRI
(3) CT scan (4) Bone scan

Ans. **(3)**

1. The mean effective dose is 4 mSv per bone scan, compared to 5.3 mSv per CT scan (all examinations).
2. The mean effective dose per bone scan is equivalent to 200 chest X-rays.

(Ref. Grainger Diagnostic Radiology, 4th Edition, Pg. 187)

2. Ultrasound transducer is made up of :

(1) Lead zirconate titanate (2) Lithium fluoride
(3) Photostimulable phosphor (4) Silver bromide

Ans. **(1)**

Currently **Lead zirconate titanate (PZT), synthetic ceramic** is the most widely used material in the *ultrasound sound transducers/probes* replacing the firstly discovered Barium titanate. Although some naturally occurring materials possess piezoelectric properties (e.g., quartz) but most crystals used in medical ultrasound are man made with artificial ones, known as Ferroelectrics.

(Ref. Christensen's Physics of Radiology 4th Edition, Pg. 329)

3. Not true regarding PET imaging :
   (1) Needs parallel hole high energy lead collimators.
   (2) Detects 511 KeV annihilation photons in coincidence.
   (3) Most accurate non-invasive method of detecting and evaluating most cancers.
   (4) A 'unique tool' to study and quantify physiological and pathological function of human tissues and organs.

Ans. **(1)**
PET permits noninvasive in vivo examination of metabolism, blood flow, electrical activity, and neurochemistry.
It uses the coincidence detection of paired 511KeV annihilation photons from positron emitting radionuclides like carbon-11, nitrogen-13, oxygen-15 and fluorine-18. The PET compounds are radio labeled with positron emitting radionuclides and injected into patient. In the tissues, positron annihilation reaction with an electron occur resulting in formation of annihilation photons, which are emitted in diagonally exactly opposite directions; in turn detected by coincidence circuit through simultaneously arriving detectors on opposite sides of patient→ electronic collimation occurs through coincidence circuit, (thus, no need of lead collimators) hence better resolution and sensitivity than SPECT.

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 112)

4. Regarding radiological evaluation of Suspected Pulmonary Embolism, wrong is :
   (1) A chest radiograph obtained the same day is essential for interpretation of the radionuclide ventilation and perfusion scan. An upright radiograph is preferred.
   (2) An electrocardiogram with no evidence of left bundle branch block is not must before pulmonary angiography.
   (3) Spiral CT with intravenous contrast is investigation of choice to rule out large proximal pulmonary artery thrombi.
   (4) Angiography is still preferred for small branch artery thrombi.

Ans. **(2)**
A chest radiograph obtained the same day is essential for interpretation of the radionuclide ventilation and perfusion scan. An upright radiograph is preferred. An electrocardiogram with no evidence of left bundle branch block is required before pulmonary angiography. Spiral CT with intravenous contrast can be performed to rule out large proximal pulmonary artery thrombi. Angiography is still preferred for medium and small branch artery thrombi.

(Ref. Diagnostic Radiology by Grainger, 4th Edition, Pg. 526)

5. A 35 yr old non-smoker presents with 2 episode of mild hemoptysis. There is no history of fever or any constitutional symptoms. A plain X-ray of chest is found to be normal. Which one of the following should be the next step in diagnostic evolution of this patient ?
   (1) BAL (2) High-resolution computed tomography
   (3) Contrast-enhanced computed tomography (4) Fiberoptic bronchoscopy

Ans. **(4)**

Sputum cytology and bronchoscopic biopsies or washings usually provide assessment of endobronchial pathologies and the cell type of central tumors, if any, but peripheral tumors may require percutaneous biopsy.

In a 35 yr old non-smoker who is presenting with 2 episode of mild hemoptysis, without history of fever or any constitutional symptoms, with plain X-ray of chest normal the cause is likely to be Endobronchial pathology, hence the next step in diagnostic evolution of this patient should be Fiberoptic bronchoscopy.

(Ref. Harrison's Principles of Medicine, 17th Edition, Vol. 2, Pg. 1594-1595)

6. "Golden S" sign is seen in :

(1) Right upper lobe collapse (2) Left upper lobe collapse

(3) Right middle lobe (4) Lower lobe collapse

Ans. **(1)**

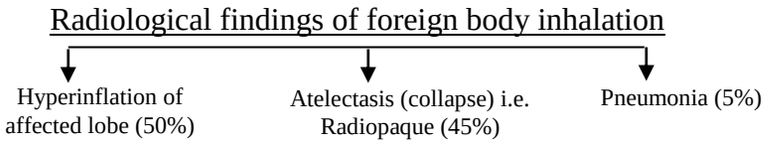
Partial or complete loss of volume of a lung is referred as collapse or atelectasis.

Golden's S sign → right hilar/central mass with upper lobe collapse seen as convexity at the medial aspect of pulled up major fissure.

(Ref. Sutton Radiology, 7th Edition, Pg. 175)

7. A child with acute respiratory distress shows hyperinflation of unilateral lung in chest X-ray. Most likely cause for above presentation is :
(1) Aspiration pneumonia (2) Congenital lobar emphysema
(3) Foreign body aspiration (4) Staphylococcal bronchopneumonia

Ans. **(3)**



(Ref. Grainger, 4th Edition, Pg. 519)

8. Investigation of choice for bronchiectasis is :
(1) VP scan (2) High resolution computed tomography
(3) MRI (4) Bronchography

Ans. **(2)**
Until recently bronchography was the definitive investigation for the diagnosis of bronchiectasis and for assessing the extent of the disease. High – resolution CT is now widely preferred.
(Ref. David Sutton, 6th Edition, Vol. 1, Pg. 342)

9. IVU features of Renovascular hypertension are all, **EXCEPT** :
(1) Delayed 'wash-out' of contrast (2) Filling defect in calyces
(3) Ureteral kinking (4) Normal or small sized kidney.

Ans. **(2)**
Renovascular hypertension
It accounts for 1-4% of patients with hypertension.
IVU features:
- Delayed/absent nephrogram (due to feeble perfusion by collaterals)
- Normal or atrophic kidney without calyceal deformity or abnormality.
- Ureteral kinking, when retroperitoneal fibrosis/aberrant vessel is the cause.
- Rim nephrogram.

(Ref. Pocket Radiologist - Abdomen 281)

10. Non-visualisation of kidney in excretory urogram is seen in :
(1) Amyloidosis (2) Renal vein thrombosis
(3) Hypoplasia (4) Duplication

Ans. **(2)**
- Non-visualization of kidney excretory urogram is due to –
  - Anatomical absence of kidney
  - Non-functioning kidney
- In duplication, there are two collecting systems seen in IVU.
- In RVT & mild hydronephrosis, there is poor or absent excretion of contrast in IVU.
- In renal hypoplasia kidneys are of normal size, while in amyloidosis kidneys are enlarged.

(Ref. Grainger & Allison Diagnostic Radiology, 4th Edition, Pg. 1743)

My Notes

(D) ABDOMINAL RADIOLOGY

SALIVARY GLAND

1.	'hot spot' an area of increased uptake seen in	:	*Warthin's tumour*
2.	Salivary gland calculi are common in	:	Submandibular gland
3.	Tumors of salivary gland are best assessed by	:	*Ct or mri*
4.	Commonest tumors of salivary gland are	:	*Plemorphic adenoma (3/4)*
5.	Salivary gland tumor with prediliction for perineural spread (like adenoidcystic carcinoma) can be best assessed by	:	*Mri*

OESOPHAGUS

Barium swallow study

- Barium studies are remain the primary imaging technique in suspected esophageal disorders, especially in cases of dysphagia.
- Barium studies are simple to perform, inexpensive and highly sensitive.
- Barium studies should precede endoscopy in high dysphagia when an unsuspected pharyngeal pouch can be readily entered and perforated with scope.
- Also esophagoscopy is less good at identifying motility disorders.

Tracheoesophageal fistula

- Plain radiography may show air in esophagus and stomach (most common variety being upper end of esophagus, being blind, and lower end connected to trachea).
- Contrast study of esophagus (***water soluble low-osmolarity nonionic iodinated contrast agent is ideal***) confirms the diagnosis.
- If simple swallow doesn't show the fistula, modification may be required in the form of contrast injection into NG tube with patient prone and as the tube (Rubber) is withdrawn the fistula is seen.

Esophageal varices

- Varices are seen as serpiginous (*worm-like*) filling defects in the regular contour of esophagus in barium studies.

Hiatus hernia

Examination of hiatal area requires the patient to be placed in prone/oblique position on a horizontal table and given a bolus of barium to swallow so there is maximal distension of hiatal segment.

- When looking for reflux during barium studies, the usual technique is to have the patient in a supine horizontal position and then slowly to lift left side off the couch while screening continuously.
- **CXR:**
  - Epiphrenic bulge
  - 4 longitudinal coarse thick gastric folds above gastroesophageal junction or in the suprahiatal pouch
  - Distance between B ring and hiatal margin > 2 cm
  - Peristaltic waves above hiatus

Esophageal motility disorders

a) Primary - Achalasia
Diffuse esophageal spasm
Presbyesophagus
Nutcracker esophagus
Achalasia
Congenital TO fistulae
Intestinal pseudoobstruction

b) Secondary - Connective tissue disorders
Neuromuscular disease
Chemical/physical injuries
Metabolic and endocrine disorders

- Esophageal manometry is considered the "gold standard" for the evaluation of esophageal motility.

Diffuse esophageal spasm

- Compartmentalization of esophagus by numerous tertiary contractions, i.e., episodes of pronounced abnormal motility occurs without cause, causing severe chest pain.
- The intermittent nature of the disorders makes it difficult to diagnose by Barium studies;
- 24 hours. Manometry is required.
- The tertiary contractions are non propulsive, uncoordinated and nonperistaltic and hence seen as intermitted 'riggles' along the wall of esophagus, as multiple simultaneous contraction rings, or as a segmented Barium column producing a "corkscrew," "rosary bead," or "curling" appearance.

Achalasia cardia

- It is a motility disorder of esophagus, probably due to degeneration of myenteric plexus in gastroesophageal junction region, resulting in failure of relaxation of the gastroesophageal junction.
- It is defined by the manometric triad of aperistalsis of the esophageal body, incomplete, impaired relaxation of the LES to less than 50% of the basal LES pressure, and hypertension of the resting lower esophageal sphincter.
- **CXR** may reveal absent fundic bubble, areas of aspiration pneumonitis in lung fields and mediastinal air-fluid level.
- Earliest change seen on **Barium study** is defective distal peristalsis associated with a slight narrowing at G-E junction.

Features*:*

- Megaesophagus/sigmoid esophagus
- "Bird beak" deformity
- Absence of primary peristalsis below level of cricopharyngeus
- Hurst phenomenon (temporary transit through cardia when hydrostatic pressure of barium column is above toxic LES pressure)
- Vigorous achalasia (numerous tertiary contractions in nondilated distal esophagus of early achalasia)

Carcinoma oesophagus

- Squamous cell carcinoma accounts for 95% of the malignant lesions of the esophagus.
- Adenocarcinomas are far less common. The great preponderance of these (59% to 86%) appears to arise from the metaplastic columnar epithelium of the Barrett esophagus.

Radiological features:

- Any stricture, mass lesion, ulcer, or mucosal irregularity of the esophagus must be viewed with suspicion of cancer. The classic radiologic patterns of esophageal carcinoma are annular constrictive, polypoid, infiltrative, and ulcerative.
  - The most frequent presentation, the annular carcinoma or *"apple core lesion,"* has sharp overhanging edges proximally and distally.
  - *"Rat-tail" esophagus*, Shouldering sign are other common features.
  - Role of CT in esophageal disease is mainly confined to *cancer staging*.
  - Endoscopic USG only overcomes limitation of CT in assessing esophagus.

1.	A sliding hiatal hernia is distinguished from para – oesophageal hernia	:	*By position of the B ring*
2.	Plummer – Vinson syndrome	:	*Also called as Patterson Kelly syndrome Consists of iron deficiency anaemia*
		:	*dysphagia, stomatitis, glossitis. Associated with webs.*
		:	*Premalignant for pharyngeal & esophageal carcinomas.*
3.	Worm like impressions on the barium in oesophagus is found in	:	*Oesophageal varices*
4.	**"KILLIAN'S DEHISCENCE"** Gap between the transverse and oblique fibres of	:	*Inferior Constrictor of Pharynx*
5.	Zenker's diverticulum	:	*Pulsion diverticulum developing at Killian's dehiscence*
6.	Commonest cause of traction diverticulum is	:	*TB lymphadenopathy*
7.	Investigation of choice for reflux esophagitis	:	*Endoscopy*
8.	Functional dysphagia is particularly found in	:	*Young women*
9.	Large hiatus hernia in chest X-Ray shows	:	*A soft tissue mass containing a fluid level*

10. Types of congenital diaphragmatic hernias →
Bochdalek hernia → posterolateral defect in diaphragm due to incomplete closure of pleuroperitoneal membrane.
Morgagni hernia → Anterior defect due to incomplete attachment of diaphragm to sternum; commonest content is bowel.

11.	"RAT TAIL" appearance of oesophagus in X-Ray is seen in	:	Achalasia Cardia (also called bird beak appearance.)
12.	Esophageal varices in advanced state has	:	*Worm eaten appearance*

13.	Apple core appearance is seen in	:	*Ca oesophagus*
14.	Oesophageal webs are best demonstrated by	:	Cine films or video swallows
15.	Absence of normal gas bubble in the cardia of stomach is a constant feature of	:	*Achalasia Cardia*
16.	Small hiatus hernia can be demonstrated by position	:	*Trendelenberg*
17.	Corkscrew oesophagus is seen in	:	Oesophageal dyskinesia (diffuse esophageal spasm)
18.	Nutcracker esophagus	:	Is a condition causing chest pain due to pressure of primary peristaltic waves exceeding 180 mm Hg. This can not be diagnosed radiologically but is manometric finding.
19.	Commonest indication of X-Ray of oesophagus is	:	*Dysphagia*
20.	For local staging of esophageal carcinoma investigation of choice is	:	*Endoscopic ultrasound*
21.	Post cricoid impression is located on the anterior wall of proximal oesophagus		
22.	Eventeration of left dome of diaphragm predisposes to	:	*Volvulus.*
23.	Saint's triad includes hiatus hernia, gall stones and diverticulitis		
24.	'Birds Beak' appearance can be seen in	:	*Ca Esophagus*

STOMACH, DUODENUM

Upper GI Imaging (barium study)

Precaution:

1) Empty stomach via nasogastric tube before study
2) Remove contrast at end of study

Barium study features of CHPS

1) Elongation and narrowing of pyloric canal (2–4 cm length)
2) Passing of small barium streak through pyloric canal seen as a string of barium known as **string sign**.
3) Crowding of muscle folds in pyloric canal known as **double/triple track sign**.
4) Transient triangular tent-like cleft/niche in mid portion of pyloric canal with apex pointing inferiorly; seen due to mucosal belonging between 2 separated hypertrophied muscle bundles on greater curvature side within pyloric canal, known as **diamond sign/twining recess**.
5) Outpouching along lesser curvature due to disruption of antral peristalsis, known as **pyloric teat/teat sign**.
6) Mass impression upon antrum with streak of barium pointing toward pyloric channel, known as **beak sign/antral beaking**.
7) Indentation of the base of duodenal bulb known as **umbrella/kirkling/ mushroom sign**.
8) Gastric hyperperistaltic waves known as **caterpillar sign**.
9) Gastric distension with fluid.

Ultrasound (investigation of choice)

1) Target Sign: Hypoechoic ring and hypertrophied pyloric muscle around echogenic mucosa centrally (transverse scan).

2) Elongated pyloric with thickened muscle
   - Pyloric muscle wall thickness 2.5-3 mm
   - Pyloric volume > 1.4 cm^3
   - Pyloric length > 1.2 cm
   - Pyloric transverse diameter 13-16 mm with pyloric channel closed.
3) Cervix sign (indentation of muscle mass on fluid filled antrum on longitudinal scan)

4) Antral nipple sign (redundant pyloric canal mucosa protruding into gastric antrum)
5) Exaggerated peristaltic waves
6) Delayed gastric emptying of fluid into duodenum and increased residue in stomach

Peptic ulcer disease

When erosions are over 5 mm in diameter, it is conventional that they be called ulcers.

Features	Benign ulcer	Malignant ulcer
Location	Distal stomach and the lesser curvature (distally) (Posterior wall > Anterior wall).	Fundus and prox half of greater Curvature.
Ba Studies (Enface) (End on)	1. Round or oval, sometimes tear- drop like or with linear contour (collection of ba on dependent wall). Ring Shadow with barium coating edge of the ulcer crater (ulcer on nondependent wall or is not filled with barium). 3. Radiating folds are smooth and symmetrical and continue to the edge of ulcer crater.	Irregular
In profile	1. 'Ulcer Niche' (Project beyond lumen of stomach).	Absent
	2. 'Hampton's Line' a pencil-thin line of lucency seen crossing the base of the ulcer due to preserved gastric mucosa with undermining of more vulnerable submucosa-	Carman's meniscus sign

	virtually diagnostic.	

"Pseudokidney" sign :

Pseudokidney Sign (sonographic mass of reniform appearance with a central hyperechoic region surrounded by a hyperechoic region) can be seen in following conditions:

- Ca stomach
- Ca colon
- Intussusception
- Inflammatory bowel disease
- Necrotizing enterocolitis
- Midgut volvulus
- Sigmoid volvulus

Benign Vs malignant gastric ulcer

	Benign	Malignant
• Age group	Young	Old
• Location	On lesser curvature	Greater curvature
• Margins	–	Heaped up, elevated, beaded
• Base	Smooth	Shaggy, necrotic
• Gastric mucosal fold	Radiate spoke like	Do not reach the edge
• Sign	Ulcer mound hampton's line	Carman's meniscus sign

Gastric carcinoma

Various types of gastric carcinoma:

1. Early gastric cancer
2. Polypoid carcinoma
3. Ulcerating carcinoma with a mass
4. Ulcerating carcinoma presenting as an ulcer
5. Scirrhous carcinoma

- By definition ***early gastric carcinomas*** are confined to the mucosa and the submucosa, irrespective of whether or not regional lymph nodes are involved.
- And by definition advanced carcinomas have spread beyond submucosa and have invaded the muscularis propria.

1. Most common benign tumor of stomach : *Leiomyoma*

2. 'Trifoliate duodenum' on Barium meal is seen in : *Scarring following chronic duodenal ulcer*

3.	Multiple peptic ulcers are found in	:	*Zollinger Ellison Syndrome*
4.	**Hypotonic duodenography** is usually used to diagnose	:	*Carcinoma of Head of Pancreas*
5.	Contrast used in Gastric or duodenal perforation	:	*Water soluble contrast media*
6.	'Leather bottle' appearance seen in	:	***Linitis plastica*** • *Carcinoma* • *Corrosive gastritis* • *Crohn's disease* • *Tuberculosis* • *Syphilis* • *Eosinophilic gastritis* • Lymphoma
7.	Most common cause of non – obstructive gastric dilatation	:	Gastroparesis diabeticorum
8.	'Pseudo – post – Billroth I' appearance is seen in	:	*Crohn's disease*
9.	Gastric carcinoma is staged by help of	:	*CT Scan*
10.	Duodenal diverticula are usually found in	:	*2nd / 3rd part of duodenum*
11.	"Cup and spill" stomach is seen in	:	*Volvulus of stomach. Some think it to be a Normal type of stomach*
12.	**'Frost Berg's Inverted 3 Sign'** is found in	:	*Carcinoma of Head of Pancreas*
13.	Commonest cause of Linitis plastica of stomach	:	*Ca – stomach*
14.	Double bubble sign in GIT is seen in	:	*Duodenal atresia*
15.	Menetrier's disease is characterized by	:	*Hypertrophy of gastric folds*
		:	*Achlorhydria*
		:	*Hypoproteinaemia*
16.	Commonest causative agents of emphysematous gastritis are	:	*E. coli & Clostridium welchii*

SMALL BOWEL

SMALL INTESTINAL

Small intestinal imaging

- Barium studies of small intestine may be classified into indirect (e.g. Small bowel meal, Peroral pneumocolon and Reflux examinations) and direct (e. g., Enteroclysis) techniques.
- Enteroclysis (small bowel enema) gives the best mucosal details.

Malabsorption

There are 4 Radiologic groups of findings in Small Intestinal Malabsorption, related to alteration in:

1. **Peristalsis** → Variable peristalsis is hallmark with hypo and hypertonic segments, overall leading to increased transit time and segmentation of barium.
   However transit time may be long/short/normal.

Painless transient intussusception may be seen on fluoroscopy.

2. **Caliber** → Dilatation of segments of bowel coils in 80% cases (>3 cm).

3. **Secretions** → Increased secretions cause dilution of barium and later clumping, segmentation and flocculation of barium.

4. **Mucosa** → Edematous mucosa with thickened valvulae conniventes giving 'Cog-wheel' pattern (colonization of jejunum), instead of their normal 'Feathery' pattern; later atrophy occurs and mucosal folds disappear with thinning of bowel wall.

Obstruction of organ	Feature
Small bowel	• Straight segments that are central and lie transversely (no gas in colon i.e. colon cut-off sign)
Jejunum	• Valvulae conniventes
Ileum	• Featureless
Caecum	• Rounded gas shadow in right iliac fossa
Large bowel	• Haustral fold spaced irregularly

Small intestine is differentiated from large intestine by –

Small intestine	Large intestine
Central location	Peripheral
Valvulae conniventes	Haustrations
Diameter 2.5-3 cm	Diameter > 5cm

- Although Enteroclysis is more reliable in patients with partial, incomplete and intermittent obstruction, CT is now recommended as the technique of choice for the investigation of suspected intestinal obstruction.
- Small intestinal obstruction is differentiated from paralytic ileus on CT by demonstrating a **transitional zone** between dilated loops of small intestine proximal to the site of obstruction and collapsed loops of small intestine or colon distal to the site of obstruction.
- USG may show dilated, fluid-filled intestinal loops in abdomen, particularly in closed loop obstruction.
- Barium study: Active peristalsis forms bulbous head of barium column in an attempt to overcome obstruction (**"snake head" appearance**) and barium appears in colon after 12 hours.
- **Strangulating obstruction** is a mechanical small bowel obstruction of two limbs of a loop by a band or within a hernia, in such a way as to compromise the blood supply by compression of the mesenteric vessels.
- The closed loop may fill with fluid and be palpable. It may be visible on a radiograph as a soft tissue mass or pseudotumor.
- The strangulated loop may contain gas, and arms of loop, separated only by the thickened intestinal walls, resembling a large coffee-bean (**Coffee-bean sign**).

- If gangrene occurs, linear gas shadows are seen in the wall of small bowel.

Intussusception

- Telescope-like invagination or prolapse of a segment of intestinal tract (intussusceptum = donor loop) into the lumen of the adjacent intestine (intussusipiens = receiving loop)

- **Radiological signs include**
  A. Plain film :
  Target sign → soft tissue mass with concentric circular areas of lucency due to the mesenteric fat of intussusceptum
  Meniscus sign → crescent of gas within colonic lumen that outlines apex of intussusceptum
  B. Antegrade barium study:
  "Coiled spring" appearance, "beaklike" abrupt narrowing of barium column demonstrating a central channel (Barium between the intussusception and surrounding colon produces a "coiled-spring" appearance).
  Pincer sign
  C. Barium enema
  Meniscus sign → convex intracolic mass
  Coiled spring sign → edematous mucosal folds of returning limb of intussusceptum outlined by barium within lumen of colon
  Claw sign
  D. USG (98–100% sensitive, 88–100% specific)
  "Crescent-in-doughnut/ Target/ Bull's eye" sign (transverse scan) → concentric rings of alternating hypoechoic and hyperechoic layers with central hyperechoic mesentery
  "Pseudokidney/ Sandwich/ Hay fork/ Hamburger" sign (longitudinal scan) → Hypoechoic layers in each side of echogenic centre of mesenteric fat
  "Doughnut" → seen after successful reduction of intussusception

Barium enema features of Ileocaecal tuberculosis:

1. Early involvement of the ileocaecal region manifesting as spasm and edema of the ileocaecal valve. Thickening of the lips of the ileocaecal valve and/or wide gaping of the valve with narrowing of the terminal ileum ("**Fleischner" or "inverted umbrella sign**") are characteristic.
2. **Fold thickening and contour irregularity** of the terminal ileum, better appreciated on double contrast study.
3. **Conical caecum**" or "**Amputed caecum"** shrunken in size and pulled out of the iliac fossa due to contraction and fibrosis of the mesocolon. The hepatic flexure may also be pulled down.
4. Loss of normal ileocaecal angle and dilated terminal ileum, appearing suspended from a retracted, fibrosed caecum ("**goose neck deformity**").
5. **Purse string stenosis**"- localized stenosis opposite the ileocaecal valve with a rounded off smooth caecum and a dilated terminal ileum.
6. **Stierlin's sign**" is a manifestation of acute inflammation superimposed on a chronically involved segment and is characterized by lack of barium retention in the inflamed segments of the ileum, caecum and variable length of the ascending colon, with a normal configured column of barium on either side. It appears as a narrowing of the terminal ileum with rapid emptying into a shortened, rigid or obliterated caecum.

7. **String sign**" - persistent narrow stream of barium indicating stenosis.
8. **Widening of IC angle** is also a common feature.

ii) Colon:

- Segmental colonic involvement
- Diffuse ulcerating colitis + pseudopolyps
- Amputated/ Coned/ Contracted caecum

iii) Gastroduodenal:

- Simultaneous involvement of pylorus + duodenum → 'Linitus plastic' appearance.
- Linitus plastic may also be a feature of gastric lymphoma and Scirrhous carcinoma, eosinophilic gastritis

Small intestinal neoplasms

These include:

- Lymphoma
- Adenocarcinoma
- GIST (Gastrointestinal stromal tumor)
- Secondaries

- CT (IV + Oral cotrast) shows the extent of spread of the mass and evaluates sites of neoplastic involvement like abdominal lymph nodes and solid organs, allowing accurate staging at a single examination.
- **X-ray signs** of acute appendicitis are appendicolith (5–60 mm), sentinel loop, widening and blurring of the properitoneal fat lines, right lower quadrant haze due to fluid and edema, scoliosis concave to the right, mass indenting the caecum, blurring of right psoas shadow and gas in appendix (unreliable). Evidence of appendicolith has high positive correlation with acute appendicitis.
- **Ultrasound and CT** show a great potential to improve diagnostic accuracy in patients with suspected appendicitis. **USG signs** include a non-compressible, nonperistaltic, blind-ending tubular structure of diameter 7 mm or greater, a appendicolith casting acoustic shadow, high echogenicity surrounding fat, surrounding fluid or abscess, edema of caecal pole and maximal probe-tenderness in RIF. **The main drawback of ultrasound is that, in most cases, a normal appendix is usually not visualized.** Nevertheless, USG can diagnose a number of conditions that mimic appendicitis clinically (e.g., ectopic pregnancy, ovarian cyst, etc.).
- CT signs of appendicitis include an appendix measuring greater than 6 mm in diameter, failure of the appendix to fill with oral contrast medium or air up to its lip, an appendicolith, and enhancement of its wall with IV contrast. Surrounding inflammatory changes include increased fat attenuation, fluid, inflammatory phlegmen, caecal thickening, abscess, extraluminal gas, and lymphadenopathy.

An 'arrowhead' sign consists of luminal contrast or air in the caecum pointing towards the obstructed origin of appendix, seen in 30% cases. A normal appendix is visualized more frequently on CT, and this is the key advantage of CT over USG. The sensitivity and specificity of CT is achieved up to 100% and 95% respectively in diagnosing appendicitis while that for ultrasound it is 78–98% and 85–98% respectively.

1. The 'String of beads sign' is virtually diagnostic of : *Small bowel obstruction*

2. Wilkie's syndrome is also known as : *Superior mesentric artery compression syndrome*

3. Raspberry thorning of intestine is seen in : *Crohn's disease*

4. **Clumping of Barium** (Flocculation) is found in : *Small intestine malabsorption*

5. Claw sign in abdominal X-ray is seen in : *Intussusception*

6. 'Triple Bubble' sign is seen in : *Jejunal atresia*

7. **'String Sign'** of Kantor is found in : *Crohn's Disease, TB*

8. Other signs seen in Ileocaecal junction tuberculosis are :
Inverted umbrella sign (broad base triangular appearance of ileocaecal valve with base towards caecum
Sterline's sign (lack of retention of barium in inflamed segment of ileum, caecum and ascending colon)
String sign (persistent narrow stream of barium indicating stenosis)
Note. Sterline's sign & string sign are also seen in Crohn's disease

9. Skip lesions are found in : Crohn's Disease

10. 'Rose-Thorn' ulcers are found in : Crohn's Disease

11. The presence of more than 2 air fluid levels in bowel measuring more than 2.5 cm in diameter is abnormal

12. Hereditary pancreatitis is : *Autosomal dominant*

13. In generalized gaseous abdominal distention the left lateral decubitus view helps to differentiate between large bowel obstruction and paralytic ileus by evaluating gas in the rectum

14. Features of Crohn's disease causing bowel separation are mesenteric disease, creeping fat, lymphadenopathy and bowel wall thickening.

15. Barium signs of Intussusceptions include claw sign and coiled spring appearance

LARGE BOWEL

Hirschsprung's disease :

It is due to failure of caudal migration of neuroblasts in the developing bowel causing the distal large bowel from the point of neuronal arrest to the anus, aganglionic.

IMAGING FEATURES:

Abdominal radiograph:

- Typically shows a low bowel obstruction commonly with colonic dilatation out of proportion to small bowel.
- Absence of rectal gas may be seen.
- Pneumoperitonium may be seen in 5% cases.
- Intraluminal small bowel calcifications (enteroliths) in long segment disease

Water-soluble contrast medium/Barium enema:

- Most vital film is a lateral view of the rectum during slow filling.
- Cone-shaped **transition zone**, abnormal i.e. reversal of **rectosigmoid ratio** (normal is >1) and irregular/tertiary rectal contractions are diagnostic features.
- The radiological transition zone is commonly found distal to pathological zone.

Rectal biopsy: A section or full thickness rectal biopsy is required for the definitive diagnosis of Hirschsprung's disease.

Necrotizing enterocolitis (NEC)

- Most common life threatening emergency of GIT in newborns
- Preterm infants particularly susceptible (Greatest Risk Factor)
- Etiology: *Triad* of intestinal ischemia, oral feedings and pathogenic organisms has been linked to NEC.
- Persistent loop sign may be seen
- Pneumatosis intestinalis → *diagnostic* of NEC (Most common in RLQ)
- Gas in portal vein is a *sign of severe* disease
- Gross pneumoperitoneum can occur if perforation occurs
- Post NEC strictures may occur, in splenic flexure in less severe cases
- Risk of NEC is significantly low in infants on exclusive breastfeeding
- Treatment includes Cessation of feeding, nasogastric decompression, IV fluids, antibiotic, and removal of umbilical catheter if any.

Ischemic colitis:

- 'Thumb-printing' appearance of the submucosal thickening due to edema and hemorrhage with its crescentic margins has been used to describe ischemic colitis, which can sometimes be detected on plain radiographs but in most cases a barium enema is necessary, which is characterized by following features:
  - Gross spasm of affected segment
  - Linear Ulcers
  - Mosaic pattern
  - 'Thumbprinting' appearance
  - Funneling of the bowel the level of transition from abnormal to normal gut
- Ischemic colitis **most often affects splenic flexure** and proximal descending colon.
- It is of three types → transient, stricturing, and gangrenous.

Crohn's disease (regional ileitis)

- Occurs any where along gut from mouth to anus
- Terminal ileum is most commonly affected
- Aphthoid/longitudinal/fissuring/rose-thorn ulcers
- Skip lesions
- Transmural involvement (distinguishing feature)
- Perianal fissure and fistulae
- Noncaseating granulomas
- Cobblestone mucosa
- "String sign" of Kantor on Barium enema
- Multiple strictures
- Enteroenteric, enterovesical fistulae
- Mesenteric inflammation, phlegmon, fibrofatty proliferation (Omega sign on Barium enema)

- Extracolonic manifestations and changes into carcinoma are less common as compare to UC

Ulcerative colitis

Inflammatory bowel disease.
Rectum is always involved.
Bloody diarrhea is the most common presentation.
Double Contrast Barium Enema (DCBE) is the radiological examination of choice to show disease extent and severity
Instant enema → In UC the large bowel is inflammed and contains no fecal matter, and hence enema study can be done without bowel preparation.

Acute changes:

1. *Earliest radiological change on DCBE is blurring of mucosal lining and a fine mucosal granularity (enface) due to edema.*
2. *Colorectal narrowing and incomplete filling due to spasm and irritability*
3. *Scalloping of the edges of colon, especially the sigmoid colon*
4. *Mucosal stippling due to crypt abscesses (continuous; not transmural)*
5. *'Collar button' ulcers*
6. *Toxic megacolon*
7. *Pseudopolyps*

Chronic changes:

1. *Shortening and narrowing of colon*
2. *'Lead pipe' colon*
3. *Loss of haustrations*
4. *Backwash ileitis*
5. *Thickened rectal valve*
6. *Widening of presacral space (normally 1.5 cm at s_4 vertebral level)*
7. *Benign stricture*
8. *Carcinoma of colon/rectum*

Diverticulosis of colon

- Barium Enema study may show:
  1. "Saw-tooth" sign (crowding and thickening of haustral fold)
  2. Bubbly appearance of air containing diverticulae.
  3. *En face* view may show circular line/ring shadow/meniscus with sharp outer edge and fuzzy/blurred inner margin or a fluid-barium level or barium pool and is extramural in location with absent Bowler's hat sign as seen in polyps in oblique view.

Volvulus

- Plain x-ray
  "Coffee Bean Sign" – Distinct midline crease corresponding to mesenteric root in largely distended loop (supine)
  - Tyre tube appearance
  - Omega sign – Single, grossly dilated loop of colon arising out of pelvis or barium enema.
- On Barium enema
  - Bird Beaks sign – Tapered hook like end of barium colon
  - Ace of spades
- On CT scan
  - Whirl sign – tightly torsioned mesentery formed by twisted afferent and efferent loop

**

Sigmoid Volvulus

- Plain radiograph can clinch the diagnosis in many cases; however, in up to one-third cases it is difficult to differentiate a twisted sigmoid from a distended but non-rotated sigmoid, or from more proximal colonic distention, when Ba enema may be helpful.

The Plain radiographic features include:

1) Inverted U shaped massively distended colonic loop.
2) Ahaustral margins
3) Liver overlap sign (ahaustral margin overlapping lower border of liver shadow)
4) Left flank overlap sign (ahaustral margin overlapping haustrated, dilated descending colon)
5) Pelvic overlap sign (ahaustral margin overlapping the left side of pelvis)
6) D_{10} overlap sign (apex of volvulus lying very high in abdomen, above D_{10} level on left side)
7) **Apex under left hemidiaphragm**
8) Inferior convergence sign on left side of pelvis (inferiorly, where the two limbs of loop converge, three white tines meet, representing the two outer walls and the contiguous inner walls of twisted loop).
9) Air fluid ratio greater than 2%.
   - Left flank overlap sign, Apex above D_{10}, under the left dome of diaphragm and Inferior convergence sign are highly specific (100%) and sensitive signs for sigmoid volvulus.
   - If there is doubt about diagnosis on plain abdominal radiograph, a contrast enema (left posterior oblique view is important) should be done, features of which include **'bird of prey' sign** (at point of torsion a smooth, curved, tapering of barium column is seen like a hooked leak), 'screw pattern' of mucosal folds at the point of twist in chronic volvulus, shouldering may be seen.

Carcinoma colon:

- Four morphologic forms are known: concentric thickening (annular or tubular), cauliflower growth, ulcerative lesion and stricturous form.
- "Apple core" appearance is classical of **Ca colon** on Ba enema (annular form).
- Double Contrast Barium Enema is the radiological examination of choice to show disease extent and severity.
- Earliest radiological change in ulcerative colitis (UC) is blurring of mucosal lining and a fine granularity when mucosa is seen enface due to edema.
- Abnormal barium adherence to alter colonic mucus and flecks of barium adhere to superficial erosion.
- Instant enema → In UC the large bowel is inflammed and contains no fecal matter, and hence enema study can be done without bowel preparation.
- TRUS is more sensitive for predicting perirectal infiltration and although capable of demonstrating small perirectal nodes, however, both CT and TRUS fail to distinguish between reactive and involved nodes.
- CT gives clearer picture of pelvic sidewalls, and would be examination of choice for assessing large fixed tumors (advance rectal malignancy).
- TRUS preferred for smaller mobile lesions being considered for local resection.
- MRI and transrectal ultrasound has overtaken CT for staging as it lags behind in ability to visualize muscularis propria. It is however unclear whether MRI or TRUS enjoy any advantage over one another as both are able to demonstrate the muscularis propria.

1. 60% of carcinoma colon situated in : Sigmoid colon
2. Carcinoma is the most common cause of large bowel obstruction followed by diverticulitis
3. Sigmoid volvulus is generally seen in geriatric or mentally retarded patient with overloaded bowel contents
4. Toxic Megacolon Is Diagnosed When Colon Diameter In More Than 5.5 Cm
5. Perforation in UC usually occurs in the sigmoid colon

6. An avascular area at SMA –IMA water shed in distal transverse colon is called Griffith's point
7. Free intraperitoneal gas is rarely seen in acutely perforated appendix
8. Commonest type of intussusception is : Ileo colic
9. Backwash ileitis is seen in : Ulcerative colitis
10. 'Target sign' in intussusception consists of : Two concentric circles of fat density lying to the right of the spine.
11. 'Coiled spring appearance' on barium enema is caused due to : Intussusception
12. Diverticula are found most often inMost common site in upper GI tract is duodenum : Sigmoid colon
13. Only antimesenteric diverticulum is : Meckel's diverticulum
14. Bird of prey sign is seen in GIT radiology in : Sigmoid volvulus. (Ileo — sigmoid knot)
15. Napkin ring defect in X-ray is seen in : Annular type of Ca colon
16. 'Invertogram' and prone lateral shoot through radiograph is used to detect : Imperforate anus
17. Grape like radioluscent clusters in X-ray of colon is seen in : Pneumatosis coli
18. Pipe stem appearance of colon is seen in : Ulcerative colitis
19. Earliest Radiological change in ulcerative colitis : Fine serrated appearance of bowel wall
20. 'Apple core' appearance in Barium Enema is seen in : Carcinoma colon
21. 'Thumb printing' of colon is seen in : Ischaemic colitis
22. Haustrations are always seen in ascending and proximal transverse colon. In the distal colon they are produced by active peristalsis and may not be always seen.
23. Metaplastic polyps are seen in the rectum and have no malignant potential
24. Sessile polyps measuring > 1 cm have greater chance of malignancy than pedunculated polyps < 1 cm
25. On double contrast barium study, Mexican hat, Bowler's hat and Meniscus signs are seen in polyps
26. Hamartomatous polyps are seen in Juvenile polyposis coli, Peutz Jegher syndrome, Cowden's disease and Canada Cronkite syndrome
27. Adenomatous polyps are seen in Gardner's syndrome, Turcot's syndrome and familial polyposis coli

Imp. Barium Enema Findings

Indication	Finding
• Ca colon	Irregular filling defect, apple core deformity
• Ileocecal TB	Pulled up caecum, obtuse ileocecal angle, filling defect, incompetent ileocecal valve
• UC	Loss of haustrations, "lead pipe" appearance
• Crohn's disease	String sign of Kantor
• Colonic polyps	Smooth regular filling defect
• Hirschsprung 's disease	Narrow zone, zone of cone, dilated proximal segment

• Diverticulosis of colon	'Saw-tooth' appearance, champagne glass sign
• Ischemic colitis	Thumb-printing sign
• Intussuscepti on	Coiled spring appearance, Claw sign clinically

LIVER, SPLEEN

Simple hepatic cysts

- They may occur in younger patients with polycystic liver disease, ADPKD and (25-33%) Von Hippel Lindau disease (usually >10).
- It is usually single an echoic lesion with thin well –defined wall, with out septae or debris in it with posterior acoustic enhancement.

Cavernous hemangiomas of Liver

- On **USG** these are typically small, less than 3 cm sized, well defined, and homogenous and hyperechoic lesions. Mixed echogenicity can, however, be a feature of atypical liver hemangioma.
- Hemangiomas are characterized by very slow blood flow that won't routinely be detected by either **color or duplex doppler**. There are usually incidental findings observed on routinely performed abdominal sonograms and confirmation is costly and unnecessary. However, atypical pattern of hemangioma needs an additional imaging technique to confirm the suspicion of hemangioma.
- If the lesion is greater than 2.5 cm in diameter, a **TC-99m RBC study with SPECT** is recommended.
- If the lesion is less than 2.5 cm in diameter, **MRI** is recommended.
- Dynamic **triple-phase contrast enhanced CT scan** with **delayed sections**, although can reliably diagnose liver hemangioma and is presently the investigation of choice.

- CECT characteristically shows delayed enhancement with 'filling in' of the hemangiomas centripetally and nodular densities of dilated vascular channels in the vicinity.
- If the imaging investigation provides indeterminate results, either percutaneous **biopsy** (USG guided) or follow-up at 3 to 6 months is recommended.

Hepatocellular carcinoma

- Doppler study may distinguish tumor from thrombus as presence of arterial signals within the material occluding a portal vein indicates the presence of tumor.
- The most sensitive approach for this study is CT in HCTAP phase and biphasic examination.
- The CT features of portal venous invasion by HCC include arterioportal fistula, periportal streaks of high attenuation, dilatation of main portal vein and its branches and the 'straight line sign' i.e. complete non enhancement of the affected lobe (seen in HAP phase).
- Invasion may also be caused by secondaries in liver also.

Liver Metastasis

- CT angiography is most sensitive imaging modality.
- *Exclusion criteria for metastasectomy:*
  1. Advanced stage of primary tumor
  2. > 4 metastases
  2. Extra hepatic disease

4. < 30% normal liver tissue/ function available after resection.

1. Most common benign tumor of liver : Haemangioma

2. Reidel's lobe is : Inferior tongue like extension from lateral margin of right lobe of liver found most commonly in women.

3. The main indication for percutaneous cholangiography is : Assessment of obstructive jaundice

4. Hepatic angiography is performed by percutaneous transfemoral catheterisation of : *Coeliac axis*

5. Bull's eye lesions in USG of liver is found in : *Metastases*

6. For **PTC** the prothrombin time should not be : *3 seconds more than control*

7. Hepatic adenoma is associated with : Oral contraceptives

8. Causes of calcified metastasis to liver are :
: *Mucinous adeno carcinoma*
: *Osteogenic carcinoma*
: *Chondrosarcoma*
: *Teratocarcinoma*
: *Neuroblastoma*

9. 99m Tc labeled denatured autologous red blood cells are used to detect : *Accessory spleen & splenosis.*

10. The liver is divided into superior and inferior halves by the : *Portal veins*

11. Light bulb sign on MR is seen in hepatic hemangiomas. They show gradual centripetal enhancement on delayed scans

12. Sequestration of platelets in a hepatic hemangioma causes the : *Kasabach Merrit syndrome*

13. Turtle shell like hepatic calcification is seen in : *Schistosoma infection*

14. Angio sarcoma of liver develops after exposure to Thorothrast, Arsenic, and poly vinyl alcohol

15. Daughter cysts are seen in 50% of hepatic hydatid cysts and are pathognomic of hydatid disease

16. The uptake of T_c^{99m} labeled sulfur colloid by a hepatic lesion is s/o FNH (Focal Nodular Hyperplasia)

17. Splenunculi are detected by uptake of T_c^{99m} labeled heat damaged RBC's

18. Asplenia is associated with severe cyanotic congenital heart disease and bilateral right sidedness (Ivermaar syndrome)

19. Polysplenia is associated with azygos continuation of IVC and bilateral left sidedness. (Abernethy malformation)

20. Thorothrast exposure is associated with development of HCC, Angio sarcoma and cholangiocarcinoma

21. Fibrolamellar carcinoma of liver occurs in the younger age group, affects both sexes equally, has a better prognosis and does not cause elevated α feto protein levels

22. A central scar is seen in focal nodular hyperplasia and fibrolamellar carcinoma, the scar of the latter being calcified

23. Rigler's triad includes gall stone in small bowel, ileus, and pneumobilia

24. T_c^{99m} labeled HIDA is investigation of choice in diagnosis of : *Acute cholecystitis*

25. No biliary tree dilation may be seen in early obstructive jaundice

26. An impacted gall bladder neck calculus causing medial displacement and compression of the common hepatic duct is called Mirizzi's syndrome

27. MRCP – Magnetic resonance cholangio pancreatography & ERCP : Procedure of choice for visualization of the biliary tree

28. Focal nodular hyperplasia : Hot spot on technetium ScanBest delineated by MRI

29. USG is the first diagnostic test to use in patients whose liver tests suggest cholestasis, to look for the presence of a dilated intrahepatic or extra hepatic biliary tree or to identity gall stones.

30. USG is the first test ordered in patients suspected of having : *Budd Chiari Syndrome*

31. Ultrasound is initial test to evaluate gallstone disease & procedure of choice

32. Frequency mostly employed for Doppler studies is : *3 – 6 MHz*

33. Endoscopic Ultra sound provides most accurate pre-operative local staging of esophageal, pancreatic & rectal malignancies

GALL BLADDER & BILIARY SYSTEM

Ultrasonography

- Ultrasound (USG) is usual screening modality in the patients with obstructive jaundice. The principal role of USG is to differentiate obstructive from non-obstructive causes of cholestasis.
- It is primary modality for examining the biliary tree also because of its ease of performance in multiple planes (multiplanar scanning). It is the suitable modality in children or during pregnancy, because there is no radiation hazard. However USG is operator dependent, stomach and bowel gas usually precludes a complete ultrasound examination of pancreas, surgical dressing or wound or an abundance of subcutaneous fat also preclude ultrasound examination in general and even mesenteric fat can be a difficulty for visualizing extrahepatic causes of obstruction.
- **Gallstone ileus - Radiological signs include:**
  a) Incomplete/complete small bowel obstruction
  b) Gas in the gallbladder and in the biliary tree branching pattern with gas being more prominent centrally.
  c) Abnormal location of a gallstone
  d) Change in the position of a gallstone
  e) Relatively large fluid:gas ratio in distended loops.

Other causes of pneumobilia (gas in the biliary tree) are:

a) **P**hysiological, due to lax sphincter
b) **G**allstone fistula
c) **M**alignant fistula
d) **P**erforated peptic ulcer into bile duct
e) **C**holangitis (emphysematous)
f) **E**ndoscopic sphincterotomy or following biliary surgery
g) **T**echniques like percutaneous or endoscopic cholangiography

- One of the rare complications of cholelithiasis is Cholecystoenteric fistula, which leads to gas in biliary tree (pneumobilia).

Acute cholecystitis

- Ultrasound is widely used for diagnosing acute cholecystitis with features including thickened wall, associated gallstone, pericholecystic collection and distended GB.
- Contrast examinations like OCG have now been superseded by scintigraphy (HIDA and P-1P-1DA).
- Scintigraphy using 99m-Tc labeled derivatives of imidoacetic acid (HIDA and PIPIDA) is a simple and highly accurate method for diagnosing it and has a specificity approaching 100%. The scan is positive when

there is no visualization of GB but prompt visualization of the bile duct and duodenum occurs with a blocked duct.

Stricture in bile duct:

- Trauma (post surgery), pyogenic or parasitic cholangitis, and sclerosing cholangitis in association with inflammatory bowel disease are the most common causes of biliary strictures. **Post surgery (cholecystectomy) is the most common cause**.

- Acute cholangitis is typically found in patients with obstruction or stone disease. Gram-negative organisms, (E. coli is most common) are often responsible. The disease can become quite severe and life threatening, requiring immediate relief of the obstruction as well as antibiotic therapy.

EHBA

- Phenobarbital augmented cholescintingraphy is 90–97% sensitive, 60–94% specific and 75–90% accurate for diagnosis of EHBA. It reveals no visualization of bowel on delayed images at 6 and 24 hrs. It is impossible to differentiate it from neonatal hepatitis in absence of small bowel activity and requires liver biopsy. Liver biopsy has 60–97% accuracy.
- Percutaneous / endoscopic / intra-operative cholangiography may be helpful but not gold standard.

Caroli's disease

- It is a communicating cavernous ectasia of intrahepatic biliary ducts
- It is a rare congenital, probably autosomal recessive disorder characterized by segmental saccular intrahepatic ducts.
- Multiple cystic structures converging toward porta hepatis communicating with bile ducts are characteristic features.
- Portal radicals completely surrounded by ciliated bile ducts, called as **'central dot sign'** is diagnostic CT feature.
- However, cholangiography is most diagnostic, featured by **segmental saccular/beaded appearance of intrahepatic bile ducts** extending to periphery of liver.
- It is equivalent to type V choledochal cyst.
- It may present as part of syndrome with congenital hepatic fibrosis and autosomal recessive polycystic kidney disease.
- Cholangiocarcinoma can develop later.
- Watson Alagille syndrome is arteriohepatic dysplasia associated with abnormal facies, butterfly vertebra and pulmonic stenosis.
- Ultrasound in **Caroli's disease** (type V choledochal cyst characterized by segmental nonobstructive dilatation or ectasia of IHBRs) shows multiple low reflective cystic areas with a **central dot** of high reflection activity representing the portal vein branch surrounded by an ectatic bile duct.
- **Hepatic Iminodiacetic acid scan (HIDA scan) is a biliary scintigraphic scan.**

Tc-99m acetanilide iminodiacetic acid analogs are HIDA agents and depending on their liphophilicity, there is a trade-off between renal excretion and hepatic uptake (HIDA is least lipophilic).

1. Oral and intravenous cholecystography are unlikely in presence of : *Obstructive Jaundice*

2.	Multiple calculi in gall bladder form a sediment called	:	***'Milky Bile' / Sludge***
3.	Gall stones in USG produce	:	*High density echoes and cast acoustic shadows (structures behind them cannot be seen – shadowing effect)*
4.	Calcification in the wall of diseased gall bladder gives rise to	:	***Porcelain Gall Bladder***
5.	Cholangiocarcinoma usually presents with	:	*Obstructive jaundice*
6.	In Tc 99,m **HIDA Scan** (iminodiacetic acid)	: : 	*Gall Bladder is visualized after 10 mins* *Biliary Tract after 30 min* *Gut after 60 min*
7.	I. V. cholangiography is contraindicated when serum bilirubin level exceeds	:	*3mg%*
8.	Gall stones are accurately diagnosed by	:	*Ultrasound*
9.	Strawberry gall bladder refers to	:	Cholesterosis

10.	Meniscus sign in PTC is seen in	:	*Choledocholithiasis.*
11.	Gas bubbles in gall bladder wall is seen in CT scan in	:	*Emphysematous cholecystitis*
12.	**HIDA SCAN** is most valuable screening test for	:	*Acute Cholecystitis*
13.	Beading, pruning and skip lesions are seen on ERCP in	:	*Primary sclerosing cholangitis (P.S.C)*
14.	Choledochal cysts are classified according to	:	Todanis system
15.	Causes of gas in the biliary tree	:	• *Gallstone fistula* • *Percutaneous or endoscopic cholangiography* • Perforated gastric ulcer
16.	Gas in portal vein	:	• *Bowel infraction* • *Acute bowel infection* • *Distention of stomach* • During double contrast barium enema

PANCREAS

Acute Pancreatitis

- CECT is imaging modality of choice for diagnosis and staging (Balthazar CT Severity Index) of acute pancreatitis.

Radiological features of pancreatitis and ca pancreas

	Acute pancreatitis	Chronic pancreatitis	Pancreatic carcinoma
ERCP	• Presence of calculi		
	• Block, dilation and beading of main product	Beaded/string of pearl appearance	Double duct sign
	• Cavities		
	• Gassless abd cut off sign sentinel loop	Chain of lake app	• Scrambled egg app.
		• Rat tail stricture of CBD	• Inverted 3 sign of Frostberg or widening of C-loop of duodenum (Antral pad sign/ Rose thorn app)

SCORING SYSTEM FOR SEVERITY OF ACUTE PANCREATITIS BY CT

(CT severity Index/CTSI) is as follows:

(Balthazar grade)

	CT features	Score
I. Grade		
	Normal gland	0
	Focal / diffuse enlargement	1
	Peripancreatic inflammatory changes	2
	Single Peripancreatic fluid collection	3
	2 or more fluid collections or abscess	4
II. Necrosis		
	None	0
	< 33%	2
	33-50%	4
	> 50%	6

TOTAL CTSI (0-10)
= BALTHAZAR GRADE (0-4) + CT SCORING (0-6)

Score	Morbidity	Mortality
0-3	8%	3%
4-6	35%	6%
7-10	92%	17%

- Imaging of extrahepatic portion of biliary system is usually more successful with CT than with ultrasound because duodenal and colonic gas and mesenteric fat all contribute to the degradation of ultrasound image of CBD.
- CT plays a relatively minor role in evaluation of some conditions like biliary atresia and primary sclerosing cholangitis, in which radionuclide scan and MRCP/ERCP may be more helpful.
- In **chronic pancreatitis**, atrophy of the gland with dilatation or multifocal stenosis of main pancreatic duct and its lateral side-branches, intraductal filling defects representing protein plugs, areas of calcification and narrowing of intrapancreatic segment of the CBD are characteristic features (**"Chain of lake" appearance**).

Radiographic features of :
Carcinoma head of pancreas include:

- Hypotonic duodenogram, ultrasound (transabdominal, endoscopic and laparoscopic), CT, MRI and ERCP may, under different

circumstances, each have a role in the diagnosis of ductal adenocarcinoma (commonest type of pancreatic neoplasm).

- Carcinoma of the head of pancreas frequently causes changes in the duodenal loop (reversed '3' sign of Frostburg) as seen on the duodenogram.
- Transabdominal ultrasound is frequently the first imaging study carried out in these patients as it is inexpensive, widely available and highly accurate in differentiating obstructive from non-obstructive causes of jaundice and even very small pancreatic tumors may be detected.
- CECT is the most effective technique for the diagnosis and staging of potential theoretical advantages over CT and promising results are now emerging.
- ERCP demonstrates stricture and obstruction of pancreatic and common bile ducts and even directly visualizes duodenum and ampulla of Vater and also allows cytological sampling.

- **CT** with IV contrast (CECT) is the most sensitive and most widely used technique for diagnosis and staging of ca pancreas. Even small sized lesion, perivascular invasion, invasion of adjacent structures; lymph node involved can be assessed to greater extent.

- **ERCP** is used in many cases as it has ability to visualize directly the duodenum and ampulla of Vater and allow cytological sampling and access for stent insertion, but extra-luminal structures are not assessed and it is not sensitive for Carcinoma Pancreas.
- **Angiography** formerly flayed an important role, that too in assessment of vascular involvement but has been superseded by CT.

Periampullary carcinoma

Double duct sign is dilatation of CBD and pancreatic duct (the CBD is dilated till the terminal end and the main pancreatic duct is also dilated).

It can be seen in:

a. Ampullary tumor (Most common)
b. Other Periampullary tumors
c. Store impacted in ampulla of vertex
d. Papillary stenosis.

Ampullary carcinoma

- Malignant epithelial neoplasm arising from ampulla of Vater
- Patients presents with jaundice, abdominal pain and weight loss with typical history of passing silvery stools
- Classic imaging appearance:
  - Lobulated soft tissue mass arising from ampulla of Vater
  - "Double duct sign" with obstruction of Pancreatic and CBD
- Endoscopic biopsy directs surgical procedure (ERCP)
- Treatment: Local excision vs. Whipple operation.

1. **CT is** the best imaging study for initial evaluation of a suspected chronic pancreatic disorder and the complication of acute & chronic pancreatitis

2. 'Scrambled egg' appearance in E.R.C.P. is seen in : *Carcinoma pancreas*

3. Most widely used method for demonstration of pancreatic morphology : ***CT SCAN***

4. X-ray finding characteristic of chronic pancreatitis is : Calcification in pancreatic region

5. The method of choice for investigation of obstructive : ***ERCP***

jaundice

6. Insulinomas can be localised by : Percutaneous venous sampling of splenic vein & its branches. Selective angiography is also done

7. **ERCP** can be performed safely even if the prothrombin time is : *Prolonged*

8. 'Double duct sign' in E.R.C.P. is seen in : *Carcinoma pancreas*

9. Gasless abdomen is seen in Acute pancreatitis.

10. Fatty replacement of pancreas is seen in : *Cystic fibrosis*

11. Von Hippel Lindau disease is associated with : Pancreatic cysts, Islet cell tumors & raised erythropoietin levels

12. Acute massive bleeding in a patient with pancreatitis is due to a ruptured pseudo aneurysm

ACUTE ABDOMEN

1. Elevation of one side of Diaphragm and restricted movement is found in : *Subphrenic Abscess*

2. Volvulus of colon is most commonly seen in : *Sigmoid colon*

3. Free gas under diaphragm is best viewed by : Lateral decubitus position/ erect. Minimum amount is 1 ml.

4. A suspected patient of gas in peritoneal cavity can't stand, so erect view can't be taken then which other view is advisable : *Cross-table lateral view (Supine) or left lateral decubitus film is preferable*

5. In perforation of viscera the cardinal radiological sign is : *Gas under diaphragm*

6. Inverted "U" like appearance of sigmoid colon is found in : *Volvulus*

7. "Coffee bean" sign : *Intestinal obstruction with strangulation.*

8. For minimal ascites investigation of choice : *CT scan*

9. Increased Tc ^{99m} pertechnate uptake is seen in Meckel's diverticulitis, Barrett's esophagus and reflux esophagitis

Causes of pseudopneumoperitoneum :

- Chiladiti syndrome (entrapment of colonic segment between liver & diaphragm)
- Subdiaphragmatic fat

- Curvilinear pulmonary collapse
- Uneven diaphragm
- Distended viscus
- Omental fat
- Subphrenic abscess
- Subpulmonary pneumothorax
- Intramural gas in pneumatosis intestinalis
- Apposition of gas-distended loops mimicking the double wall sign

Signs of gallstone ileus :

Gas within the bile ducts &/or the gall bladder.
Complete/incomplete small bowel obstruction:
Abnormal location of gallstone
Change in position of gallstone

Signs of Acute Cholecystitis :

- Gallstones seen in 20%
- Duodenal ileus
- Ileus of hepatic flexure of colon
- Right hypochondriac mass due to enlarged gallstones
- Gas within the biliary system

Signs of Acute appendicitis :

- Appendicolith (0.5 -1 cm)
- Sentinel loop – dilated atonic ileum containing a fluid level
- Dilated caecum
- Widening of the preperitoneal fat line
- Blurring of the preperitoneal fat line
- Right lower quadrant haze due to fluid & oedema
- Scoliosis concave to the right
- Right lower quadrant mass indenting the caecum
- Blurring of the right psoas outline-unreliable
- Gas in the appendix – rare, unreliable

1. Ectopic ACTH is produced by : *Thymic carcinoid*
Small cell carcinoma of lung
Pheochromocytoma
Medullary carcinoma of thyroid

2. Pituitary adenomas less than 10 mm are microadenomas, those greater than 10 mm are macroadenomas

3. Craniopharyngioma is called 90% tumor : *90% are calcified*
90% are cystic
90% show enhancement

4. Almost all thyroid cancers are cold on I^{123} scanning

5. A rapidly growing cold nodule in Hashimoto's thyroiditis is s/o lymphoma

6. The most common cause of hyperparathyroidism is a solitary adenoma

7. Hyperparathyroidism produces osseous, renal, pancreatic gastric, intestinal and psychiatric complaints

8. Thymic enlargement is known to occur in thyrotoxicosis

9. 15% of patients with Myasthenia have a thymoma while 30 – 35% of patients with thymoma have Myasthenia

10. The gastrinoma triangle is bounded by CBD – cystic duct union, D2 – D3 junction and junction between neck and body of pancreas

11. The most common site of extra adrenal paraganglionoma is organ of Zukerkandl

12. Pheochromocytoma is the 10% tumor (bilateral, familial, calcified, malignant, extra adrenal and in children)

13. A fatty adrenal mass is s/o myelolipoma

14. Familial association of pheochromocytomas is seen in : *Neurofibromatosis*
Turner's syndrome
Von Hippel Lindau
MEN II

15. PCOD have multiple small cysts arranged at the periphery of a (N) sized/ enlarged ovary called necklace or string of beads appearance

16. Varicoceles are left sided in 90% cases, bilateral in 10% cases and rarely unilateral on the right

(E) CARDIOVASCULAR SYSTEM

IMAGING TECHNIQUES

1. Seldinger technique is : *Percutaneous Arterial catheterisation*

2. In **2 DE(Two dimensional echocardiography)** the ultrasound beam oscillate through an arc of : *80 deg*

3. Perfusion scanning of myocardium mostly uses : *Thallium 201*

4. Right heart catheterisation is done through a vein in arm or groin where as left heart catheterization is done through : *Femoral artery*

5. Infarct scanning of myocardium mostly uses : *Tc (99m) pyrophosphate*

6. The gold standard for assessment of myocardial viability : *FDG – PET*

7. Intra cardiac anatomy in most neonates and children with congenital heart lesions can be known from : *2 DE*

8. Characterization of pericardial pathologies is best done by : *MRI*

9. Ventricular wall motion studies can be performed by : *MRI*
using : *Echocardiography*

10. T^{99m} macroaggregates of albumin (MAA) is used to detect R –L shunts

11. The gold standard for diagnosis of mitral stenosis : *2 D echocardiography*

12. Valvular regurgitation is diagnosed by : *Doppler echocardiography*

13. The velocity of the myocar-dium can be measured by : *Tissue Doppler echocardiography*

14. Valuable investigation in complex congenital heart diseases : *MRI*

15.	Examination of choice to show mass invading pericardium or heart	:	*MRI*
16.	Very sensitive methods for detection of coronary artery calcification	:	*CT*
17.	Detection of CAD by CT has	:	*High sensitivity, low specificity*
18.	**Duplex Ultrasound** is widely used to screen patients with suspected	:	*Internal carotid stenosis*
19.	Most accurate method for assessing abdominal nodes	:	*CT Scan*

CHAMBER ENLARGEMENT & PULMONARY CHANGES :

1.	Cardiothoracic ratio	:	In adult - *50%* *In neonate - 60%*
2.	Sign of selective left atrial enlargement causes	:	*Elevated left main bronchus*
		:	*Splaying of carina*
		:	*Double atrial shadow*
		:	*Displaced descending aorta to left. (Bed ford's sign)*
3.	Left atrial enlargement with left atrial appendage enlargement is diagnostic of	:	*Rheumatic mitral valve disease.*
4.	**Kerley - B lines** represent	:	*Thickened interlobular septa*
5.	In pulmonary venous hypertension the upper lobar veins appear prominent due to	:	*Diversion of blood from lower to upper zones*
6.	**"Bats wing shadows"**	:	*Occurs due to alveolar pulmonary oedema with blurring and haziness of central lung fields*
7.	Most characteristic of pulmonary oedema are	:	*Septal lines at C-P angle (Kerley's lines)*

CONGENITAL HEART DISEASE

Increased pulmonary perfusion (Plethora)	Decreased pulmonary perfusion (Oligemia)
ASD (Primum and secundum defect)	Tricuspid atresia/stenosis
Anomalous pulmonary venous connection	Ebstein's anomaly
Membranous/ bulbar VSD	Pulmonary infundibular/ valvular stenosis
PDA	Tetralogy of Fallot (TOF)
Sinus venous defect	Pulmonary artery atresia
Gerbode defect	Peripheral pulmonary artery stenosis
DORV	Persistent truncus (type IV)

Single ventricle	Uncorrected transposition with PVS
Aortopulmonary window	Eisenmenger reaction (lung periphery only
Persistent truncus arteriosus	
Coronary artery to right heart fistula	
TGA with ASD or VSD	
Endocardial cushion defect	

ASD	Hilar dance on fluoroscopy
VSD	Shunt vascularity
TOF	Heart size normal but marked RVH 'Coeur en Sabot' or boot-shaped heart Marked pulmonary oligemia
TGA	'Egg on side' appearance on CXR
Co-arctation of Aorta	LVH Notching of ribs inf. Surface (4^{th} - 8^{th}) usually B/L but U/L may be seen in presubclavian type Inverted 3 sign on Ba-studies
MS	LAH, straightening of left heart border 'Antler' or 'Moustache sign' Double atrial shadow on X-ray
TAPVC Non obstructive type Obstructive type	 Cardiomegaly with plethoric lung fields "Snowman or figure of 8" appearance on X-ray Normal sized heart and Ground glass appearance of lung fields due to severe pulmonary HTN
Pericardial effusion	'Leather bottle' appearance of heart

CXR features ASD

The **three types of ASD** include ostium secundum or fossa ovalis defect, sinus venosus defect, and endocardial

cushion defects (ECD).

- If the left to right shunt (ASD) produces a shunt ratio greater than 2:1, the heart is obviously enlarged, involving RA and RV.
- There is **no enlargement of the LA**, except in few cases of ECD or Lutembacher syndrome.
- The heart in ASD is sometimes displaced to left.
- The ascending aorta and its arch tend to appear smaller than normal, probably due to the rotation of ascending aorta by enlarged RA and RV, causing saggital alignment of the aortic arch (**Small aortic knuckle**).
- The central pulmonary arteries are enlarged and there is a variable degree of pulmonary plethora, depending on the size of shunt.
- Septal lines (Kerley B lines) in a patient of ASD should always suggest an associated mitral valve abnormality (ECD or **Lutembacher syndrome**).
- The "**great hilar dance**" sign characterizes ASD on fluoroscopy.
- The **"Goose-neck" deformity** is seen in ASD on cardioangiography.

CXR features of VSD

Ventricular septal defect; VSD (muscular type → maladie de Roger)

- CXR in smaller VSDs can range from normal to mild or moderate cardiac enlargement with mild or moderate plethora.
- CXR in large VSDs show moderate cardiac enlargement with prominence of the main pulmonary artery, the hilar pulmonary arteries, and the peripheral pulmonary arteries.
- CXR in VSD with pulmonary arterial hypertension may be characterized by normal size and shape of cardiac silhouette and unremarkable central pulmonary arteries.

Tetralogy of Fallot (TOF)

- At birth, heart shape is usually nonspecific but it may later become specific in about 25% patients with the classic **'Coeur-en-sabot'/'Boot-shaped' silhouette**.
- The classic 'boot-shaped' heart is due to combination of a deeply concave pulmonary bay and elevation from diaphragm of a slightly angular cardiac apex.
- The peripheral vasculature will show oligemia proportionate to the degree of cyanosis.
- A 'pink Fallot' will show plethora but the pulmonary bay will remain hollow.
- Ascending aorta is always enlarged and is typically prominent on plain X-ray.
- In 25% cases the aortic arch is on right and the descending aorta crosses to left of spine in lower thorax.
- The right ventricle most commonly becomes enlarged as a result of left ventricular enlargement.
- Pentalogy of Fallot consists of Tetralogy of Fallot with ASD.

Total anomalous pulmonary venous connection /Drainage

TAPVC/TAPVD is anomalous connection between pulmonary veins and systemic veins secondary to embryologic failure of common pulmonary vein to join the posterior wall of left atrium.

Anatomical classification

1. Supracardiac
2. Cardiac
3. Infracardiac
4. Mixed

Classification based on obstruction

1. Obstructive: In obstructive TAPVC: Normal sized heart with pulmonary hyperemia (ground glass lungs)
2. Non –obstructive (commoner)

Total anomalous pulmonary venous connection (TAPVC)

1. Subdiaphragmatic (Type III, 12%)—drainage into portal vein / IVC / ductus venosus/left gastric vein
2. Supradiaphragmatic
   i) Supracardiac (Type I, 52%)—drainage into left brachiocephalic / azygous / SVC
   ii) Cardiac (Type-II, 12%)—drainage into coronary sinus/RA
3. Mixed radiographic features of TAPVC (esp. the supradiaphragmatic variety) include:
   - Overall heart size notably normal.
   - Dilated SVC and left vertical vein giving **"Figure-of-8 or snowman" configuration** of cardiac silhouette
   - Pretracheal density on lateral film.
   - Increased pulmonary blood flow.

1. The most common cause of cyanosis at or shortly after birth : *Uncorrected TGA*

2. **Indomethacin** causes closure of ductus arteriosus, **Prostaglandin E** checks this closure

3. A right sided aortic arch is seen in Truncus arteriosus (40%), Tetralogy of Fallot (30%) and tricuspid Atresia (10%)

4. Egg on side appearance is caused by uncorrected TGA

5. Tricuspid atresia is associated with a small right ventricle, concave pulmonary bay, enlarged left atrium and VSD

6. Tetralogy of Fallot causes cyanosis by age of 4 years while cyanosis at birth is due to TGA or tricuspid atresia

7. The association of oesophageal notching in TOF indicates severe pulmonary atresia; this is due to enlarged bronchial collaterals

8. Commonest finding in coarctation of aorta : *Abnormal aortic arch*

PERICARDIUM

PERICARDIAL EFFUSION

- **CXR** shows an abrupt increase in the dimension of the cardiac silhouette without specific chamber enlargement and distinct heart borders suggest the diagnosis of pericardial effusion. Filling of retrosternal space, effacement of the normal cardiac borders, development of a **'flask' or 'water bottle'** cardiac configuration and bilateral hilar overlay are the characteristic features. The **epicardial fat pad sign** is positive, when visualized in lateral view; on anterior pericardial stripe is thicker than 2 mm. This sign is diagnostic of pericardial thickening or fluid.
  - **Echocardiography** is most commonly used method for diagnosing pericardial effusions. Pericardial effusion appears as a sonolucent layer in front of heart.
  - It may be unreliable in postoperative patients.
  - Intrapericardial clot gives false negative results while epicardial fat simulates pericardial fluid.
  - It is difficult in obese and emphysematous patients.

- **CT/MRI: Diagnosis of pericardial effusion can be confirmed by CT or MRI** and these techniques are superior to ECHO in detecting loculated pericardial effusions and pericardial thickening.

1.	The most common primary pericardial malignancy	:	*Malignant mesothelioma*
2.	Pericardial calcification in constrictive pericarditis is best seen in	:	*Lateral view*
3.	Epicardial fat sign is found in	:	*Pericardial effusion*
4.	Flask shaped cardiac configuration with pulmonary oligaemia is suggestive of	:	*Pericardial effusion*
5.	Pericardial calcification in constrictive pericarditis	:	*Atrioventricular groove and interventricular groove*

Causes of Calcification in heart

(1)	Pericardium	-	Infective, Traumatic
(2)	Myocardium	-	Aneurysm, Infarct Thrombus
(3)	Endocardium	-	Endomyocardial fibrosis
(4)	Coronary artery	-	Atheroma Aneurysm
(5)	Valve cusp	-	Any valvular heart disease homografts.
(6)	Valvulus annulus		
(7)	Tumour	-	Myxoma
(8)	Left atrium	-	Wall, clot
(9)	Aorta	-	Wall, thrombus
(10)	Pulmonary artery	-	Wall, thrombus

DISEASES

1.	Fibromuscular hyperplasia of renal arteries lead to	:	*Irregular beading and stenoses of the arterial wall*
2.	**Intra-Arterial Chemotherapy** is useful for treatment of	:	*Liver metastases* *Large malignant tumors.*
3.	Percutaneous embolisation is most helpful in	:	*Vascular Juvenile Angiofibroma*
4.	Bilateral claudication occurs in “Leriche’s Syndrome”	:	*Thrombosis of abdominal aorta near*

due to *bifurcation*

5. Embolism occurs most commonly in patients with : *Atrial fibrillation*

6. The most common site of Coarctation of aorta : *Aortic isthmus*

7. **Gruntzig balloon catheter** is useful for dilatation of : *Arterial stenosis*

8. Common causes of A-V fistula are : *Congenital, Trauma esp. iatrogenic trauma*

ANEURYSMS

1. Aortic aneurysm are at increased risk of rupture : *> 6 cm diameter*

2. Syphilitic aneurysms most commonly occur in : *Ascending aorta*

3. Most common cause of aneurysm of vessels is : Degenerative (due to atheroma)

4. Common sites of aneurysm are : Abdominal aorta and Popliteal artery

5. Williams syndrome consists of : *Supravalvular aortic stenosis*
: *Abnormal facies*
: *Mental retardation*
:

6. Aortic aneurysm can be : *1) Fusiform*
2) Saccular

7. Appropriate tests include a chest computed tomography with control or MRI scan in patients who are hemodynamically stable, transesophageal echocardiography in patients who are less stable. Aortic angiography is no longer a first test at most institution

ACQUIRED HEART DISEASE

1. Plain radiograph changes of severe mitral valve stenosis : *Upper lobe diversion*
: *Kerley A & B lines*
: *Pulmonary edema (Bat's wings appearance)*
: *Pulmonary hemosiderosis*
: *Pulmonary ossific nodules*
: *Pulmonary arterial hypertension*

2. Severe aortic stenosis, valve areas : *< 1 cm^2*

3. Lutembacher's syndrome consists of : *Congenital ASD*
Acquired mitral valve disease

Pulmonary Edema (CARDIOGENIC)

Stage – I	Stage – II	Stage – III
↑ in Pulm. Venous pressure (PVP 10-20 mmHg)	Septal interstitial edema	PVP > 25 MMHg pulm edema & B/L rales, rhonchi ↓

↓ Resistance of small airways ↑ es and lungs become less Complaint (Dyspnea)	↓ Kerley's B lines appear d/to dilatation of lymphatics (Tachypnea)	- CXR showing Bat's wing appearance/grou nd glass appearance - Blood tinged sputum

CAUSES OF INFERIOR RIB NOTCHING

Unilateral	Blalock-Taussing operation Subclavian artery occlusion Aortic coarctation involving left subclavian artery or anomalous right subclavian artery	
Bilateral	Aorta	Coarctation, occlusion, aortitis
	Subclavian	Takayasu's disease, atheroma
	Pulmonary oligemia	Fallot's tetralogy Pulmonary atresia, stenosis Truncus Type IV
	Venous	SVC, IVC obstruction
	Shunts	Intercostal-pulmonary fistula Pulmonary/intercostal arteriovenous fistula
	Others	Hyperparathyroidism Neurogenic Idiopathic

COARCTATION OF THE AORTA

- Rib notching (bilateral but asymmetric, and best seen on inferior aspects of posterior thirds of the upper ribs, **sparing 1st two**) usually takes several years to develop, and is caused by pressure erosion of adjacent ribs by enlarged tortuous intercostal arteries. So, rib notching is rare in young children, even in severe coarctation.
- In Coarctation of Aorta, small inferior notching occurs mainly in the mid-third of posterior rib, and the *first two ribs are spared* since the first and second posterior intercostals arteries arise from the costocervical trunk of the subclavian artery.
- In Neurofibromatosis type I in which the inferior notch is often wide, can be anywhere, and may be associated with soft tissue opacity.

DISSECTION OF AORTA

- Spontaneous longitudinal separation of aortic intima and adventitia by circulating blood having gained access to the media of aortic wall splitting it into two.

- Transverse tear in weakened intima (95–97%) is most common pathology.
- Peak age is 60 yrs with M:F = 3:1

Types:
Clinical Classification
1) Acute < 2 weeks old
2) Chronic > 2 weeks old

Stanford classification
Type A(60–70%) = ascending aorta +/- first 4 cm of arch
Type B(30–40%)= Descending aorta only
Debakey's classification
Type I (29–34%) = ascending aorta + portion distal to arch
Type II (12–21%) = ascending aorta only
Type III (50%) = descending aorta only
Subtype A = up to diaphragm
Subtype B = below diaphragm
Location:
Most commonly (65%) on anterior and right lateral wall of ascending aorta just distal to aortic valve.

Radiological investigations

Chest radiograph:
- Normal in 25% cases.
- Calcification sign: Inward displacement of atherosclerotic plaque by > 4–10 mm from entire aortic contour.
- Disparity in size of ascending and descending aorta.
- Irregular wavy contour of aorta.
- Widening of superior mediastinum.
- Cardiac enlargement (LV hypertrophy/hemopericardium)
- Left-sided pleural effusion (25%)
- Atelectasis of lower lobe.
- Rightward displacement of trachea and/or endotracheal tube.

2-D ECHO:
59–85% sensitive and 63–96 % specific **for type A**.
Transesophageal echocardiography (TEE) :
Up to 99% sensitive and 77–97% specific.

Angiography:

It is 88% sensitive and 75–94% specific.
- Aortography is **first choice for final confirmation**. It is superior to any other technique in demonstrating entry and reentry points, branch vessel involvement and coronary artery involvement and aortic insufficiency.
- Visualization of intimal flap, **'double barrel' aorta**, abnormal catheter position, and compression of the lumen by false channel are the features.
- But most important disadvantage is that it is invasive procedure and should be avoided in presence of infective cause.

CECT:
87–94% sensitive and 87–100% specific.

MRI (most sensitive and specific investigation): 95–100 (98.3) % sensitive and 90–100 (97.8) % specific.

- *In ideal situation where all the imaging techniques are readily available, initial assessment with CXR and 2D ECHO should be followed by MRI as MRI gives most confidant diagnosis and also give images best understood by the surgeons.If the patient is unstable, TEE should be done instead of MRI.*

Dissecting hematomas are often *subdivided as done by DeBakey*, both as to the site of the primary laceration and as to the extent of the false passage.

Type I. The primary laceration is in the ascending aorta, and the false passage within the media extends along the full length of the aorta.

Type II. The primary laceration is in the ascending aorta, and the false passage extends to about the level of the aortic arch.

Type III. The primary laceration is at the junction of the arch and descending aorta, and the false passage extends distally to the terminal part of the aorta.

CXR:

- Normal CXR in 25% cases
- **Calcification sign** (Inward displacement of calcification plaque by >4-10 mm from outer aortic contour) or the calcification in the aortic knuckle, which is separated from the outer margin by more than 1 cm, is said to be suggestive of dissection.
- **'Apical cap' sign** (The mediastinal hematoma may dissect over the lung apices (left more often than right) to produce the apical cap sign in the supine position or to produce widening of the paraspinal line to the right or to the left.)**.**
- Localized dilation of aortic knuckle and upper descending aorta, which may give rise to prominent **'Lump' sign.**
- Disparity in size between ascending and descending aorta.
- Irregular wavy contour/ indistinct outline of aorta.
- Lateral projection of aortic knuckle.
- Widening of superior mediastinum.
- Left sided pleural effusion.
- Rightward displacement of trachea.

Aortic Trauma

- Commonest site – Isthmus (80-90%)
  The most common location of traumatic aortic rupture surviving to diagnosis is the aortic isthmus (80% to 90%). In this region, the relatively fixed position of the aorta due to tethering by the ligamentum arteriosum combines with forces of rapid deceleration to create a point of shearing stress. In addition, compression of the sternum by frontal impact results in impingement on the isthmic region between the sternum and the spine, a phenomenon known as the "osseous pinch.
- 38 Spiral CT is the most sensitive means of detecting mediastinal hemorrhage, which is a nonspecific finding seen in both TAI and minor venous injury.

ICA IMAGING

- Intra-arterial carotid angiography can be performed via a catheter placed in the aortic arch or by selective catheterization of common carotid artery.
- Irregularity due to atheroma must be differentiated from spasm (due to the presence of a catheter), fibromuscular dysplasia (extensive, regular, concentric corrugations of the artery producing **"beaded or pile**

of plates" appearance, frequently bilateral and rarely extending above skull base), and from spontaneous or iatrogenic dissection (extensive narrowing, with some irregularity and slow flow, often extending up to the level of ophthalmic artery).

SCREENING PROXIMAL INTERNAL CAROTID ARTERY

Post-traumatic pseudoaneurysms can usually be differentiated from a true carotid aneurysm by locating the characteristic to-and-fro pulsed Doppler waveforms in the neck of the pseudoaneurysm and identifying the internal variability of colour flow **(*"yin yang"*)** that is typically seen in any pseudoaneurysm.

MRA: There have been number of trials comparing MRA with angiography and Doppler ultrasound. MRA is a flow-sensitive technique and areas of turbulent or slow flow may remain undetected, artificial loss of flow signal is frequent and creates a flow gap.

CTA: CT angiography can be used and has advantage of showing calcification, but uses ionizing radiation and iodinated contrast, with risk of contrast reaction more than MR contrast.

DSA: It is common practice to use intraarterial angiography for confirmation of suspected high grade stenosis and it has many advantages.

A 'four-vessel' angiogram: is performed by injection of contrast in to both ICA (CCA if there is atheromatous disease at carotid bifurcation) and at least in to one vertebral artery, but if reflux of contrast fails to display contralateral PICA, the contralateral vertebral artery is also catheterized.

Role of imaging:

1) Bi-directional Doppler study: The role of duplex scanning in diagnosis of TOS is not established; however, it can detect rare cases of vascular TOS by revealing stenosis or aneurysmal or thrombotic changes. It is a sensitive test for detecting compression of subclavian or axillary vessels with provocative positioning like:

a) **Adson maneuver** (for Scalenus anticus muscle): Hold deep inspiration while neck is fully extended, fully abduct the arm with the head turned towards opposite side.
b) **Hyperabduction maneuver** (compression by humeral head or pectoralis minor muscle): Extremity/radial pulse monitored through range of 180^{o} abduction, complete cessation of flow in one position noted.
c) **Costoclavicular maneuver** (compression between clavicle and 1st rib): **Exaggerated military position** with shoulders drawn back and downward.

2) Photoplethysmography
3) Angiography: May appear normal or equivocal with the arm in returns position, and Adson maneuver may be necessary to confirm the lesion. Findings one should look for are abnormal course of distal subclavian artery, focal stenosis/occlusion, aneurysm, poststenotic dilation of distal subclavian artery, mural thrombus + distal embolization and venous thrombosis or obstruction.
4) DAS or MRA can investigate the case in a certain manner and less invasively.

NEONATAL CYANOSIS

With oligemia + Cardiomegaly	**With oligemia but no cardiomegaly**	**With pleonemia (plethora)**
(All have an ASD) • PS • Pulm atresia • Ebstein anomaly • Tricuspid atresia • Hypercyanotic spells & polycythemia may develop • T/t palliative shunt surgery	(Sign appear usually after 1wk) • TOF • Pulm atresia with VSD* • Tricuspid atresia	Cyanosis + CCF • TAPVC • Hypoplastic LV • Interrupted aortic arch • TGA • Truncus arteriosus • Treat CCF & Rashkind atrial septostomy is done in these patients as an emergency measure to decompress LA

(C) MUSCULOSKELETAL DISORDER

(a) BONES – CONGENITAL ANOMALIES, INFECTIONS, TUMORS

DIAGNOSTIC IMAGING TECHNIQUES FOR MUSCULOSKELETAL DISORDER

Method	Imaging Time, h	Cost[a]	Current Indications
Ultrasound[b]	<1	+	Synovial cysts Rotator cuff tears Tendon injury
Radionuclide scintigraphy			
^{99m}Tc	1-4	++	Metastatic bone survey Evaluation of Paget's disease Quantitative joint assessment Acute infection Acute and chronic osteomyelitis
^{111}In-WBC	24	+++	Acute infection Prosthetic infection Acute osteomyelitis
^{67}Ga	24-48	++++	Acute and chronic infection Acute osteomyelitis
Computed tomography	<1	+++	Herniated intervertebral disk Sacroiliitis Spinal stenosis Spinal trauma Osteoid osteoma Tarsal coalition
Magnetic resonance imaging	1/2-2	+++++	Avascular necrosis Osteomyelitis Intraarticular derangement and soft tissue injury derangements of axial skeleton and spinal cord Herniated intervertebral disk Pigmented villonodular synovitis Inflammatory and metabolic muscle pathology

[a] Relative cost for imaging study.

[b] Results depend on operator.

CONGENITAL ANOMALIES

Osteopetrosis/Albers Schonberg disease/Marble done disease

- Thick sclerotic bones that are structurally weak and brittle characterize it.

- Splayed metaphyses and costochondral junctions and fracture even from minor trauma characterize infantile autosomal recessive type.
- Adult autosomal dominant type (benign), phenotype I is characterized by diffuse osteosclerosis with cortical thickening and sparing (relatively) of mandible.
- While phenotype II is characterized by
  - Endobones ("bone within bone" appearance)
  - Sandwich vertebrae/Rugger-Jersey spine
  - Metaphyseal lines
  - Longitudinal metaphyseal striations
  - Erlenmeyer flask deformity (club-like long bones)

Osteogenesis imperfecta (OGI)

- It occurs due to defect/mutation in genes responsible for **type I collagen**.
- It is relatively rare disorder manifested by increased fragility of bones and osteoporosis, dental abnormalities, wormian bones, and lax joints.
- In **Osteogenesis imperfecta congenita** osteoporosis occurs with short, broad and weak long bones, while in **Osteogenesis imperfecta tarda**, which is a benign form, the bones are bowed, thin and gracile.
- There are **four types of OGI** with type I being the most common and mildest form with normal stature and dentigenosis imperfecta in Ib form.
- Type II is the most lethal form.
- All the 4 forms have autosomal dominant inheritance except type III, which may have AD/AR inheritance.
- In 10%, fractures are seen at birth and in 10% fractures never occur.
- Most fractures occur in young children and are often diaphyseal rather than metaphyseal as in battered baby syndrome in which multiple fractures of long bones, often in various stages of repair may occur.
- Fractures are usually transverse and heal with normal callus.

- **Radiological features:**
  - Generalized osteoporosis
  - Bilateral diaphyseal long bone fractures
  - Exuberant callus formation
  - Wormian bones
  - Platybasia
  - Basilar invagination
  - Tam O'Shanter skull (typical skull shape due to platybasia)
  - Kyphoscoliosis
  - 'Codfish' vertebrae
  - Calcific 'pop-corn' like lesions in metaphysis
  - Severe Protrusio acetabuli

Battered baby syndrome

- Multiple asymmetrical fractures
- Fractures in different stages of healing
- Periosteal reaction in the bones of distal forearms or legs
- Epiphyseal separation
- Metaphyseal infarction
- Injuries to skull and ribs
- Multiple growth recovery lines

Caffey (1946) described a syndrome of Subdural hemorrhage, associated with multiple fractures of long bones,

and often in various stages of repair is now known as battered infant.

Radiographic findings:
1. Fracture in different stages of healing.
2. Periosteal reaction (particularly in bones of distal forearm or leg)
3. Multiple growth recovery lines.
4. Injury to skull and ribs.
5. Fractures at unusual sites.
6. Epiphyseal separators and metaphyseal infarctions.

Melorheostosis

It is a nongenetic disease characterized by asymmetrical dense irregular cortical longitudinal hyperostosis of particularly the long bones giving appearance like wax running down the side of a candle **('flowing candle wax' appearance)**, vascular anomalies, abnormal pigmentation and muscle contracture and wasting.

Multiple epiphyseal dysplasia

- Autosomal dominant
- Delayed ossification of epiphyses of the tubular bones
- Delayed ossification of carpus and tarsus
- Short tubular bones of hand and feet and shortening of limbs
- Epiphyseal irregularities
- Only mild irregularity of vertebral endplates
- Mild wedging of vertebral bodies
- Mild acetabular hypoplasia
- Early joint degenerative changes

Achondroplasia

It is prototype of rhizomelic (disproportionate) dwarfism with autosomal dominant /sporadic (80%) occurrence, caused by defective endochondral bone formation, related to advanced paternal age. Epiphyseal maturation or ossification is unaffected.

Chevron sign is V-shaped deformity of the metaphyses at the wrist due to overtibulation deformity. In Achondroplasia the tubular bones are short and wide with the epiphysis deformed by their insertion into V-shaped defects at the metaphyses. The epiphysis thus themselves have V-shaped distal ends with deep intercondylar notches – the 'chevron' sign.

It is also a feature of mucopolysaccharidosis.

Hands, feet and limbs
- Rhizomelia (Humeri and femora predominantly affected)
- Trident hands (fingers of equal length and diverge from one another in two pairs) with short stubby fingers
- Chevron sign (V-shaped notch in the growth plates)

Skull and face
- Depressed nasal bridge with prominent forehead
- Disproportionately large skull

Pelvis
- Small Square shaped iliac bone with 'tombstone' appearance
- Small pelvis with narrow pelvic inlet resembling a 'champagne glass'

Skull

- Skull changes are mandatory for diagnosis of achondroplasia
- Bullet-nose vertebrae
- Posterior scalloping of vertebrae
- Small funnel shaped foramen magnum

Chest

- Short ribs with wide anterior ends.

1. Features associated with Menke's Kiny hair syndrome : *Wormian bones*
Corkscrew vessels
Fragile hair, mental retardation

2. Marble bone appearance is characteristic of : Osteopetrosis (Albers-Schonberg's disease)

3. The joint where congenital dislocation is commonly seen is : *HIP joint*

4. Congenital dislocation of hip is common with :
Breech presentation
First born child
Caesarian section
Excessive foetal moulding
Other congenital anomalies

5. Normal acetabular angle is : *$40\text{-}45^0$*

6. Metacarpal index is used for diagnosing : *Marfan's syndrome*

7. Metacarpal sign is used for diagnosing : *Turner's syndrome*

8. Epiphyses at both ends of metacarpals and metatarsals are found in : *Down's Syndrome*

9. **Perthes disease** (Osteochondritis of Femoral Head) starts in children of age : *5-10 years*

10. Bullet shaped first lumbar vertebra is seen in : *Achondroplasia.*

11. Arachanodactyly (Elongated, slender, tubular bone of hand and feet) are found in :
(1) *Marfan's syndrome (n*
(2) Homocystinuria (osteop

12. The commonest type of Osteogenesis imperfecta : *Type I (80%)*

13. Cricket bat shaped ribs are seen in : *Morquio disease*

14. Hurler's syndrome / Gargoylism/ mucopolysacchroidosis type I is caused due to : *Deficiency for α - L- I – iduronidase enzyme*

15. Eleven pairs of ribs are found in : *Down's syndrome*

16. Commonest fatal neonatal dysplasia is : *Thanatophoric Dwarfism*

17. 5 D's seen in neuropathic joint :
Debris
Dislocation
Destruction
Disorganization
Lack of Deossification

18. Avulsion fractures seen commonly are
Sartorius – Anterior superior Iliac spine
Hamstrings – Ischial tuberosity
Adductor's – Inferior ischial ramus
Iliopsoas – Lesser trochanter

19. Disruption of the sacroiliac joints and pubic symphysis is called an open book fracture

20. Vertical shear forces of the pelvis cause disruption of ipsilateral sacroiliac and contralateral pelvic ramus, this is called the Malgaigne's complex
21. Hill Sach lesion are seen on the posterior superior aspect of the humeral head
22. The "trough sign" is a vertical sclerotic density parallel to the medial cortex of the femoral head after posterior dislocation
23. Proximal humeral fractures are classified according to neer
24. The posterior fat pad sign is more s/o a humeral fracture than an anterior fat pad sign
25. Injuries pathognomonic of child abuse are :
- *Metaphyseal fracture (bucket handle)*
- *Posterior rib fractures*
- 'S' fracture, scapular, spinous process

26. Most common site of a hemophiliac pseudo tumor is the pelvis (Iliopsoas muscles
27. Telephone receiver femoral shafts are seen in Thanatophoric dwarfism
28. Polydactyly is seen in Ellis van Crevald syndrome
29. Vertebra plana and floating teeth are seen in Eosinophilic granuloma
30. Findings favoring myeloma over metastasis include loss of disc space, mandibular lesions, (N) alkaline phosphatase levels, pedicles being normal and presence of associated soft tissue mass
31. Ivory vertebra is caused by lymphoma, infection, metastasis, Pagets disease and haemangioma
32. Stippled epiphyses are seen in chondrodysplasia punctata, hypothyroidism, avascular necrosis and Multiple epiphyseal dysplasia's
33. Erlenmeyer flask deformity is seen in Gaucher's and Nieman Picks disease, osteo petrosis and Thalassemia
34. Marble bone disease is osteopetrosis
35. Candle wax appearance is seen in Melorrhosteosis

RADIAL DEFECTS

1. Ectodermal dysplasia
2. Holt-Oram syndrome
3. Fanconi syndrome
4. Thrombocytopenia - absent radius syndrome
5. Trisomy 18
6. Thalidomide embryopathy
7. Renal ear and esophageal anomalies

Imp. Findings in X-ray Hand

Disease	Findings	Other/f
• Hypopara-thyroidism	Subperiosteal erosion + Tufting of phalanges	Brown's tumour salt & peper skull
• Pseudo-hypopara-thyroidism	Markedly short 4th metacarpal	
• Acromegaly	Arrow head distal phalanx	↑ heel pad thickness
• Psoriatic arthropathy	Tufting of distal phalanx, sausage shaped digits, Gull's Wing app.	

1. Causes of reduced bony density in a child include osteogenesis imperfecta, Gaucher's disease, Idiopathic Juvenile osteoporosis
2. A spiral fracture of distal tibia is called : *Toddlers fracture*
3. Carpal sign, metacarpal sign and phalangeal preponderance are used for diagnosis of Turner's syndrome
4. Iliac index, Iliac angle and acetabular angle are used for diagnosis of Down's syndrome
5. Sesamoid index and heel pad thickness are used for diagnosis of acromegaly
6. Erosion of the radial aspect of middle phalanges is seen in hyperparathyroidism

7. The following sign's are seen in scurvy : *Wimberger's sign*
Pelkan spur
White line of Frankel
Trummerfield zones
Coroner sign

RADIOLOGICAL FEATURES OF PERTHE'S DISEASE

1. Lateral displacement of the femoral head	Early on, and in the irritable hip syndrome, displacement of the femoral head (Waldenström's sign) is seen. Possibly due to effusion or to thickening of the ligamentum teres. Later, the superior part of the joint may also be widened. These changes may be seen on ultrasound.
2. A subcortical fissure in the femoral ossific nucleus.	This sign is seen early in the disease but is transient. It is best seen in the 'frog" lateral view.
3. Reduction in size of the ossific nucleus of the epiphysis	This is found in some 50% of cases and is due to growth retardation. The medial joint space then seems wider.
4. Increase in density of the femoral ossific nucleus	This is due to trabecular compression, dystrophic calcification in debris and creeping substitution.
Catterall (1971) has grouped Perthes' disease according to the degree of epiphyseal involvement as assessed radiologically. Prognosis depends on the degree of radiological involvement.	

1. Exuberant callus formation is seen in osteogenesis imperfecta, Neuropathic joints and Cushing's disease
2. Ground glass appearance of bones is seen in fibrous dysplasia
3. Dagger, shiny corner, tram track and Rail road track appearance are seen in ankylosing spondylitis

LABORATORY CHANGES IN METABOLIC BONE DISEASE

Serum Levels					**Urine Levels**	
	Calcium	*Phosphorous*	**Alkaline phosphatase**	**Urea or creatinine**	**Calcium**	**Hydroxy proline**
Osteoporosis	N	N	N	N	N	N or ↑

Hyperparathyroidism						
Primary	↑	↓	N or ↑	N or ↑	N or ↑	↑
Secondary	N or ↓	↑	↑	↑	↓	↑
Tertiary	↑	N or ↓	N or ↑	↑	N or ↑	N or ↑
Hypoparathyroidism	↓	↑	N	N	↓	N
Pseudohypoparathyroidism	↓	↑	N	N	↓	N
Hyperthyroidism	N or ↑	N	N	N	↑	↑
Rickets/osteomalacia						
Vitamin D deficiency	↓	↓	↑	N	↓	N
Vitamin D refractory	N	↓	↑	N or ↑	↓	N
Hypophosphatasia	N or ↑	N	↓	N	N or ↑	↓
N = Normal		↑ = Elevated		↓ = Lowered		

METABOLIC BONE DISORDERS

Rickets

- Faulty mineralization of the bone before the fusion of growth plate, i.e., during enchondral bone growth, is known as RICKETS.
- Location: Metaphyses of long bones subjected to stress are particularly involved (wrist, ankles, knees)
- **Radiological features include:**
  - Poorly mineralized epiphyseal centers with delayed appearance
  - Widening and lengthening of growth plate (zone of provisional calcification affected) is earliest radiographic feature of rickets
  - Increased distance between end of shaft and epiphyseal center
  - Epiphyseal plates widening and irregularity
  - Fraying, splaying and cupping of metaphysis
  - Periosteal reaction
  - Indistinct cortex with coarse trabeculations
  - Metaphyseal spur projecting at right angles to metaphysis in the cortex
  - Additional features:
    - Bowing of long bones
    - Genu recurvatum
    - At costochondral junction, epiphyseal widening results in typical 'rachitic rosary'
    - Frontal bossing
    - Scoliosis

- Slipped capital femoral epiphysis
- Triradiate configuration of pelvis
- Basilar invagination

Fraying and cupping of metaphyses

Metaphyseal dysplasias are of many types: Schmid, Jansen's, Pena, Vaandrager and McKusick metaphyseal dysplasia. Metaphyses of long bones are cupped and resemble rickets.

Hypophosphatasia is autosomal recessive congenital disease with low alkaline phosphatase activity causing poor mineralization.

Scurvy	Rickets
• Classical X-ray changes are seen in – Knee - White line of Frankel - Corner sign (d/t periosteal infarct) - Ground glass appearance - Subperiosteal hematoma & elevation of periosteum, Pelkan spur d/t metaphyseal #	• X-ray changes are best seen at the wrists : - Widening (double malleoli) - Cupping (Saucer like depression) - Flaring (Widening, champagene glass app.) - Fraying (rarefaction)
• Epiphysis - Signet ring/ringing of epiphysis - Narrow growth plate (physis)	• Epiphysis - Increased distance b/n epiphyseal centre & shaft of long bone. - Wide growth plate
• Generalized osteoporosis (seen in adults)	• Multiple green stick fractures and Bowing
• Pseudoparalysis	• Earliest change is loss of ZPC
• Scorbutic rosary Post displacement of sternum, tender & step shaped configuration. Sternum depressed.	• Rachitic rosary Non-tender, smooth rounded costochondral beading
• Pencil thin cortex	• Pigeon chest / pectus carinatum Harrison’s sulcus /

Scurvy	Rickets
	groove (Rarely pectus excavatum)
• Wimberger's Sign (Halo sign)	
• Trummer field zone (fragmented metaphysis	

Hyperparathyroidism

Incidence is greatest in middle-aged females.
Parathyroid adenomas account for over 90% of cases of hyperparathyroidism.

Key **imaging features** of hyperparathyroidism include:

- **Subperiosteal bone resorptio**n (a essentially diagnostic / pathognomonic finding): seen most commonly along the radial aspect of the middle phalanges of the second and third digits and commonly involves phalangeal tufts and the medial metaphysis of the proximal humerus, femur and tibia.
- Bone resorption in other locations (intracortical, endosteal, subchondral, trabecular and subligamentous) characterized by cortical striations, intracortical tunneling and **osteitis fibrosa cystica**, the hallmark of this disorder, seen best in tubular bones of hands.
- **Osteopenia** in vast majority of cases (rarely, osteosclerosis)
- **Brown tumor** represent focal, bone replacing lesions that occur most often in metaphysis, diaphysis where jaw is known site of involvement manifesting radiologically as radiolucencies. The majority of these lesions heal after removal of the adenoma.
- **Erosions** involving sacroiliac joints, symphysis pubis and ligamentous insertions in addition to resorption of distal or medial end of clavicle and vertebral end plates (aggressive Schmorl's nodes), attributed to **subchondral resorption**.
- Skull may show a characteristic **'pepper pot' pattern** resulting from trabecular resorption and widening and remodeling of the diploic space.
- Erosions of calcaneum and inferior aspect of distal clavicles, attributed to **subligamentous resorption**.
- **Chondrocalcinosis**
- Loss of **lamina dura** of mandible

In children, metaphyseal changes (like cupping, splaying and fraying, wooly moth-eaten appearance) resembling rickets are common in uraemic osteodystrophy (chronic renal failure), which together with cortical erosions can give rise to the so-called **' rotting fence-post '** appearance, particularly at the femoral neck. Otherwise, widening and lengthening of growth plate is earliest radiographic feature of rickets.

Paget's disease of bones

- Paget's disease is a chronic skeletal disease characterized by disordered and exaggerated bone remodeling, affecting order individuals.
- Sites:(usually polyostotic and asymmetric) Pelvis > lumbar spine > thoracic spine > proximal femur > calvarium > scapula > distal femur > proximal tibia > proximal humerus.
- Fibula is virtually never affected.

Radiological features:

- Skull:
  - Widened diploic spaces
  - Osteoporosis circumscripta
  - "Cotton wool" appearance (mixed lytic and blastic pattern of thickened calvarium) and
  - Basilar impression
- Long bones:
  - "Candle flame"/"blade of grass" lysis originating in subarticular site
- Spine:
  - "Picture-frame" vertebra,
  - "Bone with bone" appearance
  - "Ivory" vertebra
  - Ossification of spinal ligaments

1.	Saucer shaped epiphyses are seen in	:	*Rickets*
2.	Periostitis is found in hypervitaminosis of	:	*Vitamins A & D*
3.	Tri-radiate pelvis is seen in	:	Osteomalacia
4.	Post menopausal osteoporosis is due to	:	*Reduced oestrogen levels*
5.	Pseudo-fractures or Looser's zone are seen with	:	*Osteomalacia*
6.	'Rugger – Jersey spine' is found in	:	Renal osteodystrophy
7.	Prolonged steroid therapy can induce bone changes similar to	:	*Cushing Syndrome*
8.	Bone changes in **Cushing Syndrome** mainly affect	:	*Axial skeleton*
9.	Osteomalacia is commonly seen in	:	Women
10.	Herniation of discs into vertebral bodies due to osteoporosis produces	:	*'Cod-Fish Vertebra'*
11.	**Nephrocalcinosis** is seen in advance stages of	:	*Hyperparathyroidism*
12.	Cortical erosions of phalanges in hyperparathyroidism occur characteristically on	:	*Radial side of Phalanges*
13.	Loss of lamina dura of teeth is found in	:	*Hyperparathyroidism*
14.	Percentage of patients with renal calculi suffering from Hyperparathyroidism is	:	*5 - 20%*
15.	Salt and pepper skull is found in	:	Hyperparathyroidism
16.	Bilateral resorption of lateral end of clavicle is seen in	:	*Hyperparathyroidism*
17.	Shortened 3rd and 4th metacarpals [' Metacarpal sign'] is seen in	:	*Pseudohypoparathyroidism, Turner syndrome*
18.	Delayed bone age, and stippling of Epiphysis; is seen in	:	*Myxoedema*
19.	'Tufting of Terminal phalanges' of fingers and toes are seen in	:	*Acromegaly*
20.	Celery stick appearance of long bones is seen in	:	*Congenital Rubella*

21.	Commonest areas involved in **Paget's disease**	:	*Pelvis, Skull, Lumbar Spine*
22.	**"Osteoporosis Cirumscripta**" A type of Paget's disease in which	:	Large areas of bone resorption occurs in skull.
23.	'Picture-frame vertebra' is seen in	:	Paget's disease
24.	Avascular necrosis of bone radiologically appears as	:	*Greatly dense*
25.	Most useful view to visualize osteochondritis of tibial tubercle	:	*Lateral*
26.	X-ray finding (most common) in acute fracture scaphoid	:	No changes. Findings seen only after 7-14 days
27.	Best X-ray-view for visualizing fractured patella is	:	*Skyline view*
28.	Sclerotic end of a fracture indicates	:	Non-union
29.	The double line sign on MRI seen in	:	AVN avascular necrosis
30.	AVN is most commonly seen at	:	Femoral head
31.	Doughnut appearance on radionuclide scan	:	*AVN*
32.	Radiological findings of osteomyelitis	:	*1) Blurring of fat planes* *2) Osteoporosis* *3) Involucrum is usually visualized after 3 weeks*
33.	Callus formation following stress fracture is seen within	:	*3 weeks*
34.	Best X-ray-view for visualizing shoulder dislocation (Recurrent)	:	*Stryker view*
35.	Earliest radiological evidence of myositis ossificans is seen after	:	*4-6 weeks of injury*
36.	Multiple osteolytic lesions in the skull is seen in	:	Letterer-Siwe disease (Histiocytosis X)
37.	Flask shaped lower end of femur is seen in	:	Gaucher's disease, Osteopetrosis
38.	Skull vault thickened and enlarged paranasal sinuses are a feature of	:	*Acromegaly*

INFECTIONS

Osteomyelitis:

HEMATOGENOUS OSTEOMYELITIS OF TUBULAR BONES

	Infant	Child	Adult
Localization	Metaphyseal with epiphyseal extension	Metaphyseal	Epiphyseal
Involucrum	Common	Common	Not

			commo n
Sequestrati on	Common	Common	Not commo n
Joint involvemen t	Common	Not common	Commo n
Soft-tissue abscess	Common	Common	Not commo n
Pathologica l fracture	Not common	Not common	Commo n
Fistulae	Not common	Variable	Commo n

- In children metaphysis is involved, while in adults epiphysis is involved
- Swelling, with edema and blurring of fat planes become apparent immediately
- Osteoporosis may be visualized within 10-14 days of onset of symptoms
- Plain radiograph may not show changes until 2 weeks after MRI/USG have demonstrated the abnormality
- Involucrum → cloak of laminated/ spiculated periosteal reaction or the layer of living bone surrounding the dead bone which forms beneath the elevated periosteum, (develops after 20 days)
- Sequestra → detached necrotic cortical bone fragments if surrounded by pus, are not absorbed and remain as sequestra, seen as more radioopaque densities than the surrounding bone (develops after 30 days)
- Cloaca → are defects in Involucrum or the hole in bone with sclerotic margins or the space in which dead bone resides and also allows the pus and sequestra to escape

Brodie's abscess

- Localized Subacute form of osteomyelitis/ a intraosseous abscess surrounded by **intense sclerosis**
- Usually found in the cancellous tissue, near the end of a long bone (metaphysis)
- Seen as well-circumscribed area of bone lysis/destruction with surrounding zone of reactive sclerotic rim
- May have a finger-like extension into neighboring bone (tunneling) toward the epiphyseal plate, which, when present, is **pathognomonic** feature
- D/D Osteoid osteoma
- Brodie's abscess **typically** enhances on the delayed isotope scan, while osteoid osteoma enhances centrally, both on the blood-pool and delayed scan due to central vascularity (the **double density sign**).
- On MRI, central vascular area of osteoid osteoma exhibit bright signal and enhancement, while necrotic tissue in the Brodie's abscess does not (the **penumbra sign**).

Skeletal tuberculosis

- It is due to hematogenous spread from a primary site, usually the lungs but at times primary lesion may not be identified.
- Spine is most common site of infection and is present in over 50% children, followed by the involvement of large joints of lower extremely like the hip and knee.
- **Shoulder joint (caries sicca)** and bones of the hand and feet **(spina ventosa)** can also be involved.
- In skeletal tuberculosis single joint affection is the most common pattern.
- **Tuberculous dactylitis (spina ventosa)** involves the short tubular bones of hands and feet with bony

expansion; increased bone density with periosteal reaction and soft tissue swelling. The differential diagnosis of tuberculous dactylitis includes sickle cell dactylitis and small round cell neoplasm of childhood.

- The radiographic features of tuberculous arthritis
- Periarticular osteoporosis
- Soft tissue swelling
- Joint space narrowing
- Fibrous ankylosis is more common than bony ankylosis except in cases of spinal tuberculosis.
- Reactive new bone formation is minimal or absent.

Tubercular spondylitis or Pott's spine

- It is infection and destruction of the vertebral body and intervertebral disc by *Mycobacterium tuberculosis*.

Radiological features:

Spine radiograph:

- Demineralization (**the first sign**);
- Mild contour irregularity of anterior and lateral aspect of vertebral body due to erosion from subligamentous extension of tubercular abscess (**gouge effect**);
- Loss of the intervertebral disc space (however, maintained longer than in pyogenic arthritis);
- Collapse of vertebral body, angular kyphotic deformity (**gibbus**);
- **"Vertebra within vertebra"** appearance (growth recovery lines);
- **Ivory vertebra** (due to reossification as healing response to osteonecrosis);
- Anterolateral scalloping of vertebral bodies.
- Large fusiform paraspinal bulge due to cold abscess in paravertebral gutters/psoas, commonly bilateral. The abscess may extend into groin and thigh.
- Amorphous/teardrop-shaped **calcification in paraspinal region** (nontuberculous abscess rarely calcifies).

MRI is the **investigation of choice** for diagnosis of the disease and evaluation of its complications.

Complications of Pott's spine:

- Kyphoscoliosis
- Bony ankylosis
- Osteonecrosis
- Spinal cord compression from abscess, granulation tissue, bone fragments and arachnoiditis
- Extensive spread of abscess
- Amyloidosis

CONGENITAL SYPHILIS

Transplacental transmission cannot occur < 16 weeks gestational age

1. Diaphyseal Periostitis (commonest feature)
   a. **Saber tibia** (anterior convex bowing of upper 2/3rds of tibia with bone thickening)
   b. Bone within bone appearance
2. Metaphysitis
   a. Metaphyseal irregularities
   b. Metaphyseal fractures
   c. **Wimberger sign** (symmetrical focal destruction of medial portion of proximal tibial metaphysis, pathognomonic sign)

3. Osteitis and osteomyelitis (symmetrical and bilateral involving multiple bones)
4. Syphilitic dactylitis
5. Skull lesions (frontal bossing due to diffuse thickening of outer table; purely sclerotic or mixed lesions with **"hot cross bun" skull**)
6. Spontaneous epiphyseal fractures causing joint immobility due to pain (Parrot's **pseudoparesis**)
7. **Hutchinson's triad** (dental abnormalities, interstitial keratitis and 8th nerve deafness)
8. Saddle nose, high palate, short maxilla
9. Anaemia

1. Phemister's triad is seen in : *Tuberculous arthritis*
2. Most common site of sclerosing osteomyelitis of Garre : *Mandible (2nd Tibia)*
3. "Saw Tooth" metaphysis is found in : *Congenital Syphilis*
4. "Lace-Work" periosteitis is seen in : *Syphilis*
5. Wimberger's sign in syphilis indicates : *Bilateral symmetrical perichondritis & osteitis of tibial upper growth plate medially*
6. X-Ray in early stages of tuberculous arthritis shows : *Joint effusion and periarticular osteoporosis*
7. Commonest form of bone tuberculosis : Tuberculosis of Spine (most common site D-L junction)
8. Spina ventosa means : Medullary expansion of affected phalanx due to tuberculous infection.
9. Moth eaten skull is characteristically found in : *Syphilis.*
10. Brodie's abscesses are usually seen in : *Long bones*
11. Hutchison's fracture affects the distal radial styloid
12. A fracture of the talar neck causes avascular necrosis of the proximal part
13. Horizontal dislocation of the vertebral body is called a : Chance or seat belt fracture
14. Tear drop fracture caused by flexion injury are the most unstable type of injuries
15. Vanishing bone disease is also called : Massive Osteolysis of Gorham's
16. Fallen fragment and trap door sign are seen in : Solitary bone cyst with fracture
17. Presence of multiple fluid levels on MR is s/o aneurysmal bone cyst (ABC)
18. Diaphyseal aclasia (osteochondromatosis) is autosomal dominant, enchondromatosis is sporadic in inheritance
19. Most common malignant bone tumors are metastasis
20. H shaped vertebrae on lateral view are seen in sickle cell disease, on frontal view in thanatophoric dwarfism.

TUMOURS

Imaging Bone Tumors

- MRI is **modality of choice** for diagnosis and evaluation of bone tumors.
- **CT scores over MRI only in** detection of small foci of calcification and fine osseous details, which many times are not visualized on MRI.

Skeletal metastasis

- Bone scintigraphy remains the most cost-effective method for detection of the bony metastatic deposits, although MRI is more sensitive for identification of metastatic disease.
  Diffuse osteoblastic metastatic disease, typically from breast or prostate may result in a 'superscan' appearance. The identification of a 'halo' of high signal intensity around a lesion is a highly specific feature of metastasis on T2W MRI.

BONE LESIONS ACCORDING TO THEIR PREDOMINANT/PRIMARY SITE OF OCCURRENCE/ORIGIN

Epiphyseal	Metaphyseal	Diaphyseal
Chondroblastoma	Chondromyxoid fibroma	Fibrous dysplasia
Giant cell tumor	Osteochondroma	Eosinophilic granuloma
Subchondral cyst	Brodie's abscess	Metastasis
Aneurysmal bone cyst	Solitary bone cyst	Adamantinoma
Eosinophilic granuloma	Osteosarcoma	Leukemia, lymphoma
Chondrodysplasia punctata	Chondrosarcoma	Ewing sarcoma
Metastasis and myeloma after 40 years	Non-ossifying fibroma	Non-ossifying fibroma
Clear cell chondrosarcoma	Osteomyelitis	

Fibrous dysplasia

- Its tumor like lesion of the bone (nongenetic)
- It can be Monostotic or polyostotic
- The association of polyostotic fibrous dysplasia, patchy café-au-lait spots of skin pigmentation and sexual precocity, usually in girls, constitutes the McCune Albright syndrome.

Radiological features:

- 'Ground-glass' or radiolucent area of trabecular alteration in the long bones with patchy sclerosis and expansion with cortical thinning and endosteal scalloping
- Smoky ground glass affected bony matrix is classical of FD
- Pathological fractures and deformities like 'shepherd's crook' deformity of femoral necks
- Asymmetrical thickening of skull vault with sclerosis at the base with multiple lucencies
- Obliteration with ground glass appearance of paranasal sinuses
- Leontiasis ossea (marked facial deformity)

Simple bone cyst:

- Age and Sex: 3–19 years
- M:F = 3:1

- Location: Proximal humerus + femur (60–75%), fibula, Calcaneum (at the base of its neck)
- After growth plate closure, 52% are in pelvis and calcaneum.
- Site: Metaphyseal (intramedullary expansile centric)
- Prognosis: Spontaneous regression mostly.

Radiologic features include:

- Lytic geographic lesion, broad at metaphyseal end, narrows at diaphyseal end and longer than wide, "giving truncated cone appearance", with or without septa and endosteal scalloping.
- It's simply a expansile lesion without cortical disruption.
- *Fallen fragment sign* (10% cases) i.e. small-detached fragment floats in lytic defect is characteristic feature.
- *Hinged fragment sign* in which the fragments remains attached to the lytic area is another vital feature.

Osteoid osteoma

Affects young people,10–25 years of age.
Classical clinical presentation is pain during nighttime, which is relieved by aspirin.
50% are in femur or tibia, predilection for spine in 10% cases, usually in neural arch (sclerotic pedicle); however it can occur in almost any bone.
Usually cortical, but may be intramedullary or subperiosteal.

Radiological features

- Diaphyseal lesion.
- Cortically located lesions. Lucent **nidus** surrounded by reactive sclerosis. May have central fleck of target calcification in the centre.
- Intramedullary lesions. Lucent nidus may be the only visible abnormality.
- Spinal lesions: Most often affects lamina. 60% are in lumbar spine. Mature sclerotic lesion may present as sclerotic 'Ivory pedicle' or 'ivory lamina'.

Radionuclide bone scan may show "**double density sign**".

Chondrosarcoma

It is a malignant tumor originating in cartilage.
Secondary chondrosarcoma arise in a pre-existing bony lesion like:

Usually →

- An Enchondroma (**central type**) or
- An Osteochondroma (**peripheral type**) and

Rarely in →

- Chondromyxoid fibroma
- Chondroblastoma
- Synovial chondromatosis
- Enchondromatosis
- Maffucci's syndrome
- Diaphyseal Aclasis

Most osteochondromas (**cartilage cap tumor/exostosis**) have cartilage caps no thicker than 5 mm, and a cap more than 20 mm in thickness is likely to be malignant. Destruction of part of a well formed calcified cap or

ossified stem is also a radiological feature of Osteochondroma favoring malignant transformation.
Age: Peak incidence is at 50 years age.
Sex: Slight male predominance (M:F is 1.5:1)
Common location: Flat bones (pelvis, scapula), proximal femur and proximal humerus.

Radiological features:
- Lytic lesion with endosteal resorption, periosteal reaction, periosteal new bone formation and bone expansion
- Multilobulated appearance with well-defined scalloping of endosteal surface and cortical destruction in more aggressive lesions
- Soft tissue extracortical mass out of proportion to the size of the intraosseous lesion is characteristic
- Being a chondroid tumor, presence of calcification **(dense/stippled / nodular / conglomerate popcorn-like/ring/arc-like calcification)** is characteristic feature.

The **prognosis** of chondrosarcoma is good when complete resection is achieved before metastatic spread.
The tumor shows poor response to radiotherapy and cytotoxic drugs.

Osteosarcoma:
- Most common malignant primary tumor of bone in young adults and children
- 2nd most common primary malignant bone tumor after multiple myeloma
- It has **bimodal age distribution**: 10–25 years and > 60 years with M:F = 3:2 to 2:1
- Constitutes 15% of all primary bone tumors confirmed at biopsy.
- Factors for Secondary Osteosarcoma

Paget's disease
Diaphyseal aclasis
Enchondromatosis
Post-radiation

Location:
Metaphysis is common site of origin (90–95%) with long bones affected in 70–80% cases; femur lower end (40–45%), tibia (16–20%) and 50–55% thus seen around knee; facial bones (8%), flat bones affected usually in age >50 years (ilium).

Radiographic features:
1) Large Osteosclerotic lesion (90%)
2) Osteolytic lesion (fibroblastic)
3) Aggressive periosteal reaction (sunburst/hair-on-end/onion-peel laminated periosteal reaction)
4) Codman's triangle
5) Moth-eaten bone destruction with cortical disruption
6) Soft tissue mass with new bone formation (osseous/cartilaginous type)
7) Physis does not act as barrier to tumor spread
8) Spontaneous pneumothorax (due to subpleural metastasis)
9) **String sign** → fine radiolucent line separating tumor mass from cortex seen in Parosteal osteosarcoma

CT features:
Metaphyseal bone lesion with
a) Soft tissue attenuation (non mineralized part)

b) Replacing fatty bone marrow
c) Low attenuation (chondroblastic component/ hemorrhage/necrosis)
d) Very high attenuation (mineralized matrix)
e) Evaluate for extent of marrow and soft tissue involvement, epiphyseal invasion, joint and neovascular involvement and distant metastasis

MR (preferred modality)
Tumor of intermediate signal intensity on T1W1 and high signal intensity on T2W1
Clearly defines marrow extent (best on T1W1), vascular involvement and soft tissue component (best on T2W1)
Radionuclide bone scan (NUC):
Intensity increased activity on blood flow, blood pool, delayed images (hypervascularity, new bone formation). Local extent, skip lesions, metastasis to bone and soft tissues detected. **Doughnut sign** (peripherally increased uptake with central photopenia on bone scan) is a classical feature. Soft tissue extension demonstrated especially on SPECT.

EWING'S SARCOMA:

Ewing's sarcoma is the highly malignant primary bone neoplasm having specific cytogenetic analysis, i.e., t(11,12), is a PNET with 75% patients being under the age of 20 years and having male predilection.
Histologically small oval/round tumor cells are seen arranged in sheets with occasional rosette-like pattern and most tumors are **PAS-positive** indicating presence of **glycogen** in the tumor cells.
Radiological features:

- Ill-defined osteolytic medullary lesion involving diaphysis
- Extension along the length of the marrow with Permeative bone destruction
- Cortical saucerization
- Classical multilaminar periosteal reaction giving 'onion-peel' appearance
- Codman's triangles with elevated periosteum, although classically seen in osteosarcoma
- Soft tissue mass disproportionately large compared to the extent of osseous involvement, resembling osteomyelitis
- Bone sarcoma metastasizing to bone

Chordoma

- It is a destructive bone tumor believed to arise from ectopic remnants of notochord/ notochord cell rest.
- Its maximum incidence between 50-70 years.
- It is locally malignant with strong tendency to recur after excision.
- Predilection for sacral (50%) and cranial (40%) regions (the extreme ends of the axial skeleton);
- In sacrum at S_4 and S_5 and in cranium basisphenoid (clivus and dorsal aspect of sella)
- Above sacrum and below C_2, chordomas are rare.
- Radiologically appears as a oval or lobulated well-defined purely lytic mass in midline, which may contain calcification and a soft tissue component.
- Recurrence rate is high but it **metastasis occurs late**.
- Chordoma at the base of skull carry best prognosis

1. Dots and commas or 'rings and broken rings' calcification seen in : Enchondroma or chondrosarcoma
2. Sun ray calcification in bone tumor is seen in : *Osteosarcoma*

3.	Fluffy pulmonary secondaries with calcification is seen in(pneumothorax is often seen with osteosarcoma metastases)	:	*Osteogenic sarcoma*
4.	Osteosarcoma can occur in	:	Fibrous dysplasiaPaget's diseaseDue to radiation therapy
5.	Lamellated periostitis is characteristic of	:	*Ewing's tumor*
6.	Onion peel appearance of bone is seen in	:	*Ewing's sarcoma*
7.	Saucerization defect due to bone erosions and new bone formation is typical of	:	*Ewing's sarcoma.*
8.	Codman's triangle is seen in	:	Both benign and malignant disorders hence non-specific
9.	Epiphyseal tumour is	:	Chondroblastoma (Codman's tumor)
10.	Risk of malignancy in the form of chondrosarcoma in osteochondroma is	:	*1% (when single)* 10% (when multiple- diphyseal aclasia)20% (with Maffucci syndrome)
11.	Maffucci syndrome includes	:	Multiple enchondromas with cavernous hemangiomas.
12.	Most common site of skeletal hemangioma is	:	*Spine*
13.	CT appearance of vertebral haemangioma is called	:	*Polka dot appearance*
14.	Soap bubble appearance of bone tumor is seen in	:	*Giant cell tumor.*
15.	Blown out cysts are found in bone in	:	Aneurysmal bone cyst.(eccentrically placed)
16.	Most common site of solitary bone cyst	:	Humerus – upper end
17.	Primary bone tumor which may present with symptoms that mimic osteomyelitis	:	*Ewings sarcoma*
18.	Punched out lesions in skull is found in	:	Multiple myeloma (rain drop lesions)
19.	Shepherd's Crook appearance of the femur is seen in	:	*Fibrous dysplasia*
20.	Large expansile, lytic metastases are seen from	:	*Kidney tumours*
21.	The most widely used bone scanning agent is	:	*Tc 99m Diphosphonate*
22.	Predominantly osteoblastic metastasis occurs in	:	*Ca prostate* *Ca stomach* Carcinoid
23.	NHL may affect lung parenchyma without nodal affection unlike HL		
24.	Most common location for small bowel lymphoma is the Ileum		
25.	The upper limit for lymph node size is the following regions is or follows	:	*Retro crural - 6mm* *Upper Retro peritoneum – 8 mm* *Lower Retro peritoneum - 10 mm* *Pelvis – 8 mm*
26.	HL is more common in the spleen and mediastinum, NHL is more in the alimentary tract, mesentery, bones and intraosseous affection		
27.	Lymph node enlargement is greater in NHL than HL		
28.	The most common site of head and neck lymphoma is the Waldeyer's ring		
29.	The testis and brain (CNS) are a common site of recurrence of lymphoma after chemotherapy		
30.	In carcinoma lung ipsilateral hilar adenopathy is N1, while ipsilateral mediastinal adenopathy is N2, and contralateral hilar or mediastinal adenopathy is N3, N2 does not preclude surgery, but indicates a poor prognosis. N3 precludes surgery		

31. In^{111} labelled octreotide is better for diagnosing neuroendocrine tumors than CT or MR
32. The use of FDG glucose is done in the fasting state

BONE SECONDARIES

- Bone is a common site of metastasis for carcinoma of prostate, breast, lung, kidney, bladder and thyroid and also for lymphoma and sarcomas.
- According to CSDT order of frequency of primary carcinoma metastasizing to bone is – breast > prostate > lung > kidney > thyroid > pancreas / stomach
- Tumours usually spread to bone hematogenously (BM metastasis), but local invasion from soft tissue may occur
- Sites of bone involved from secondary in descending order – vertebrae > proximal femur > pelvis > ribs > proximal humerus > skull
- Pain is the most common symptom of bony metastases
- Most common primary source of solitary skeletal metastasis at the time of diagnosis is – RCC
  Therefore, an IVP should be part of prebiopsy workup of solitary metastases with on obvious primary

Majority of the bone secondaries are osteolytic, but few can be osteoblastic as Carcinoma of the prostate in males and carcinoma of breast in females are the commonest tumour to give rise to sclerotic secondaries in the bone,

- Mostly blastic -- Prostate, carcinoid
- Usually lytic but frequently blastic -- Breast
- Invariably lytic -- Kidney, thyroid
- Rest are mixed type
  - Vertebral bodies are most frequent site others are ribs, pelvis, tumour and femur.
  - Most common symptom is bone pain in the spine. Pathological fracture are common in spine.
  - Secondaries in the bone are uncommon distal to the elbow and knee.

(b) BONES – ARTHRITIS, SOFT TISSUES

ARTHRITIS

Radiological features of Osteoarthritis/ Degenerative arthritis

- Joint space narrowing
- Subchondral sclerosis/eburnation
- Central and peripheral osteophytosis including tibial spiking in knees
- Subarticular cyst or Geode formation
- Loose bodies
- Joint deformities
- Heberden's nodes at DIP and Bouchard's nodes at PIP joints.

OA in Hands

- The carpometacarpal joint of the thumb and the trapezioscaphoid joint are commonly affected in OA, especially in females. These joints are seldom affected in RA.
- In OA, in contrast to RA, the distal interphalangeal (DIP) joints are most commonly affected. DIP joint prominences due to osteophytes are known as Heberden's nodes and those at PIP joints are called Bouchard's nodes.
- Typical hand involvement in Osteoarthritis includes DIP, PIP and 1st carpometacarpal joint and scaphotrapezial joints.

Rheumatoid arthritis

The plain X-ray film joint changes of RA include:

1) Soft tissue changes
2) Osteoporosis (Juxtaarticular/ juxtaepiphyseal)
3) Joint space changes and alignment deformities
4) Periostitis
5) Bone erosions
6) Secondary Osteoarthritis

Charcot's joint

Repeated trauma to the joints in the absence of normal pain and proprioception will give rise to a severe destruction arthropathy known as Charcot's joint.

5 D's of Charcot's joint:

D - Disorganization
D - Density of bone increased
D - Debris within joint capsule
D - Destruction of bone
D - Deformity leprosy

Causes of Charcot's joint

- Diabetes (most common joint involved- tarsometatarsal joints)
- Neurosyphilis (knee joint)
- Syringomyelia (upper limb (shoulder) joint)
- Spina bifida (knee joint, foot joint)
- Congenital indifference to pain (ankle joint)
- Alcoholism (foot joint)
- Leprosy (foot joints)

Developmental dysplasia of the hip (DDH)/ Developmental hip dysplasia; DDH; Congenital dysplasia of the hip; Congenital dislocation of the hip; CDH

Causes, incidence, and risk factors

- Problems resulting from very mild developmental dysplasia of the hip may not become apparent until the person is in their 30's or 40's.
- One or both hips may be involved.
- Risk factors include being the first child, being female, a breech delivery, and a family history of the disorder.
- It occurs in about 1 out of 1,000 births.
- DDH is 4-8 times more common in female infants than in male infants. This difference is believed to be the result of the increased levels of circulating estrogens and relaxin at the time of birth and an increased susceptibility to them.

Symptoms

- Diminished movement in the affected side
- Asymmetry in leg positions

- Asymmetry of the thigh fat folds
- After 3 months of age, asymmetry of rotation of the leg and apparent shortening of the affected leg.
- There may be no symptoms.

Signs and tests
There are several maneuvers that can detect a dislocated hip or a hip that is able to be dislocated.
But some mild cases are "silent" and cannot be picked up on physical exam.

INVESTIGATIONS
A hip radiograph is helpful in older infants and children.
But, ultrasound of the hip remains the most important imaging study and will demonstrate hip deformity.

Heterotopic soft tissue calcification

Generalized Heterotopic/Soft tissue calcification and/or ossification:
- Metabolic disorders with hypercalcemia, e.g., hyperparathyroidism
- Metabolic disorders without hypercalcemia, e.g., gout, alkaptonuria, hypoparathyroidism
- Connective tissue disorders
  - Fibrodysplasia ossifications progressiva
  - Ehlers Danlos syndrome
  - Pseudoxanthoma elasticum
  - CPPD (Pseudogout)
  - Dermatomyositis
  - Scleroderma
  - CREST syndrome
- Infection
  - TB
  - Leprosy
  - Cysticercosis
  - T. spiralis
  - *Armillifer armillatus* (comma shaped calcifications)
- Tumor calcinosis
- Sarcoidosis
- Renal osteodystrophy
- Idiopathic calcinosis universalis
- Ankylosing spondylitis
- DISH

Localized Heterotopic calcification:
- Burns
- Frost bite
- Subperiosteal/soft tissue hematoma
- Myositis ossificans
- Neurogenic heterotopic calcification e. g., spinal trauma with traumatic paraplegia
- Hemangiomas (Phleboliths)
- Synovial sarcoma
- Soft tissue chondroma and osteosarcoma

1.	Charcot's joint is usually due to	:	Syringomyelia, Tabes dorsalis
2.	Joints mainly involved in **Osteoarthritis**	:	Hips and Knees (most common site is Knee, most common site in males is hip)
3.	Subchondral cyst in acetabulum in osteoarthritis are called as	:	*Egger's cysts*
4.	The joints involved in rheumatoid arthritis	:	Metacarpophalangeal and proximal interphalangeal joints
5.	Neuropathic arthropathy in syringomyelia affects	:	*Shoulder*
6.	The joint most commonly involved in Diabetic arthropathy	:	*Foot and ankle*
7.	Earliest radiological sign of rheumatoid arthritis is	:	Periarticular soft tissue swelling
8.	Early and subtle changes of rheumatoid arthritis in metacarpal heads are well demonstrated on	:	*Ball catcher's view (Norgaard view) of hands.*
9.	Felty syndrome consists of	:	*Rheumatoid arthritisSplenomegaly Leukopenia.*
10.	Earliest X-Ray changes in ankylosing spondylitis are seen in	:	*Sacro-lliac joint*
11.	"Bamboo spine in ankylosing spondylitis is due to	:	Ossification of Longitudinal spinal ligaments
12.	HLA – B27 antigen is positive in ankylosing spondylitis in	:	*90% of patients*
13.	Other signs seen in ankylosing spondylitis	:	*Dagger sign (ossification of supraspinous & interspinous ligaments)* Trolley track sign (ossification of supra & interspinous ligaments & capsules of apophyseal joints)
14.	Other names of ankylosing spondylitis are	:	*Marie Strumpbell's disease* Bechterew's disease
15.	Most characteristic changes in Gout are seen in	:	*Feet (1st MTP joint)*
16.	**"Punched Out" appearance** of articular margins in **Gout** is due to	:	Bone erosion by deposition of Di Sodium urate
17.	Most common cause of neuropathic bone disease is	:	*Diabetes*
18.	Most common site for Charcot's joint	:	*Hip / Knee*
19.	Calcified olecranon bursa is pathognomonic of	:	*Gout*
20.	Commonest cause of calcification of pinna	:	*Frost bite*
21.	Auto amputation of distal phalanx of fingers is seen in	:	*Scleroderma*
22.	Symmetrical periosteal elevation seen in lung cancer	:	Hypertrophic pulmonary osteoarthropathy

IMPORTANT CLUES

GIT system

- Birds beak esophagus – achalasia.
- Cork screw esophagus– diffuse esophageal spasm.
- String sign of Kantor – Crohns disease.
- Thumb printing – ischemic colitis.
- Saw tooth appearance – diverticulosis.
- Apple core appearance – carcinoma colon.
- Bulls eye lesion in git – lymphoma
- Bulls eye lesion in liver – candidiasis
- Bulls eye in stomach – melanoma.
- Apple core lesion – carcinoma colon
- Claw appearance – intussusception
- Rose thorning, wide C loop, mucosal irregularity, scrambled egg appearance, inverted 3 sign-carcinoma, head pancreas.
- Sandwich sign – mesentric lymphadenopathy.
- Pneumatosis intestinalis – necrotising enterocolitis.
- Double bubble – duodenal atresia.
- Triple bubble – jejunal atresia.
- Uplifted liver – eventeration diaphragm, collapse lung.
- Pearl neck gallbladder– adenomyomatosis of gallbladder.
- Coiled spring appearance – intussusception.
- Adrenal and ear pinna calcification – Addison's.
- Beaded appearance, string of pearls app., chain of lakes app., rat tail CBD – chronic pancreatitis.
- Colon cut off sign, gasless abdomen, sentinel loop, and renal halo sign – acute pancreatitis.
- Loss of haustrations, pseudo polyps on barium enema – ulcerative colitis.
- Fleischner sign, Sterling sign– ileocecal TB.
- Coffee bean sign, bird's beak deformity, and arc of spade deformity –sigmoid volvulus

Obstruction of organ	Feature
Small bowel	• Straight segments that are central and lie transversely (no gas in colon i.e. colon cut-off sign)
Jejunum	• Valvulae conniventes
Ileum	• Featureless
Caecum	• Rounded gas shadow in right iliac fossa
Large bowel	• Haustral fold spaced irregularly

Volvulus :

- Pain X-ray

"Coffee Bean Sign" – Distinct midline crease corresponding to mesenteric root in largely distended loop (supine).

  - Tyre tube appearance
  - Omega sign – Single, grossly dilated loop of colon arising out of pelvis or barium enema.
- On Barium enema
  - Bird Beaks sign – Tapered hook like end of barium colon
  - Ace of spades
- On CT scan

- Whirl sign – tightly torsioned mesentery formed by twisted afferent and efferent loop.

Important radiological features of some CVS Diseases :

- ASD : Hilar dance on fluoroscopy
- VSD : Shunt vascularity
- TOF : Heart size normal but marked RVH 'Coeur en sobot' or boot-shaped heart
  Marked pulmonary oligemia
- TGA : 'Egg on side' appearance on CXR
- Co-arctation of aorta : LVH, Notching of ribs inf. Surface (4^{th} – 8^{th}) usually B/L but U/L may be seen in pre subclavian type
  Inverted 3 sign on Ba-studies
- MS : LAH, straightening of left heart border 'Antler' or 'Moustache sign'
  Double atrial shadow on X-ray
- TAPVC :
  Non obstructive type : Cardiomegaly with plethoric lung fields "Snowman or figure of 8" appearance on X-ray.
  Obstructive type : Normal sized heart and Ground glass appearance of lung fields due to severe pulmonary HTN
- Pericardial effusion: : 'Leather bottle' appearance of heart

Skeletal system

- Sun ray/sun burst appearance, codmans triangle – osteosarcoma.
- Onion peel app., moth eaten appearance – Ewing's sarcoma.
- Soap bubble app. – osteoclastoma.
- Patchy/mottled calcification – chondrosarcoma.
- Driven snow appearance – pindborg tumor.
- Honey combing – adamantinoma.
- Wormion bones – osteogenesis imperfecta.
- Trethowans sign – SCFE (slipped capital femoral epiphysis)
- Aneurysmal sign – TB spine.
- Short 4th metacarpal – pseudohypothyroidism.
- Arrow head distal phalanges– acromegaly
- Subperiosteal erosion of phalanges, salt pepper app., basket work app., brown tumor – hyperparathyroidism.
- Tufting of distal phalanges, sausage digits, opera glass deformity, gulls wing appearance, pencil in cup deformity – psoriasis.
- Hair on end appearance of skull– hemolytic anemia (sickle cell, thalassemia)
- Bullet shaped vertebral body– hypothyroidism.
- Loose bodies, osteophytes, subchondral cyst and subchondral sclerosis – osteoarthritis.
- Tophi (at 1st MTP jt.) with bifringent crystals – gout.
- Articular cartilage calcification – pseudogout.
- Vertebra plana, punched out skull lesions, floating teeth., – eosinophilic granuloma.
- Decreased disc space – earliest sign of TB spine.
- Fish mouth vertebrae – sickle cell, homocystinuria.
- Intervertebral disc calcification – alkaptonuria.
- Autoamputation (acro-osteolysis), sausage digits, tapering finger, calcinosis – scleroderma.
- Meniscal calcification – pseudogout.

- Bone in bone – Gauchers
- Trident hand, tomb stone iliac, V shaped epiphysis – achondroplasia.
- Enthesopathy, bamboo spine, squaring of vertebrae, Anderson lesion,dagger sign – ankylosing spondylitis.

Imp. Findings in X-ray Hand

Disease	Findings	Other
• Hypoparathyroidism	– Subperiosteal erosion + Tufting of phalanges	Brown's tumour
• Pseudohypoparathyroidism	– Markedly short 4th metacarpal	Salt and peper skull
• Acromegaly	– Arrow head distal phalanx	↑ heel pad thickness
• Psoriatic arthropathy	– Tufting of distal phalanx, sausage shaped digits, Gull's Wing app.	

Bone secondaries :

- Bone is a common site of metastasis for carcinoma of prostate, breast, lung, kidney, bladder and thyroid and also for lymphoma and sarcomas.
- According to CSDT order of frequency of primary carcinoma metastasising to bone is – breast > prostate > lung > kidney > Thyroid > pancreas/stomach.
- Tumours usually spread to bone hematogenously (BM metastasis), but local invasion from soft tissue may occur
- Sites of bone involved from secondary in descending order – vertebrae > proximal femur > pelvis > ribs > proximal humerus > skull.
- Pain is the most common symptom of bony metastases
- Most common primary source of solitary skeletal metastasis at the time of diagnosis is –RCC

Therefore, an IVP should be part of prebiopsy workup of solitary metastases with no obvious primary

Majority of the bone secondaries are osteolytic, but few can be osteoblastic as Carcinoma of the prostate in males and carcinoma of breast in females are the commonest tumour to give rise to sclerotic secondaries in the bone.

- Mostly blastic- Prostate carcinoid
- Usually lytic but frequently blastic- Breast
- Invariably lytic- Kidney, thyroid
- .Rest are mixed type
- Vertebral bodies are most frequent site others are ribs, pelvis and femur
- Most common symptom is bone pain in the spine. Pathological fracture are common in spine.
- Secondaries in the bone are uncommon distal to the elbow and knee

PRINCIPLES OF RADIOTHERAPY

IONIZING RADIATION

ELECTROMAGNETIC RADIATION | **PARTICULATE RADIATION**

X-RAYS • Produced extranuclearly • Produced in an electrical device that accelerates electrons to high energy & then abruptly stops them in a target	**γ-rays** • Produced intranuclearly • Emitted by radioactive isotopes in an attempt to achieve stability.	**NEGATIVELY CHARGED** • Electrons • Negative π - mesons **UNCHARGE** • Neutrons	**POSITIVELY CHARGED** • Protons • α-particles • Heavy charged particles (carbon, neon, silicon, argon)

PROPERTIES OF ELECTROMAGNETIC RADIATION

1. They have the same velocity $=3x10^{10}$cm./sec=18600miles/sec.
2. Transfer of energy from place to place is in Quanta.
3. They travel in free space in a straight line.
4. They are emitted **isotropically** i.e. equally in all directions.
5. In passing through matter, the intensity of radiation is reduced **(ATTENUATION).** This attenuation is due to the fact that some of the energy is taken up by the material **(ABSORPTION)** and some of the energy is deflected from its original path to travel in different direction **(SCATTERING)**. "Note: The effect of radiation on matter depends on how much energy that matter receives from the beam."
6. In free space all electromagnetic radiations obey **"INVERSE SQUARE LAW".**

"INVERSE SQUARE LAW" = For a point source, the intensity of radiation ***(i)*** At any place varies inversely as the square of the distance ***(d)*** From the source to the point it is measured.

$I \propto 1/d^2$ $I = k/d^2$ where k is a constant.

ACTION OF RADIATION

DIRECT ACTION

Radiation is absorbed in the materials. The photons of the incident radiation interact directly with the critical targets and causes ionization and excitation of the atoms of the target material itself, causing the biological change.

INDIRECT ACTION

The radiation interacts with other atoms or molecules in the cell of the target material and produces free radicals which in turn diffuse far enough to cause damage to the critical targets and causes the biological change

TYPE OF IONIZATION BY THE RADIATION

DIRECTLY IONIZING	INDIRECTLY IONISING
When the individual particles have sufficient kinetic energy to cause disruption of the atomic structure through which they pass and produce chemical and biological change. *e.g.**particulate radiation***	The radiation itself does not produce the chemical and the biological changes, but after absorption in the target material, give up their energy to produce fast moving charged particles. e.g. **X-rays & γ-rays**

DIFFERENCE BETWEEN DIAGNOSTIC AND RADIOTHERAPY X-RAY TUBE

Sr.	Feature	Diagnostic Tube	Radiotherapy Tube
1	**Length**	25 cms.	2 times the diagnostic tube (as higher voltage is required, the long length prevents sparks)
2	**Tube Current**	>200mA for a fraction of a second.	Upto 20mA for a few minutes.
3	**Cooling**	Limiting factor is the amount of instantaneous heat the target can tolerate.	Limiting factor is the rate at which the heat can be removed from the target.
4	**Focal Point**	1x1 mm	Around 1 cm
5	**Target Angle**	17^0 (small focal spot)	30^0 or else the effective field size obtained would be too

			small for effective use.

- **Most common Energies used in teletherapy**

	Energy	D_{max}
▪ Cobalt – 60 r rays	1.33 (Avg) mv	0.5 – cm
▪ X–rays	6 mv photon	1.5 cm
▪ Linear Accelerator	10 mv photons	2.5 cm
	15 mv photons	2.8 cm

- With increasing energy there is greater penetration
- D_{max}-peak absorbed dose on central axis is called dose maximum (D_{max})
- Electrons are use to treat superficial lesions & in intra –op radiotherapy.
- Electrons are used to treat :
  1. Skin cancers
  2. Mycosis fungoides
  3. Other superficial cancers

Some points about X-ray machine

- Anode – Tungsten z = 74, Melting point 3370^{o}C
- Production of X-ray efficiency depends on atomic number
- Efficient removal of heat from the target is an important requirement for anode design cooled by oil, water or air.
- Cathode filament is made up tungsten.

Linear accelerator (Linac)- Used to accelerate electrons, & produces X-ray beam
Cyclotron - Produces neutrons, photons
Microtron - Is an electron accelerator, combines principles of both linac + cyclotron
Betatron - Device for accelerating electrons used for production of electron beam for R_T & an X–ray beam
Simulator - Apparatus that uses a diagnostic X-ray tube but duplicates a radiation t/t. Main function is to display the t/t field to accurately deliver the dose.

Radioactive Sources

- γ - ray sources : Co, Cs, Tc, Ra
- β - ray sources : Sr-90, Y-90, Au, P
- Both β & γ rays are emitted by : I-131 (mainly β > γ), Ra, Au
- Neutron emitting Radioisotope : Californium

Radioisotope capable of displacing calcium from body Strontium

C^{14} is used for carbon dating

The m/c form of irradiation is by use of external beam photons or electrons. Photons are x-rays or gamma rays
The modern radiotherapy unit, linear accelerator produces both X-rays and electrons
Primary radiation : which emerges from the tube & reaches patient.
Secondary radiation : radiation which scatters on contact with the patient.

HIGH YIELD FACTS:

- Ionizing radiation deposits energy as it collides with sub-atomic particles in tissue, generating damage to macromolecules.
- The creation of **DNA double-stranded** breaks is thought to represent the primary lethal event.
- Radiation damages DNA in one of the two ways
  - Indirect ionization – generating hydroxy radical
  - Direct ionization – subatomic particle collides with DNA
- Dose describes the quantity of energy deposited per unit mass of tissue by radiation.
- Dose is expressed with unit Gray (Gy) = 1 J/kg.
- An X-ray dose of 1 Gy results in $\cong 10^5$ ionizations events per cell, producing about 1000 to 2000 single stranded breaks and 40 double stranded breaks per cell.
- Cells in the G2 and M phase are most sensitive ionizing radiation and S phase cells are radioresistant.
- Maximal effect from ionizing radiation requires the presence of molecular oxygen and hypoxia may reduce cellular radiosensitivity by a factor of upto 3.
- Therapeutic radiotherapy is fractionated : divided into many small fractions delivered over time (typically five daily fractions per week over 2 to 4 weeks).
- Fractionated schedules are better tolerated by normal tissues than single large doses, resulting in improved therapeutic ratio.

CELL CYCLE

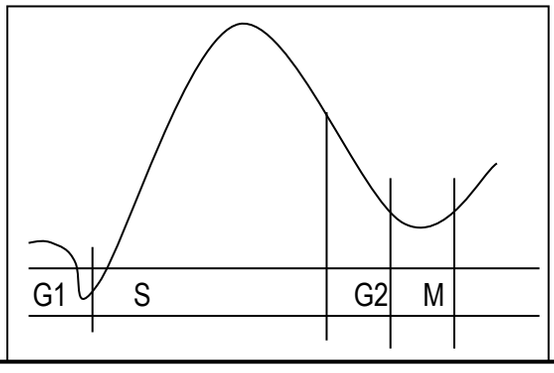
S-PHASE

All mammalian cells propagate and proliferate by mitosis. When a cell divides, 2 daughter cells are produced, each of which caries a chromosome complement identical to that of the mother cell. After some time the daughter cells also undergo further division. The time between successive divisions is the **mitotic cycle time** or **the cell cycle time.**

All proliferating mammalian cells have a **mitotic cycle** comprising of the following phases.

1. **MITOSIS (M-phase)** In this phase there is division of cell into to two daughter cells by condensation of the chromatin network of cell.
2. **G1-phase** is the first resting phase
3. **SYNTHESIS (S-phase)** is in which there is synthesis of DNA taking place within the cell
4. **G2-phase** is the second resting phase of the cell

- The difference in the length of the cell cycle of different cell is always by the difference in the length of G2-phase as all the other phases are of the nearly the same duration.



CELL CYCLE

- This pattern of sensitivity and resistance depends on the levels of the **sulfhydryl compound** content of the cells

RADIOBIOLOGY

- **Radiobiology** is the study of the action of radiation on living things.

Rs of Radiobiology :

1. Repair of sublethal damage
2. Reassortment of cells within the cell cycle
3. Repopulation
4. Reoxygenation
5. Radiosensitivity (now taken as the 5th 'R' of radiobiology)

This is the basis of fractionation in radiotherapy.

RADIOBIOLOGY

6.	Chromosome abnormalities are seen when cells are irradiate in	:	*G_0 or G_1 phase*
7.	Chromatid abnormalities are seen when cells are irradiated in	:	*G_2 phase*
8.	Dose response curve for all mammalian cells appears to have a	:	*Linear Quadratic relationship (LQ model)*
9.	Linear component represents/results from	:	*DSB double stranded chromosomal breaks*
10.	Quadratic/exponential component represents	:	*Break produced by multiple hits*
11.	The shoulder of cell survival curve represents	:	*Cells ability to repair sublethal Sublethal damage*
12.	Cells are most sensitive at	:	*G2/mitosis interface*

13. The linear energy transfer (LET) is the amount of ionization occurring per unit length of the radiation trac

14. LET increases with square of the charge of the incident particle

15. Hypoxic and oxygenated cells respond similarly to : *High LET radiation*

16. 1 Gy of neutrons produces a greater biologic effect than 1 Gy of X-rays

17. Skin sparing effect is achieved with : *Megavoltage radiation*

18. Beams which may be somewhat more effective than X-rays in treating salivary gland tumor : *Neutron beam*

19. Radiation dose has three determinants : *Total absorbed dose No. of fractions Time*

20. Dose homogeneity in the target volume is the goal

21. The dose required to deliver an average of one lethal hit to all the cells in a population : D_0 *of the tumor*

22. A measure of the cells ability to repair sublethal damage : *Dq*

RADIATION HAZARDS

Acute Effects of Total Body Irradiation

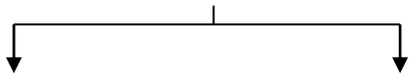
At the human level the effects of radiation are studies and conclusions drawn from the nuclear accidents e.g. **nuclear survivors of Hiroshima & Nagasaki, Marshallese accident** in 1954, **Chernobyl** reactor accident.

Sr. No.	Dose (cgy)	Time post exposure to death	System affected	Presentation
1.	250-500	Weeks	Haemopoietic syndrome	Mitotically active precursor cells are sterilized by radiation. This prevents replenishment of these cells. Time of crisis is seen after all the circulating cells in the body reach the minimum value. **Prodromal Symptoms**: Nausea & Vomiting. Infection & Chills, fatigue, petechial hemorrhages and ulceration of mouth. These symptoms are the manifestation of depression of blood elements
2.	500-1200	Days	Gastrointestinal Syndrome	Nausea, vomiting and prolonged diarrhoea. Loss of appetite, sluggishness and lethargy. Symptoms and death are due to **depopulation of the epithelial lining** of the GIT.
3.	>10,000	24-48 hrs	Cerebrovascular Syndrome	NO PRODROMAL SYMPTOMS Severe nausea and vomiting within minutes. Disorientation Loss of coordination of muscular movement Respiratory distress Diarrhoea Convulsions Coma and finally **DEATH**. At this dose all other systems are also seriously damaged. But cerebrovascular damage brings death so fast, that the failure of the other systems does not become obvious.

- HAEMOPOIETIC & GASTEROINTESTINAL SYNDROMES are reversible with good symptomatic and supportive care.

Late Effects of Radiation

LATE EFFECTS OF RADIATION



Deterministic / Non-stochastic effects		Indeterministic / Stochastic effects
Depend on the total dose of the given radiation. Chances of the occurrence increase as the dose given increases		Independent of the total dose of radiation. It is an "**ALL OR NONE**" type of a phenomenon.

E.g. alopecia in the irradiated portal	• E.g. genetic mutations

TOXICITY OF RADIATION THERAPY :

1. Treatment may be compromised by dose limiting (compromising tumor control) : *Acute toxicities*

2. More serious of toxicity is : *Chronic ones*

3. Radiation of head & neck region often produces : *Thyroid failure*
Xerostomia
Cataract

4. A serious late toxicity is the development of second malignancy in or adjacent to radiation field

5. Necrotizing reaction in brain seen 4 – 12 month after treatment with methotrexate and cranial irradiation is called

6. The most common manifestation of radiation induced heart disease : *Asymptomatic pericardial effusion*

7. A contracted bladder may result from doses of : 76 Gy

RADIOPROTECTORS AND RADIOSENSITIZERS

Radiosensitizers	Radioprotectors
Chemical or pharmacological agents that increase the lethal effects of radiation when administered in conjunction with it. **Aim** is to move the tumor control curve to lower doses by **differentially sensitizing** tumor cells while not or minimally the normal tissue complication curve. **Types** of sensitizers	Chemical or pharmacological agents that reduce the biological effects of radiation Dose reduction factor $= \frac{\text{Dose of radiation in presence of the drug}}{\text{Dose of radiation in absence of the drug}}$
1) Halogenated pyrimidines. These are incorporated into the DNA in place of the methyl group in the thymidine	Aim is to selectively protect the normal tissues and not the tumor cells.
2) Hypoxic cell sensitizers. These increase the radiosensitivity of hypoxic cells but nor aerated cells. **e.g.** Misonidazole, Etanidazole.Mitomycin C, Organic Nitroxides (SR 4233) and **AK 2123**	**e.g.** sulfhydryl groups, WR 638 (Cystaphos) and **Amifostine (WR 2721)**

RADIATION PROTECTION

- For the safety of the radiation workers and the general population the **ICRP (**International Commission on Radiological Protection**)** has laid down certain guidelines. The objectives are to prevent clinically significant deterministic effects by keeping doses below the practical threshold and to limit the risk of stochastic effects.
- All radiation exposures are governed by the **ALARA** principle
- **Sieverts (Sv)** is the SI unit to measure the equivalent dose of radiation received. This depends on the type of radiation exposure and the amount. **rem [radiation equivalent men]** is the old unit of equivalent dose of radiation.
- **1 Sievert =** 100 rem [1 rad = 1 rem = 100 mSv].

Area Exposed	Radiation Worker	General Population
Whole body	20mSv/ year total over 5 years. Not to exceed effective dose of 5mSv/year.	1mSv/ year total over 5 years.
Lens	150mSv/ year	15mSv/ year
Skin, Hands, Feet	500mSv/ year	50mSv/ year
Embryo or Fetus	0.5mSv/ month. Dose of 2mSv for remainder of the pregnancy.	

- The individual worker's life time exposure should not exceed: age in years x 10mSv.
- No occupational exposure below 18 years of age.
- **Radiotherapy** is the treatment of neoplastic diseases with the help of ionizing radiation (electromagnetic or particulate) and also certain non-malignant conditions (eg. Pituitary adenoma).

RADIOLOGIC UNITS DEFINITIONS

Unit	Quantity measured	Definition
Roentgen (R)	Exposure	Amount of x-rays or gamma rays that produces a specific amount of ionization in a given volume of air
Red	Dose	100 ergs deposited per gram of tissue
Gray (Gy)	Dose	SI ergs deposited per gram of tissue
Rem	Dose equivalence	Unit that reflects the biologic response. It is used to compare various types of radiation
Sievert (Sv)	Dose equivalence	SI unit of dose equivalence; equals 100 rem

1. **CURIE (Ci) = (unit of activity)** the amount of radon in equilibrium with 1 gramme of radium. Activity is the number of disintegrations per second. An amount of radioactive material is said to have an activity of **1 curie** when it undergoes **$3.7x10^{10}$** disintegrations per second.

2. **BECQUREL (Bq) = (SI unit of activity)** a source has an activity of **1 Bq** when its disintegration rate is 1 per second.

1 Curie = 3.7×10^{10} Bq

3. **GRAY (Gy)** SI unit of absorbed dose. **1Gy = 100cGy**. Older unit of absorbed dose was **Rad**. **1 Gy = 100 rads.**

4. **ROENTGEN (R)** unit of exposure.
It is the amount of x or γ radiation such that the associated corpuscular emission, per 0.001293 gram of air produces in air ions carrying 1 electrostatic unit of charge of either sign.
   - **0.001293** is the weight of 1 c.c. of air at 0^0C and 760mm of mercury pressure.
   - **'Associated corpuscular emission'** is the photo-electrons, Compton recoil electrons and/or the pair-production electrons set in motion by the primary interactions b/w the radiation photons and air.

*** RADIOISOTOPES, NUCLEAR SCANNING

RADIOISOTOPES

A radioactive substance is one which is unstable and spontaneously decays to form a more stable substance, giving out electromagnetic rays.

Radio nuclides in Radiation Therapy

Linear accelerator (linac)	Used to accelerate electrons & produces X-ray beam
Cyclotron	Produces neutrons, photons
Microtron	Is an electron accelerator, combines principles of both linac + cyclotron
Betatron	Device for accelerating electrons used for production of electron beam for R_T & an X-ray beam.
Simulator	Apparatus that uses a diagnostic X-ray tube but duplicates a radiation t/t. Main function is to display the t/t field to accurately deliver the dose.

- **Radioactive Sources**

• **γ-ray sources**	Co, Cs, Tc, Ra
• **β-ray sources**	Sr-90, Y-90, Au, P
• **Both β & γ rays are emitted by**	**I-131** (mainly β > γ), Ra, Au
• **Neutron emitting Radioisotope**	Californium.

- ❖ Radioisotope capable of displacing calcium from body Strontium
- ❖ C14 is used for carbon dating.
- ❖ The m/c form of irradiation is by use of external beam photons or electrons. Photons are x-rays or gamma rays.

- ❖ The modern radiotherapy unit, linear accelerator produces both X-rays and electrons
- ❖ Primary radiation : which emerges from the tube & reaches patient.
- ❖ Secondary radiation : radiation which scatters on contact with the patient.

RADIOACTIVE MATERIALS

1. **Naturally occurring radioactive materials**
   - All naturally occurring radioactive materials have atomic number greater than 80 and are grouped in three radioactive families starting with **uranium, thorium** and **actinum.**
   - All elements with atomic no > 82 are radioactive.
   - It appears that as the no.of particles inside the nucleus increases, the forces that keep the particles together become less effective since chance of particle emission are increased.

2. **Radioactive "induced" by neutron bombardment**
   Also called **n-γ reaction**. Here the neutron enters the nucleus and some energy is liberated in the form of gamma ray.

$$\longrightarrow \quad {}^{31}_{15}\mathbf{P} \qquad {}^{32}_{15}\mathbf{P} + {}^{0}_{0}\gamma.$$

Phosphorus

$$\longrightarrow \quad {}^{59}_{27}\mathbf{Co} \qquad {}^{60}_{27}\mathbf{Co} + {}^{0}_{0}\gamma.$$

Cobalt

3. **Radioactive "induced" by proton bombardment**
   Also called **p-n** reaction and is caused by the proton bombardment of nucleus. The proton is positively charged. So there is increase in the electrostatic repulsion of the proton as it approaches the nucleus and the proton needs considerable energy to achieve the desired penetration. For this purpose the protons have to be accelerated in **a CYCLOTRON.**

$$^{34}_{16}\mathbf{S} + {}^{1}_{1}\mathbf{p} \longrightarrow {}^{34}_{17}\mathbf{Cl} + {}^{1}_{0}\mathbf{n}$$

sulphur + proton chlorine + neutron

CLINICALLY USED RADIOACTIVE ELEMENTS

SR.	ELEMENTS	HALF LIFE	ENERGY	REMARKS
•	Radium	1620 years	1 MeV	Not used
•	Cobalt 60	5.2 years	1.17 & 1.34 (1.25) MeV	Very commonly used teletherapy
•	Cesium 137	30 years	0.66 MeV	Brachy therapy
•	Iridium 192	74.2 days	0.38 MeV	Brachy therapy
•	Strontium 90	28 years	0.06MeV	Brachy therapy (eye-pterygium–choroid melanoma Retinoblastoma)
•	Yttrium 90	64 hours	2.25 MeV	Brachy therapy (eye-pterygium–choroids melanoma Retinoblastoma
•	Phosphorus 32	14.3 days	MeV	Bone Mets (Radio nuclide) Ascites malignant
•	Technetium	6 hours	0.14 MeV	Radionuclide

	99m			
•	Iodine 125	60 days	0.035/ 0.027 MeV	Pellets Prostate cancer
•	Iodine 131	8 days	0.36 MeV	Ablation of thyroid
•	Iodine 132	2.3 hours	0.38/ 1.39 MeV	Imaging of thyroid
•	Gold 190	2.7 days	0.412 MeV	
•	Palladium 103	16.97 days	21 KeV	Prostate Cancer

DIFFERENT ENERGY RANGES

20-30 k.v.	Rays Grenz
50-150 k.v.	Superficial X-rays
150-500 k.v.	Deep X-rays (orthovoltage)
500-1000 k.v.	Supervoltage
> 1000 k.v.	Megavoltage

Isotopes: Atoms having same atomic numbers, different mass numbers (hence different neutron number) e.g. $_{17}Cl^{35}$, $_{17}Cl^{37}$

Isobars: Atoms having same mass numbers, different atomic number (hence different neutron number) e.g. $_{28}Ni^{64}$, $_{30}Zn^{64}$

Isotones: Atoms having same neutron number, different atomic mass number e.g. $_{18}A^{40}$

Isomers: Atoms having same atomic and mass numbers but different energy states in nucleus.

HALF LIFE OF IMPORTANT RADIONUCLIDES:

(1) I^{131} - 8 days
(2) I^{132} - 2.3 hours
(3) Co^{60} - 5.2 years
(4) Tc^{99} - 6 hours
(5) P^{32} - 14 days
(6) Thallium - 3 days
(7) Gallium - 3 days
(8) Rn^{22} - 3-6 days

DIAGNOSTIC USES

1. The radioactive isotope may be given *to define an organ* such as the thyroid.
2. To test for *selective uptake in an organ*; by scanning the whole body.
3. To determine the presence of uptake in organs suspected of being the site of *metastases*.
4. To *estimate the activity of an organ* such as the thyroid so that an assessment of the degree of thyrotoxicosis may be made.
5. Some tumors of the thyroid-follicular carcinomas-may produce functioning secondary deposits and if radioactive iodine is given these may be detected, and also *treated by* larger doses of iodine.

THERAPEUTIC USES

Role of radionuclides in radiotherapy
Those used therapeutically (either in tele or brachy or in both)
Bismuth-213, Cobalt-60, Dysprosium-165, Erbium-169, Holmium-166, Iodine-125, Iodine-131, Iridium-192, Lutetium-177, Palladium-103, Phosphorus-32, Rhenium-186, Rhenium-188, Samarium-153, Strontium-89, Yttrium-90, cesium, gold and ruthenium (Radium outdated), etc.

Precursors:
Molybdenum-99, Ytterbium-177, Strontium-92, etc.

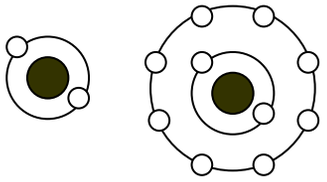
SOME USEFUL RADIONUCLIDES USED IN CLINICAL RADIOTHERAPY

Sr. no.	Radionuclide	Energy	Half life	Medical uses
1.	***Radium-226***	0.83 MV	1625 years	For brachytherapy but not used now a days
2.	***Cobalt-60***	1.25 MV	5.4 years	Teletherapy & brachytherapy
3.	***Caesium-137***	0.666 MV	30 years	Teletherapy & brachytherapy
4.	***Iridium-192***	0.380MV	72 days	Brachytherapy only
5.	***Iodine-125***	0.030MV	60 days	Brachytherapy
6.	***Iodine-131***	0.61 MV	8 days	Unsealed radioiodine for thyroid cancer Rx
7.	***Gold-198***	0.412MV	2.7 days	Brachytherapy
8.	***Strontium-90***	2.24MV	30 years	For shield (mould) in eye tumors
9.	***Phosphorous-32***	1.71MV	14 days	Intraperitoneal

NUCLEAR SCANNING (MEDICINE)

Atomic Structure
An ATOM is the smallest part of an ELEMENT. It has a central **nucleus** that is surrounded by orbits of **electrons.** These electrons are negatively charged. Nucleus of an atom is made up of two fundamental particles, **PROTONS** and **NEUTRONS.** Protons are positively charged and the neutrons do not carry any charge.
The electrons are held in their orbits by the electrostatic forces between their negative charges and the positive charges on the nucleus

No of electrons in an orbit = $2n^2$



PARTICLE	**CHARGE (*Z*)**	**MASS (*A*)**
Proton	+1	1
Neutron	0	1
Electron	-1	1/1850
Positron	+1	1/1850

Often Regarded as 0

A nucleus is characterized by its charge **ATOMIC NUMBER (*Z*) [**= the no of protons in the nucleus of an atom**]** and by its mass on the atomic scale **MASS NUMBER (*A*) [**= the sum of the protons and the neutrons in the nucleus of an atom **]**.

ISOTOPES are substances with the same atomic number but different mass numbers and therefore they have identical chemical properties but different physical properties.

Important radioisotopes

• Gadolinium	Paramagnetic contrast dye used in NMR (MRI)
• Xenon	For regional cerebral blood flow (CBF) studies
• Tc^{99m} labelled RBCs	Imaging of spleen, GIT bleeding
	Ventriculography
• Tc ^{99}MAG3	Diagnostic of transplant rejection
• Gallium	Isotope selectively concentrated in abscess cavity
• Tc^{99m} (technetium) pyrophosphate	Used for infarct avid imaging Standard isotope for "Hot spot" imaging in MI
• Thallium	Agent used for myocardial perfusion studies
(TI^{201})	Imaging agent of choice to assess myocardial viability
	Shows "Cold spot" in MI on perfusion scan (in Non avid infarct imaging)
• Iodine – 123	Evaluation of radio active

	Iodine uptake (RAIU)
• Iodine – 131	For detection of thyroid cancer
• Cr^{52}	For Red cell survival studies
• FDG	Most frequently used moiety in PET is – 2 [^{18}F] fluro-2-deoxy-D-glucose

RADIOACTIVITY is the spontaneous, uncontrolled, unaltered emission of particulate and electromagnetic radiation by an unstable atom's nucleus, in an attempt to achieve stability.

RADIOACTIVE DECAY is the gradual reduction (due to nuclear disintegrations), with the passage of time, of the number of parent nuclei remaining and of the intensity of the emitted radiation.

Units of

Radiation exposure	Roentgen
Radiation absorbed dose	Gray & Rad [1 Gy = 100 Rads]
Radioactivity	Curie
Radiation effectiveness (or public health measure of radiation)	Rem, Sievert

HISTORY OF RADIOACTIVITY

No.	Year	Event	PERSON
1	1895	Discovery of x-rays	Von W Roentgen
2	1897	Isolation of Uranium	Henri Becquerel
3	1898	Isolation of Polonium & **RADIUM**	Pierre & Madam Curie
4	1899	Radiation is made up of α & β	Rutherford
5	1934	Artificial radioactivity	Irene Curie & Prof. Joliot
6	1939	Uranium Fission	Hahn & Strassman

NUCLEAR STABILITY AND RADIOACTIVE DECAY

- Nucleides with odd numbers of neutrons and protons are usually unstable.
- Nuclear decay may involve a simple release of energy from the nucleus or may actually cause a change in

the number of protons or neutrons within the nucleus.

- When decay involves a change in the number of protons, there is a change of element. This is termed a *transmutation.*
- Isotopes attempting to reach stability by emitting radiation are *radionuclides.*
- Several mechanisms of decay achieve stability:
  1. Alpha decay
  2. Beta decay
  3. Electron capture
  4. Isomeric transition

1. BETA (β) PARTICLES

Nuclei which have too many neutrons achieve stability by emission of electrons, which are also called β particles. A neutron of the nucleus changes into a proton and a –ve electron. The electron is emitted and proton remains in the nucleus. So mass number remains same and atomic no increases by 1.

$^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}e.$

Neutron Proton Electron

$^{32}_{15}P \longrightarrow {}^{32}_{16}S + {}^{0}_{-1}e.$

Radioactive phosphorous Sulphur Electron

2. POSITRONS

Nuclei which lack neutrons achieve stability by emission of positron (+ve electrons). Here the excess proton of the nucleus changes into a neutron proton and a positron. The positron is emitted and neutron remains in the nucleus. So mass number remains same and atomic number decreases by 1.

$^{1}_{1}p \longrightarrow {}^{1}_{0}n + {}^{0}_{+1}e.$

Proton Neutron Positron

$^{11}_{6}C \longrightarrow {}^{11}_{5}B + {}^{0}_{+1}e.$

carbon boron positron

3. GAMMA (γ) RAYS

The emission of the beta particle or the positron in some cases completes the radioactive decay process, but in some others, the daughter nucleus has too much energy for stability and it gets rid of the excess energy in the from of **electromagnetic radiation** which is called as **GAMMA (γ) radiation.**

$^{60}_{27}C\bar{o} \longrightarrow {}^{60}_{28}Ni + {}^{0}_{-1}e + \gamma$

cobalt nickel electron gamma radiation

,

4. ANNIHILATION RADIATION As compared to electrons, positrons are rare and they combine with electrons causing disappearance of both the particles and their masses are converted into photons of electromagnetic radiation.

5. ALPHA (α) PARTICLES

There is emission of alpha (α) particles only amongst radioactive materials whose atomic number is more than 80.

$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{+2}He.$

Radon gas Helium

6. K-ELECTRON CAPTURE

` When the nuclei have too few neutrons the nucleus attracts its own encircling k electron which is accompanied by emission of X-rays. This occurs in "PHOTOELECTRIC EFFECT"

7. ISOMERIC TRANSITIONS

In certain cases the excited nuclear state following the emission of a beta particle may be a nearly stable state and the nucleus remains in this state for minutes, hours or even days. The **isomer** thus behaves as a separate radioactive material decaying spontaneously by **isomeric transition** with the emission of a gamma ray only.

Molybdenum 99 ⟶ Technetium 99m + $^{0}_{-1}e$

RADIOACTIVE DECAY

- The amount of radioactivity present (the number of disintegrations per second) is referred to as *activity.*
- In the past, the unit of radioactivity has been the curie (Ci), which is 3.7×10^{10} disintegrations per second.
- Because the curie is an inconvenient unit, it is being replaced by an international unit called a becquerel (Bq), which is one disintegration per second.
- *Specific activity* refers to the activity per unit mass of material (mCi/ g or Bq/ g).
- For a carrier-free isotope, the longer the half-life of the isotope, the lower is its specific activity.
- Radionuclides decay in an exponential fashion, and the term *half-life* is often used casually to characterize decay.
- Half-life usually refers to the *physical half-life*, which is the amount of time necessary for a radio nuclide to be reduced to half of its existing activity.
- The physical half-life *(Tp)* is equal to 0.693/A, where A is the decay constant. Thus, A and the physical half-life have characteristic values for each radioactive nuclide.

LAW OF RADIOACTIVE DECAY

- *Rate of disintegration i.e. the number of atoms disintegrating per second at any instant is directly proportional to the number of atoms of that substance present at that instant*

$= N_0 e^{-\lambda t}$

Gives the number of radioactive atoms at any given instant t.

Where,
N = No. of atoms of a substance at an instant t
N_0 = Initial no. of radioactive atoms
E = No. denoting the base of natural along with (e = 2.718)
λ = Decay constant and is negative because the no. of atoms decrease as the time increases.

HALF LIFE

Half life is defined as the time required for either the activity or the no. of radioactive atoms to decay to half the initial value.

$$T_{1/2} = \frac{0.693}{\lambda} \quad \lambda = \text{decay constant}$$

$T^{1/2}$ (Half life of radioisotopes)

$T^{1/2}$ in hours		$T^{1/2}$ in days		$T^{1/2}$ in years	
I^{132}	2.3 hrs	Gold	2.7 days	Co^{60}	5.2 yrs
Tc^{99}	6 hrs	Thallium	3.2 days	Tritium	12 yrs
		Gallium		St^{90}	28 yrs
I^{123}	13 hrs	Radon	3.8 days	Cs^{137}	30 yrs
		Xenon	5.2 days	Ra	1622 yrs
		I^{131}	8 days	U	701 x 10^8 yrs
		P^{32}	14 days		
		I^{125}	60 days		

Maximum Half-life is of uranium 701 x 10^8 yrs > Ra (1622 yrs)
Radium emits α, β, γ rays and decays to radon

ACTIVITY

- The rate of decay is referred to as activity of a radioactive material.
  Unit of activity is curie.
  1 Ci = 3.7 x 10^{10} disintegration/sec.

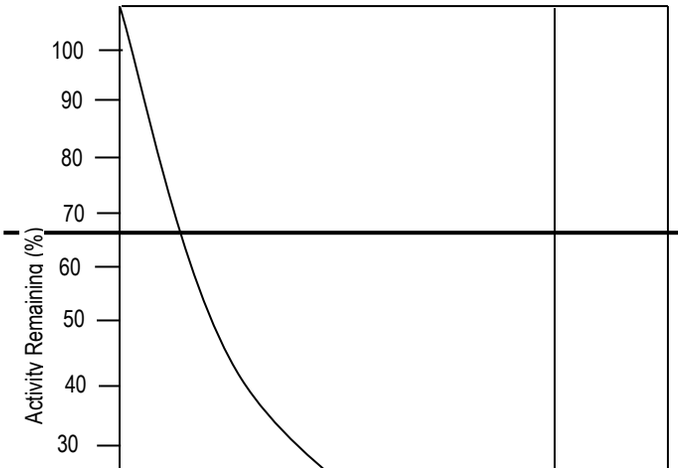
- This definition is based on the rate of decay of 1 g of radium which was originally measured to be 3.7 x 10^{10} dps.

MEAN OR AVERAGE LIFE

- Mean or average life is the average lifetime for the decay of radioactive atoms.

$$Ta = \frac{1}{\lambda}$$

$$Ta = 1.44\, T_{1/2}$$



GENERAL DECAY CURVE

RADIONUCLIDE SCANS

Radiopharmaceutical	Critical organ/Disease(imaged)
I-131, I-125, I-123	Thyroid
MDP	Bone
Tc-99m pertechnetate	Meckle's diverticulum, Gastric mucosa, Intestine, thyroid, choroid plexus
Tc-99m DTPA	Renal GFR
Tc-99m DMSA	Renal cortical function
Xe-127, Xe-133, Kr-81m	Lung (VP scan), Trachea
Tc-tagged RBCs	Spleen, GI bleeding
Tc-99m HMPAO	Acute cerebral infarction (Brain)
Tc Stannous pyrophosphate	Acute myocardial infarction (Heart)
HIDA/DISIDA	Acute cholecystitis (Biliary scintigraphy)
Tc-99m Sulfur Colloid	Liver pathologies
Indium labeled WBC	Intraabdominal abscess and inflammatory bowel disease

(C) MODES OF RADIOTHERAPY & NEWER TECHNIQUES IN RADIOTHERAPY

MODES OF RADIOTHERAPY

A) Brachytherapy
B) Teletherapy (including newer techniques)
C) Systemic Radiotherapy

External Radiation or Teletherapy	Internal radiation therapy or Brachytherapy or Plesiotherapy
1.Cobalt machines 2.Linear Accelerators	Subtypes: 1. **Intracavitary**: radioactive source is kept in the cavity e.g. carcinoma of the cervix 2. **Intraluminal**: radioactive source is placed in the lumen of the tubes in the body e.g. carcinoma of esophagus, bronchus 3. **Interstitial**: the needles are implanted into the tumor tissues e.g. carcinoma of base of tongue 4. **Surface Mould**: a mould is made over the involved area and the radioactive source is placed in this mould e.g. superficial skin tumors

BRACHYTHERAPY

- Brachy means '*short range'* in Greek language. When the radiation source (sealed radionuclides as tube, seeds, needles) is placed close to the tumor is called brachytherapy.

- Brachytherapy, also known as sealed source radiotherapy or endocurietherapy, is a form of radiotherapy where a radioactive source is placed inside or next to the area requiring treatment.

TELETHERAPY/ External Beam Therapy

- Teletherapy in radiation oncology means a source of radiation coming from a distance. It is also called percutaneous radiotherapy. It is the most commonly used type of radiotherapy.
- About 60% of cancer patients referred for radiotherapy are treated with external beam radiotherapy or teletherapy equipments.

BRACYTHERAPY SOURCES	SOURCES OF TELETHERAPY
226Ra accelerator (Main source) 137Cs 198Ir 125i therapy Strontium	4 MV & 10 MV linear 137Cs teletherapy 60Co teletherapy 150-440 KVp X-ray Cyclotron 20-24 MV Betatron

226Ra	4 MV & 10 MV linear accelerator (Main source)
137Cs	137Cs teletherapy
198Ir	60Co teletherapy
125i	150-440 KVp X-ray therapy
Strontium	Cyclotron
	20-24 MV Betatron

NEWER TECHNIQUES IN RADIOTHERAPY

General Principles

1. A patient to be treated with radiation is initially planned on : *Simulator*

2. Simplest portals used for treating patients with radiation : *Bilateral*
Anterior/posterior

3. Individualized treatment planning employs lead shielding tailored to shape the field and limit the radiation exposure to normal tissues

4. 3D-CRT and IMRT involves use of : *MLC*
Multi-leaf collimator (to shape beam as required)

5. Radio protector amifostine is being used to prevent normal tissue toxicity. Amifostine (WR 2721) is a sulfhydryl compound, which selectively scavenges free radicals in normal tissues.
7. 3D-CRT requires : CT scanor CT Simulator Treatment planning system (TPS)

Virtual Simulation, 3-Dimensional Conformal Radiotherapy, and Intensity-Modulated Radiotherapy

The planning of radiotherapy treatment has been revolutionised by the ability to delineate tumours and adjacent normal structures in 3 dimensions using a specialised CT scanner and dedicated computer planning software. In its most basic form, virtual simulation, this process allows more accurate placement of conventional radiotherapy fields than is possible using conventional X-rays, where soft-tissue structures are often difficult to assess clearly.

- 3-Dimensional Conformal Radiotherapy (3DCRT) is an elaboration of this process, whereby the profile of each radiation beam is sculpted to fit the profile of the target from that Beam's eye view (BEV) using a *multileaf collimator (MLC)* and a variable number of beams. The aim of this process is to improve the therapeutic index of the radiotherapy. By conforming the radiotherapy treatment volume closely to the shape of the tumour, the relative toxicity of radiation to the surrounding normal tissues can be reduced, allowing a higher dose of radiation to be delivered to the tumour than would be possible using conventional techniques.
- Intensity-modulated radiotherapy (IMRT) is an ***iteration of 3DCRT*** that employs dynamic multileaf collimation to shape not only the profile of the beam, but also to vary the intensity of the beam over its area. This may allow *greater conformality than standard 3DCRT*. It also provides the novel ability to conform the treatment volume to concave surfaces. This may be useful if the tumour is wrapped around a vulnerable structure such as the spinal cord, where a therapeutic dose of radiation might otherwise cause unacceptable damage.

  3DCRT is used extensively. IMRT is becoming more widely used but is limited by the fact that it is a very resource-intensive process, in terms of manpower and computing time. The proven benefits from both of these modalities over conventional radiotherapy in terms of improved overall survival are limited to a few tumour sites. There has been some concern about increased exposure of normal tissues to radiation, particularly with IMRT, and the potential for secondary radiation-induced malignancy. The downside of tight conformality is that there is an increased chance of geographically missing disease, which may be invisible on the planning scans (and therefore not included in the treatment plan) or which may move between treatments, either because of internal organ movement (such as respiration) or because of inadequate patient immobilisation. Whatever the criticisms of conventional radiotherapy, it gives a wider margin for error than conformal techniques.

MCQ

1

.True about X-rays:

a. Differ from light in their charge
b. Are produced when Electron beam strikes the Cathode
c. Bone scan makes use of high-energy X-rays.
d. Can be emitted as well as absorbed.

2.The magnetic field strength of a 1.5 T MRI machines which are routinely used today in day to day radiology practice is how many times greater than earth's magnetic field?

a. It is equal
b. 100 times
c. 2000 times
d. 30,000 times

3.Highly ionizing radiation:

a. Deutron particles
b. Alpha particles
c. X-rays
d. Gamma radiations

4.Penetration of an X-ray beam mainly depends on:

a. mAs
b. kV
c. Ripple factor
d. All of the above

5.The radiation unit used to for effective dose is:

a. (A)Rad
b. (B)Rem
c. (C)Sievert
d. (D)Gray

6.Which of the following is the most penetrating?

a. Electron beam
b. Gamma photons
c. X-ray photons
d. Proton beam

7. Investigation of choice for dural ectasia?

a. Contrast myelography
b. Multislice CT
c. Angiography
d. MRI

8. Investigation least helpful in evaluation of a case of Prostate cancer?

a. CT chest
b. MRI pelvis
c. TRUS
d. Bone scan

9. Investigation of choice for pulmonary sequestration?

a. Digital X-ray
b. MRI Thorax
c. Color Doppler
d. DSA

10. Ionizing radiation are involved in?

a. Elastography
b. Thermography
c. Color Doppler
d. Positron emission tomography

11. Investigation of choice for evaluation of a suspected case of partial small bowel obstruction?

a. Standing X-ray abdomen
b. Barium Follow through
c. Ultrasonography
d. CT scan

12. Imaging modality that permits best degree of differentiation between Radiation necrosis and recurrence of a brain malignancy?

a. PET scan
b. SPECT Imaging

c. MR spectroscopy
d. Color Doppler study

13.Hounsfield unit value of Acute intracranial hematoma :
a. 0-20 HU
b. 20-40 HU
c. 40-60 HU
d. 100-120 HU

14.Of the following structures, which are better visualized in a CT scan in comparison to MRI:
a. Vascular malformations
b. White matter lesions
c. Interverterbral disc herniations
d. Sinonasal Diseases

15.High-resolution CT of the lung is a specialized CT technique for greater detail of lung parenchyma and it utilizes:
a. Special lung filters
b. Thick collimation
c. Bone algorithm for image reconstruction
d. Large field of view

16.Real time imaging is possible with: following except:
a. Spiral CT
b. EBCT
c. Fluoroscopy
d. USG

17.Maximum radiation exposure is by:
a. MCU
b. CT abdomen
c. Radionuclide scans
d. Bilateral nephrostogram

18.Probability of effect is function of dose in which effects of radiation?
a. Stochastic effect
b. Deterministic effect
c. Nonstochastic effect
d. Radiation call phenomenon

19.Enteroclysis is study of:
a. Esophagus
b. Liver
c. Small intestine
d. Rectum

20.All of the following show Perihilar ground-glass' haziness on chest X-ray, EXCEPT :
a. ARDS
b. Pulmonary edema
c. Pneumocystis carinii infection
d. Staphylococcal pneumonia

21.Which of the following is investigation of choice for Congenital Lobar Emphysema?
a. Bronchography
b. Helical CT
c. MRI
d. Bronchoscopy

22.“HRCT” is ideal for evaluating a suspected case of?
a. Pleural effusion
b. Bronchoalveolar cancer
c. Lung mass
d. Mediastinal adenopathy

23.Opacity with nodular & Irregular calcification is seen in
a. Pulmonary Histiocytosis
b. Sarcoidosis
c. Bronchial adenoma
d. Pulmonary hamartoma

24.Which of the following is not the correct match?
a. Rheumatoid arthritis : Diffuse pulmonary hemorrhage
b. Scleroderma progressive pulmonary fibrosis
c. SLE : shrinkage lung syndrome
d. Wegener’s granulomatosis : Cavitating lung lesions

25.The extent of superior sulcus tumor is best demonstrated by :
a. Nerve conduction studies
b. HRCT
c. CECT
d. MRI

26.Earliest sign of LA enlargement on chest X-ray:

a. Elevation of left main bronchus
b. Smooth anterior indentation on esophagus
c. Double cardiac density
d. Cephalization of blood flow

27.A 50-year-old diabetic female presents with right flank pain and fever since 4-5 dys. She also has pyuria and minimal hematuria. Her urine analysis revealed several pus cells ad RBCs. X-ray KUB showed streaky radiolucencies in left renal region. CT scan abdomen reveals streaks of low attenuation foci in renal parenchyma and pevicalyseal system with perirenal fat stranding and rim of fluid collection. The likely diagnosis is:

a. (A)Pyonephrosis
b. (B)Emphysematous Pyelonephritis
c. (C)Xanthogranulomatous Pyelonephritis
d. (D)Renal abscess

28.Test used to diagnose PUJ obstruction in utero is:

a. (A)USG
b. (B)Retrograde pyelography
c. (C)Whitaker test
d. (D)MRI

29.All of the following statements about Acute Renal Colic are true, EXCEPT :

a. (A)Sonography is highly sensitive in the detection of hydronephrosis.
b. (B)Sonography can detect ureteral stones very sensitively.
c. (C)Helical NCCT is an easy and sensitive way to detect obstructing or nonobstructing ureteral calculi.
d. (D)Cystine stones are hard.

30.A well-circumscribed low attenuation mass lesion with central stellate scar and mild homogenous enhancement in a otherwise healthy middle aged female is very likely to be:

a. (A)Angiomyolipoma
b. (B)Renal Cell Carcinoma
c. (C)Oncocytoma
d. (D)Mesoblastic nephroma

31.Which of the following is the incorrect statement regarding GI Bleeding?

a. (A)The sensitivity of angiography for detecting GI Bleeding is about 10-20% less as compared to nuclear Imaging
b. (B)Angiography can image bleeding at a rate of 0.05-0.1 ml/min or less
c. (C)99mTc-RBC scan will image bleeding at rates as low as 0.05-0.1ml/min
d. (D)Angiography will detect bleeding only if extravasation is occurring during the injection of contrast.

32.Posterior indentation on esophagus on barium column is seen in:

a. Right aortic arch
b. Double aortic arch
c. Aberrant right subclavian artery
d. Scleroderma

33.False about are MRCP :

a. MRI is used with HASTE being the “Work-horse”pulse sequence used
b. Screening tool of choice for primary sclerosing cholangitis
c. Secretin MRCP is extremely useful in diagnosis of dysfunction of sphincter of Oddi
d. Dye has to be injected endoscopically

34.‘Carman’s meniscus’ sign diagnostic of :

a. Peptic ulcer disease
b. Strawberry gallbladder
c. Carcinoma stomach
d. Patent vitellointestinal duct

35.‘Double duct’ sign is seen in :

a. Benign biliary stricture
b. Malignant biliary stricture
c. Periampullary carcinoma
d. Duodenal obstruction

36.Multislice CECT is most poor in delineating which of the following in cases of Ca stomach:

a. Pancreatic infiltration
b. Peri-gastric lymphnode enlargement

c. Ascites
d. Liver secondaries

37.All the following are diagnostic barium follow through features of Ileo-caecal tuberculosis, EXCEPT :
a. Pulled up contracted caecum
b. Widening of ileocaecal angle
c. 'Tooth paste' appearance of ileum
d. Strictures involving terminal ileum

38.Which is not a usual feature of Ulcerative colitis on Ba enema?
a. Fine mucosal granularity
b. Pseudopolyps
c. Lead pipe colon
d. Colovesical fistula

39.Study of choice for Intussusception:
a. Barium enema
b. Colonoscopy
c. Ultrasonography
d. CT scan

40.Cupola sign on Abdominal X-Ray is a feature of:
a. Small Intestinal obstruction
b. Meconium ileus
c. Large intestinal obstruction
d. Pneumoperitoneum

41.Caroli's disease:
a. Type 3 choledochal cyst
b. PTC is currently investigation of choice
c. Association with tuberous sclerosis known
d. Central dot sign

42.The initial investigation of choice for a Post-cholecystectomy biliary stricture is:
a. USG
b. ERCP
c. Computed Tomography
d. MRCP

43.The best investigation for diagnosis of Acute Pancreatitis:
a. USG
b. CECT
c. MRI
d. ERCP

44.Which one of the following hepatic lesions can be diagnosed with high accuracy by using nuclear imaging?
a. Hepatocellular carcinoma
b. Hepatic adenoma
c. Focal nodular hyperplasia
d. Cholangiocarcinoma

45.Reversible ischemia of the heart is detected by :
a. Angiography
b. Thallium-201 scan
c. MUGA
d. Resting Echocardiography

46.Kerly B lines are seen in:
a. Pulmonary embolism
b. Pulmonary infarct
c. Pulmonary hemosiderosis
d. Pulmonary venous hypertension

47.Investigation of choice for pericardial effusion is :
a. CT Scan
b. MRI
c. Echocardiography
d. X-Ray Chest

48.False about Cardiac MRI:
a. Sensitive most for assessing left ventricular function
b. LV non-impaction syndromes can be diagnosed.
c. Gating is not required with 1.5T MRI machines.
d. Best modality for detection of pericardial tumors.

49.Investigation of choice in aortic aneurysm:
a. USG
b. CT scan
c. MRI
d. Digital subtraction Angiography

50.MRI is Best investigation for following except?
a. Traumatic paraplegia
b. ADEM
c. Diastomatomyelia
d. Fracture of dens

51.'Wormian bones' can be seen in following EXCEPT:
a. Hypophosphatasia
b. Down's syndrome
c. Pyle's disease
d. Menke's kinky hair syndrome

52.NOT true about congenital hip dislocation?
a. It is 6 times more common in males
b. Ultrasound is investigation of choice
c. The 'hourglass' appearance of the joint capsule may prevent a successful closed reduction.
d. When the ossification center is in the lower medial quadrant, the hip is normal.

53.Most common cause of endplate destruction with reduction of Intervertebral disc space on X-ray:
a. Lymphoma
b. Tuberculosis
c. Eosinophilic granuloma
d. Metastasis

54."Iliac horns":
a. Ankylosing spondylitis
b. Juvenile Rheumatoid arthritis
c. Nail Patella syndrome
d. Osteitis condensans ilii

55.In scurvy all the following radiological signs are seen, EXCEPT:
a. Pelican spur
b. Growth arrest lines
c. Zone of demarcation near epiphysis
d. Frenkel's line

56.Which one of the following is the investigation of choice for evaluation of suspected Perthes' disease ?
a. Plain X-ray
b. Ultrasonography (US)
c. Computed Tomography (CT)
d. Magnetic Resonance Imaging (MRI)

57."Bone within bone" appearance is seen in :
a. CML
b. Osteoporosis
c. Osteopetrosis
d. Bone infarct

58."Licked candy-stick" appearance of bones is seen in :
a. Leprosy
b. Sarcoidosis
c. Hypertension
d. Madura foot

59.A 55-years–old female presented with painful swelling over the left iliac blade area. Radiograph of the pelvis showed 'an large osteolytic area of destruction with mottled areas of calcification' involving the iliac blade. Which of the following is the most likely diagnosis?
a. Metastases
b. Chondrosarcoma
c. Giant Cell Tumor
d. Osteochondroma

60.Geographic lytic lesions in skull with beveled edges seen in:
a. Multiple myeloma
b. Eosinophilic granuloma
c. Sickle cell anemia
d. Minke's Kinki Hair syndrome

61.What is the imaging study of choice in the setting of head trauma?
a. Helical CT scan without IV contrast
b. Spiral CT scan with IV contrast
c. MRI
d. Digital skull radiographs.

62.Which of the following is classic CT appearance of an acute subdural hematoma:
a. Lentiform-shaped hyperdense lesion
b. Crescent-shaped hypodense lesion
c. Crescent-shaped hyperdense lesion
d. Lentiform-shaped hypodense lesion

63.A young male develops fever, followed by headache, confusional state, focal seizures and a right hemiparesis. The MRI performed shows bilateral temporal lobe hyperintensities. The most likely diagnosis is:
a. Acute pyogenic meningitis
b. Herpes simplex encephalitis
c. Neurocysticercosis (resimose type)
d. Carcinomatous meningitis

64.Juvenile nasal angiofibroma:
a. Radiotherapy is treatment of choice
b. 'Antral sign' can be evident
c. Per-operative embolization is warranted.
d. CT Scan-contrast enhanced is the investigation of choice for juvenile nasal angiofibroma

65.Which one of the following brain tumors is highly vascular in nature?
a. Glioblastoma.
b. Meningiomas.
c. C P angle epidermoid.
d. Pituitary adenomas.

66.The procedure of choice for the evaluation of an aneurysm is:
a. Ultrasonography
b. Computed tomography
c. Magnetic resonance imaging
d. Arteriography

67.Which of the following is generally non-enhancing tumor?
a. Pituitary Adenoma
b. Low grade astrocytoma
c. Optic chiasmal glioma
d. Germinoma

68.Which one of the following tumors most commonly shows 'bracket calcification'?
a. Ependymoma
b. Medulloblastoma
c. Meningioma
d. Corpus calllosal lipoma

69.Posterior scalloping of vertebrae is seen:
a. Multiple myeloma
b. Neurofibromatosis
c. Bestrew disease
d. Aortic aneursm

70.The MR imaging in multiple sclerosis will show lesions in:
a. White matter
b. Grey matter (Deep)
c. Thalamus & Hypothalamus
d. Basal ganglia & External capsule

71.A middle-aged man presents with progressive atrophy and weakness of hands and forearms. On examination, he is found to have slight spasticity of legs, generalized hyperreflexia. T2W MRI reveals increased signal in the corticospinal tracts. The most likely diagnosis is:
a. Multiple sclerosis
b. Amyotrophic lateral sclerosis
c. Subacute combined degeneration
d. Pontine myelinolysis

72.Intradural metastases (drop metastasis) are a frequent complication of all, EXCEPT:
a. Medulloblastomas
b. Oligodendroglioma
c. Pineal germinomas
d. Ependymoblastoma

73.Best method to diagnose hydrocephalus in 1 month old child is:
a. X-ray
b. Ultrasound
c. CT scan
d. MRI

74.A patient comes with proptosis and Abducent N palsy. A dark homogenous mass on T2W MRI is seen which shows intense enhancement with contrast. Diagnosis is?
a. Cavernous hemangioma
b. Meningioma
c. Astrocytoma
d. Glioma

75.C1 C2 best seen in:
a. Lat view

b. Oblique view
c. AP view
d. Odontoid view

76.Which is not a sign of Hydatid cyst?
a. 'Cart-wheel' apperance
b. 'Mercedes Benz' sign
c. 'Cyst in cyst' sign
d. 'Floating membrane' sign

77.On MRI the differential diagnosis of spinal cord edema is:
a. Myelodysplasia
b. Myelomalacia
c. Myelochisis
d. Cord tumors

78.Characteristics of Thyroid carcinoma include all, EXCEPT:
a. Hyperechoic
b. Hypoechoic
c. Microcalcifications
d. Majority shows invasion into thyroid stroma.

79.Best imaging modality for neuroendocrinal tumors:
a. PET
b. CECT
c. Radio nucleotide scan
d. MRI with gadolinium scans

80.In a male fetus, ultrasound identifications of bilateral hydronephrosis and bladder dilatation (with oligohydramnios) is diagnostic of:
a. Polycystic kidney disease
b. Multicystic dysplastic kidney
c. Ureteropelvic junction obstruction
d. Posterior urethral valve

81.Which of the following features on second trimester ultrasound is not a marker of Down's syndrome?
a. Single umbilical artery
b. Choroid plexus cyst
c. Diaphragmatic hernia
d. Duodenal atresia

82.Best for unruptured ectopic pregnancy is:
a. Per abdominal US
b. HCG
c. Trans vaginal US
d. Amniocentesis

83.Intrauterine diagnosis of pyeliectasis can reliably be done when AP diameter of renal pelvis is more than?
a. 2 mm
b. 6 mm
c. 10 m
d. 14 mm

84."Omental caking" in CT scan high possibility that patient is having:
a. Ca colon
b. Ca pancreas
c. Ca stomach
d. Ovarian tumour

85.Investigation of choice in DCIS:
a. Mammography
b. CT
c. MRI
d. PET

86.Investigation of choice for preoperative evaluation of endometrial carcinoma:
a. Hysteroscopy
b. CEMRI
c. HRCT
d. Transvaginal ultrasound

87.Which ultrasound finding with an adnexal mass is most suspicious for malignancy?
a. 8 cm in diameter
b. Several internal excrescences
c. Cystic with two thin septations
d. Free pelvic fluid

88.A 55 year old post menopausal woman, on hormone replacement therapy (HRT), presents with heaviness in both breasts. A screening mammogram reveals a high density speculated mass with cluster of pleomorphic microcalcification and ipsilateral large axillary lymph nodes. The mass described here most likely represents:

a. Cystosarcoma phylloides
b. Lymphoma.
c. Fibroadenoma
d. Carcinoma.

89.Radiological investigation of female of reproductive age group is restricted to:
a. Menstrual Period
b. First 10 days of Menstrual Cycle
c. 10-20 days of M. C.
d. Last 10 days of M. C.

90.A highly accurate intracranial as well as extracranial delivery of high radiation doses with small radiation fields is best possible with?
a. CyberKinfe
b. CHART
c. IORT
d. 3D-CRT

91.Radionuclide agent of Choice for prostate implants:
a. Gold-198 seeds
b. I^{125} seeds
c. Palladium-103 seeds
d. Co-60

92.Which compound is not considered as a radiosensitizer?
a. Hyperbaric oxygen
b. Misonidazole
c. Amifostine
d. Idoxyuridine

93.Maximum radiation permitted for a worker for a year is:
a. 3 mSievert
b. 20 mSievert
c. 8 mSievert
d. 10 mSievert

94.Which of the following is a stochastic effect of radiation ?
a. Alopecia in the irradiated portal
b. Local desquamation in the irradiated field
c. Genetic mutation
d. All of the above

95.Radiation induced transverse myelitis occurs in:
a. 1-3 days
b. 4-6 months
c. 1-3 weeks
d. 1-2 years

96.Longest half life is seen in:
a. Radon
b. Radium
c. Uranium
d. Cobalt

97.True match:
a. Gallium: Ideal agents for bone scan
b. Rubidium-82: Myocardial perfusion imaging
c. Indium-111 is used for brain studies
d. MAG3 is used for functional images of pulmonary ventilation

98.Cobalt-60 is
a. A naturally occurring radioisotope
b. An artificially made radioisotope
c. A positron
d. None of the above

99.Following agents can be used in form of eye plaque for radiation treatment of lesions in the eye (like melanoma) except:
a. 90Sr/90Y
b. ^{106}Ru
c. ^{125}I
d. Plutonium

100.Which is not the R of radiolobiology:
a. Repair.
b. Repopulation.
c. Redistribution.
d. Resortment .

101.The following features help to differentiate mega voltage x-ray therapy from orthovoltage therapy, EXCEPT:
a. More skin damage
b. Very low lateral scatter
c. Homogenous distribution of radiation
d. Greater deposit of energy in the tumor

102.Gamma camera in Nuclear Medicine is used for:
a. Organ imaging.
b. Measuring the radioactivity.
c. Monitoring the surface contamination.
d. RIA

103.Sestamibi Scan is used in:
a. Ectopic thyroid
b. Ectopic parathyroid
c. Parathyroid adenoma
d. Extra adrenal pheochromocytoma

104.Which one of the following has maximum ionization potential?
a. Electron
b. Proton
c. Alpha particle
d. Gamma Photon

105.True about teletherapy?
a. Phosphorous-32 is used as a radioactive material in Teletherapy machines.
b. X-rays & gamma rays are the forms of radiation most commonly used to treat cancer.
c. X-rays rays are generated from decay of atomic nuclei in radioisotopes such as cobalt & radium.
d. It is rarely used form of radiotherapy.

106.In the treatment of Papillary Carcinoma of Thyroid, Radioiodine destroys the neoplastic cells predominantly by:
a. Alpha rays
b. Beta rays
c. Gamma rays
d. X-rays

107.Isotope commonly used in interstitial & mould therapy:
a. Iridium192
b. Cobalt60
c. Caesium137
d. Gold198

108. Low dose rate (LDR) brachytherapy means dose rate at the dose specification point(s)=
a. 0.1– 0.2 Gy/h
b. 0.4–2 Gy/h
c. 2–12 Gy/h
d. >12 Gy/h

109.Most IORT programmes today are based on electron beams produced by megavoltage linacs, since electrons provide which of the following advantage over X rays for the purposes of IORT?
a. The electron dose is deposited over a definite range.
b. The dose can be deposited homogeneously throughout the target volume.
c. No much difference between the tissue and bone absorption of megavoltage electron beams.
d. All of the above

110.Which of the following is a correct selection criterion for endocavitary rectal Radiotherapy?
a. Very poorly differentiated rectal Ca;
b. Immobile lesion with a diameter > 3cm;
c. The location of the lesion within 10 cm from the anal canal;
d. Presence of lymph node or distant metastases.

111.Multiple daily fractions, usually two with doses per fraction of ≤180–200 cGy, usually 100–120 cGy, separated by 4–8 hours, to total doses higher than those given with “standard” fractionation is defined as:
a. Hypofractionation RT
b. Hyperfractionation RT
c. Accelerated RT
d. Continuous hyperfractionation accelerated RT

112.According to recent trials palliation of metastatic disease can be done by:
a. 8 Gy in one fraction
b. 20Gy in 5 fractions
c. 30 Gy in single fraction
d. Above 70 Gy

113.Factors associated with increased risk of

radiation injury to the central nervous system tissues include following except?

a. Medical illness (hypertension and diabetes).
b. Whole brain irradiation.
c. Use of Low LET beams.
d. Concomitant use of methotrexate.

114.Which of the following is not an indication of radiotherapy in parotid tumor?

a. Recurrent disease
b. Resectable local lesion
c. High grade lesion
d. Unfit for surgery

115.Gamma knife radiosurgery is most useful in Rx of?

a. Lung carcinoma
b. Renal tumors
c. Brain tumors
d. Cancer cervix

116.Point B in treatment of Ca cervix corresponds to:

a. Mackenrodts ligament
b. Obturator Lymph node
c. Ischial tuberosity
d. Round ligament

117.Total skin electron irradiation is most commonly employed for treatment of:

a. Leukemia
b. Hodgkin's disease
c. Mycosis fungoides
d. Neuroblastoma

118.PET-CT is investigation of choice for?

a. Rhinocerebral mucormycosis
b. Recurrent ovarian cancer
c. Progressive-multifocal leucoencephalopathy
d. Ductal Carcinoma in Situ of breast

119.'m' in Tc99m stands for?

a. Mass number
b. Multiple
c. Metastable
d. Measurable

120.Investigation of choice detecting liver metastases in a case of carcinoma stomach?

a. Ultrasound
b. CT scan
c. MRI
d. SPECT scan

1.**(D) . Can be emitted as well as absorbed**

X-rays are ionizing electromagnetic radiations, essentially produced when a stream of K shell electrons of an atom accelerated by a high voltage applied between the filament (cathode) and the target (anode), strikes the target and the electrons give up their energy producing characteristic radiations i.e., the X-rays. X-rays have dual property – they can be emitted as well as absorbed. In bone scan gamma radiations are used (*not x-rays*).
(Ref. Principles of Radiation – Therapy by Thomas Deeley, Pg. 33)

2.**(D). 30,000 times**

The strength of a magnetic field may be measured in tesla (T) or gauss. One tesla is equal to 10,000 gauss. The earth's magnetic field at the earth's surface varies between 0.3 and 0.6 gauss. Most clinical CMR scanners use a magnetic field of 1.5 T, or 15,000 gauss, i.e., approximately 30,000 times stronger than the earth's magnetic field. .
(Ref. MRI and CT by Lee & Rao, 4th Edition, Pg. 71)

3.**(B). Alpha particles**

Radiation interacts with other atoms or molecules in the cell of the target material and produces free radicals, which in turn diffuse far enough to cause damage to the critical targets, and causes the biological change – the indirect action. The radiation inside the cytoplasm causes hydrolysis of water (H_2O) to H^+ and OH^- ions. The

free radical (OH ion) can penetrate the nuclear membrane and induce damage to the cellular DNA in presence of nascent oxygen by cross-linking. Alpha particles have highest ionization power.
(Ref. Farr & Allisy-Roberts – Physics for Medical Imaging, 1st Edition, Pg. 150)

4.**(B). kV**
mAs controls film density, while kVp controls image contrast and penetration of X-ray.
To increase contrast, reduce kV; to reduce contrast, increase kV.
(Ref. Farr & Allisy-Roberts – Physics for Medical Imaging, 1st Edition, Pg. 14)

5.**(C). Sievert**

Quantity	**Old unit**	**New SI unit**
Activity	Curie	Becquerel
Exposure	Roentgen	Coulomb/kg
Absorbed dose	Rad	Gray
Dose equivalent	Rem	Sievert

(Ref. Park – PSM, 20th Edition, Pg. 650-651)

6.**(B). Gamma photons**
Gamma photons have highest penetrating power.
The energy of proton & electron beams has not been defined.
For same energy- photon has greater penetrating power than proton (hydrogen nuclei –greater mass)
i.e. 18 MV photon > 18 MeV proton
18 MV photon > 18 MeV electron
Therapeutically used Proton beams have energy range of 150 MeV – 200 MeV.
(Ref. O.P.Tondon General chemistry)

7.D. MRI

8.A. CT chest

9.D. DSA

10.D. Positron emission tomography

11.D

12.A.

13.C.

14.D.

15.**(C). Bone algorithm for image reconstruction**

Three factors significantly improve the spatial resolution of CT such that it can be described as high resolution CT (HRCT)

Narrow beam collimation	**High Spatial reconstruction algorithm (Edge enchancing or sharp algorithm) Ex Bone algorithm**	**Small field of view**
i.e. it cuts thin slices of ≈ 1.5 mm as compared to ≈ 10 mm of CT scan	Makes structure visible sharper & reduces smoothing (opposite to sharp) but it makes image noise more obvious	Increase resolution

(Ref. Grainger, 4th Edition, Pg. 278, 279)

16.**(A). Spiral CT**

The EBCT scanner operates on the principle of electron beam tomography, whereby moving electrons are bent electromagnetically onto one of four tungsten target rings lying in the gantry below the patient. Each sweep of the target ring requires 50 ms, and there is an 8-ms delay to reset the electron beam. The x-rays generated from this electron bombardment of the target ring are tightly collimated and pass through the patient onto a double ring of *cadmium tungstate detectors* lying in the gantry above the patient. The resultant images are 8 mm in thickness. Since each of the four target rings produces two images, eight tomographic images can be generated in one scan sequence. The *images produced are contiguous*, except for a 4-mm gap between images from adjacent target rings.

Conventional and helical CT can produce excellent static images of cardiac anatomy and pericardium, whereas EBCT, a newer imaging modality, is capable of evaluating not only the static anatomy but also the functional anatomy of the heart.

Electron beam computed tomography (EBCT) (ultrafast CT) (cine CT) (fast CT), has taken its place as an important modality in the assessment of ischemic heart disease. The EBCT scanner can quantify myocardial function, assess wall motion abnormalities, evaluate intracardiac thrombi and ventricular aneurysms, and determine coronary artery bypass graft (CABG) patency. EBCT is also an important imaging modality in the evaluation of coronary artery calcification.

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 108)

17. **(B). CT abdomen**

Examination	**Effective total dose (mSv)**
Chest radiograph	0.06
Skull radiograph	0.2
Pelvis radiograph	0.65
Lumbar spine radiograph	1.3
Upper GI series (Barium)	2.45
Abdomen radiograph	0.55

Barium enema	2.8 to 4
IVP/IVU	1.6
Extremities	0.01
Enteroclysis	1.5
CT chest	8
CT abdomen	10
CT head	3.5
RNI	4.8

(Ref. Bailey and Love, 25th Edition, Pg. 130)

18. **(A). Stochastic effect**

Deterministic/non-stochastic effects are the effects not subjected to the laws of chance or probability. There is a threshold dose below, which the effect does not occur. Dose significantly above the threshold will inevitably produce the effect, and its severity increases with radiation dose, e.g. somatic effects and radiation accidents.

Non-deterministic/stochastic are the effects obey the laws of chance or probability. The risk of an effect occurring is increased as exposure to radiation increases, but the effect is not inevitable. Also the severity of effects is not related to dose received. There is no threshold dose below, which the effect does not occur, e.g. induction of cancer and genetic effects i.e. Chromosomal mutations and Leukemias and tumors.

(Ref. Harrison's Principles of Medicine, 17th Edition, Vol. 1, Pg. 2610)

19. **(C). Small intestine**

In enteroclysis, often, barium is infused through a nasogastric tube placed in duodenum or jejunum.

(Ref. Sutton, 6th Edition, Pg. 864)

20. **(D). Staphylococcal pneumonia**

Causes of perihilar ground-glass haziness include:

- (A) ARDS
- (B) Pulmonary edema
- (C) Pneumocystis carinii infection

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 312)

21. **(D). Helical CT**

Congenital lobar emphysema

- Progressive over inflation of one or multiple lobes, usually of the upper lobes or right middle lobe.
- Left upper lobe is most commonly affected (43%).
- The word emphysema is misnomer as there is no alveolar wall destruction
- The etiology is unknown in many cases but is related to obstruction of the bronchus by a ball valve mechanism
- Present with respiratory distress (90%) with progressive cyanosis within 6 months of life.
- Associated congenital anomalies (cardiovascular) are seen in 50% cases
- Treatment is by lung resection

(Ref. Grainger Diagnostic Radiology, 4th Edition, Pg. 459,652)

22. **(B)** Bronchoalveolar cancer

1. Pleural effusion is seen by plain X-ray chest AP view and in lateral decubitus view. If these are still doubts, we can go in for USG
2. Interstitial lung disease is ideally evaluated with High Resolution CT.

3. Lung mass also can be evaluated by CT.
4. Mediastinal adenopathy is visible in plain X-ray chest, PA view as well as in CT.

HRCT is superior to the plain chest X-ray for early detection and confirmation of suspected ILD. Also, HRCT allows better assessment of the extent and distribution of disease, and it is especially useful in the investigation of patients with a normal chest radiograph. Coexisting disease is often best recognized on HRCT scanning, e.g., mediastinal adenopathy, carcinoma, or emphysema. In the appropriate clinical setting HRCT may be sufficiently characteristic to preclude the need for lung biopsy in IPF, sarcoidosis, hypersensitivity pneumonitis, asbestosis, lymphangitic carcinoma, and PLCH. When a lung biopsy is required, HRCT scanning is useful for determining the most appropriate area from which biopsy samples should be taken.

The other tests used for interstitial lung diseases would include

Radionuclide scanning: Gallium-67lung scanning is of limited value in evaluating the inflammatory component diethylenetriamene pentacetate (DTPA) is an index of pulmonary epithelial permeability that results from inflammation. This test may provide a means of assessing the activity of ILD. Normal 99mTC-DTPA clearance in IPF predicts stable disease, while rapid clearance identifies patients at risk for deterioration.

Pulmonary function testing: Spirometry and lung volumes measurement of lung function is important in assessing the extent of pulmonary involvement in patients with ILD. Most forms of ILD produce a restrictive defect with reduced total lung capacity (TLC), functional residual capacity, and residual volume. Forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) are reduced, but these changes are related to the decreased TLC. The FEV1/FVC ratio is usually normal or increased. Reductions in lung volumes increase as lung stiffness worsens with disease progression. A few disorders (uncommon in sarcoidosis and hypersensitivity pneumonitis, while common in tuberous sclerosis and LAM) produce interstitial opacities on chest X-ray and obstructive airflow limitation on lung function testing.

Diffusing capacity: A reduction in the diffusing capacity of the lung for carbon monoxide DLCO is a common but nonspecific finding in most ILDs. This decrease is due, in part, to effacement of the alveolar capillary units but more importantly, to mismatching of ventilation and perfusion (V/Q). Lung regions with reduced compliance due to either fibrosis or cellular infiltration ma be poorly ventilated but may still maintain adequate blood flow and V/Q in these regions act like true venous admixture. The severity of the reduction in DLCO does not correlated with disease stage.

Arterial blood gas: The resting arterial blood gas may be normal or reveal hypoxemia (secondary to a mismatching of ventilation to perfusion) and respiratory alkalosis. A normal arterial O_2 tension (or saturation by oximetry) at rest does not rule out significant hypoxemia during exercise of sleep. CO_2 retention is rare and is usually a manifestation of end-stage disease.

Cardiopulmonary exercise testing: Because hypoxemia at rest is not always present and because severe exercise – induced hypoxemia may go undetected, it is useful to perform exercise testing with measurement of arterial blood gases to detect abnormalities of gas exchange. Arterial oxygen desaturation, a failure to decrease dead space appropriately with exercise [i.e., a high VD/VT ratio], ad an excessive increase in respiratory rate with a lower than-expected recruitment of tidal volume provide useful information about physiologic abnormalities and extent of disease. Serial assessment of resting and exercise gas exchange in an excellent method for following disease activity and responsiveness to treatment, especially in patients with IPF.

Fibre optic bronchoscopy and bronchoalveolar lavage (BAL)

In selected disease (e.g., sarcoidosis, hypersensitivity pneumonitis, DAHs, cancer pulmonary alveolar proteinosis), cellular analysis of BAL fluid may be useful in narrowing the differential diagnostic possibilities among various types of ILD. The role for BAL in defining the stage of disease and assessment of disease progression or response to therapy remains poorly understood, and the usefulness of BAL in the clinical assessment and management remains to be established.

(Ref. Textbook of Radiology and Imaging, David Sutton, 7th Edition, Pg. 187)

23. **(D). All of the above**

All these conditions are associated with eggshell calcification

Honey combing is seen in:

- Histiocytosis X
- Tuberous sclerosis
- Sarcoidosis
- Pneumoconiosis
- Cryptogenic Fibrosing alveolitis
- Scleroderma
- Rheumatoid arthritis
- Lipoid pneumonia
- Extrinsic allergic alveolar
- Lymphangiomatosis
- Amyloidosis

Crazy pavement appearance is seen in alveolar proteinosis

(Ref. Harrison, 15th Edition, Pg. 1470; Oxford Textbook of Medicine 17.10)

24. **(A). Rheumatoid arthritis : Diffuse pulmonary hemorrhage**

Rheumatoid arthritis	:	Lung nodules
Scleroderma	:	Progressive pulmonary fibrosis
SLE	:	'*Shrinking lung*' syndrome
Wegener's granulomatosis	:	Cavitating lung lesions
Sarcoidosis	:	Bilateral symmetrical hilar adenopathy Parenchymal, interstitial & pleural changes
Good Pastures syndrome	:	Diffuse pulmonary hemorrhage
Sjogren's syndrome	:	Interstitial fibrosis similar to cryptogenic fibrosing alveolitis mainly affecting lower zones and lymphocytic interstitial pneumonitis

(Ref. Harrison's, 17th Edition, Vol. 2, Pg. 2078, 2088)

25.**(D). MRI**

Pancoast tumor includes bronchogenic carcinoma, usually squamous cell type, affecting left lung apex, eroding ribs (1st and 2nd) involving brachial plexus and sympathetic chain (Horner's syndrome). MRI is optimal modality to demonstrate the extent of superior sulcus tumor.

(Ref. Grainger Diagnostic Radiology, 4th Edition, Pg. 321, 463, 475)

26.**(A) Elevation of left main bronchus.**

Elevation of left main bronchus is the earliest chest x-ray sign of LA enlargement on chest xray . On barium swallow study the esophageal indentation is earliest evident.

(Ref. David Sutton, 6th Edition, Vol. 1, Pg. 345)

27.**(B) Emphysematous Pyelonephritis**

Emphysematous Pyelonephritis

- It is chronic suppurative granulomatous infection in diabetics.
- It can be type1 or type2.
- The infecting organism is usually E. coli.
- There is female preponderance.

- On x-ray there may be air lucencies seen.
- CT findings include loss of CM differentiation with calculi and low attenuation air foci in the renal parenchyma with/without in PCS and perinephric space and perirenal fat stranding.
- If untreated it can be life threatening.

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 1551, 1764)

28.**(A). USG**

Ultrasound scanning is the least invasive means of detecting hydronephrosis and has been used to diagnose pelviureteric junction obstruction in utero.

Excretion urography is helpful if there is still significant function in the obstructed kidney. The extrarenal pelvis is dilated and the minor calyces lose their normal cupping and become 'clubbed'. In very advanced cases, the thin rim of poorly functioning renal parenchyma may give a faint nephrogram around the dilated calyces — a 'soap-bubble' appearance. If the level of obstruction is in doubt it can help to take follow up films up to 24 hours after the contrast has been injected. The radio-opaque medium slowly diffuses to fill the obstructed system down to the block.

Isotope renography is the most helpful test to establish that dilatation of the renal collecting system is due to obstruction.

(Ref. Bailey and Love, 25th Edition, Pg. 1294)

29.**(B). Sonography can detect ureteral stones very sensitively and is therefore commonly used in the evaluation of renal colic**

Spiral CT without intravenous contrast is an easy and sensitive way to detect obstructing or nonobstructing ureteral calculi. If the calculus is larger than 5 mm, lithotripsy is usually necessary to fragment the stone to allow its passage. With stones less than 5 mm, hydration with pain management is usually adequate. The passage can be monitored with plain films.

Sonography is highly sensitive in the detection of hydronephrosis. It cannot detect ureteral stones, however, and is therefore not commonly used in the diagnosis or management of renal colic.

In patients with renal colic in whom CT does not detect a ureteral stone, other causes of pain can be evaluated with CT, thereby simplifying the diagnostic work-up.

(Ref. CEDT, 5th Edition, Pg. 761)

30.**(C).** Von Hippel Lindau syndrome

A well-circumscribed low attenuation mass lesion with central stellate scar and mild homogenous enhancement in a otherwise healthy middle aged female is very likely to be Oncocytoma.

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 1529)

Topic 2 – Gastrointestinal System, CVS, Musculoskeletal System

31.**(B). Angiography can image bleeding at a rate of 0.05-0.1 ml/min or less**

Detection of gastrointestinal bleeding depends on:

Angiography:

- Angiography will detect bleeding only if extravasation is occurring during the injection of contrast.
- Angiography detects bleeding at the rate of 0.5 mL/min
- Angiography is 63% sensitive for upper GI bleed and 39% for lower GI bleed while radionuclide methods are very sensitive in detecting blood loss from GIT, but less accurate than angiography in localizing the site of bleeding.
- Advantages:
  - Precise localization of bleeding site in areas inaccessible to endoscopy
  - Even in significant active bleeding, good angiography is almost certain in identifying the culprit site

- Transcatheter embolization can be simultaneously applied, especially to much wider range of lesions than endoscopy can.

Radionuclides scan:

- RBC nuclear scan (Tc-99m Sulfur colloid) detects bleeding at the rate of 0.05 - 0.1 mL/min with almost higher specificity, however are usually used as a complimentary to arteriography.
- Tc 99m-labeled RBCs are not useful in occult bleeding and detect acute /intermittent bleeding of 0.35ml or more per minute.

(Ref. Grainger Diagnostic Radiology, 4th Edition, Pg. 1171; RRM Dahnert, 5th Edition, Pg. 1111)

32. (C). Aberrant right subclavian artery

- **Aberrant right subclavian artery passes posterior to esophagus from left to right and cause indentation on esophagus.**

(Ref. Sutton, 7th Edition, Pg. 552-554)

33. **(A). MRI is used with HASTE being the "Work-horse"pulse sequence used**

- MRCP (Magnetic resonance cholangiopancreatography) is a radiological technique that produces images of the pancreatobiliary tree that are similar in appearances to those obtained by invasive radiographic methods, such as endoscopic retrograde cholangio-pancreatography (ERCP), MRCP do not require administration of contrast agents.

Diagnostic advantages	**Diagnostic contraindication**	**Contraindication**	**Complications**	**Comment**	**Limitations**
i) Magnetic resonance cholangiopancreatography :					
Useful modality for visualizing pancreatic and biliary ducts	Cannot offer therapeutic intervention		Claustrophobia		None
	Intervention		Certain metals (iron)		
Has excellent sensitivity for bile duct dilatation biliary stricture and intraductal abnormalities. Can identify pancreatic duct dilatation or stricture, pancreatic duct stenosis, and pancreas divisum					

ii. **Endoscopic Retrograde Cholangiopancreatogram :**

Simultaneous Gastroduodenal pancreatography	Pregnancy obstruction	Pancreatic	Cholangiogram of
Best visualization of distal biliary tract Bile or pancreatic cytology Endoscopic sphincterotomy and stone removal Biliary manometry treatment possibility	? Roux en Y biliary enteric anastomosis Perforation (rare) Prior biliary surgery Endoscopic Sphincterotomy - α	? Acute Severe cardio infected pancreatic pseudocyst pulmonary	Cholangitis, sepsis choice in : pancreatitis Absence of dilated ducts? pancreatic ampullary disease or grastroduodenal disease

(Ref. Harrison, 16th Edition, Pg. 1889)

34. **(C). Carcinoma stomach**

Ulcerating carcinoma of the stomach with mass is the most frequent type encountered in North America and Western Europe. These carcinomas have been described as irregular, saucer-shaped lesions with ulcerated centers. Such a configuration may produce the meniscus or Carman sign, which indicates a large irregular ulcer with a mass. This is a long-present lesion. The size of the tumor is not in itself an indication of benignity or malignancy. The most important criteria for malignancy are irregularity of the ulcer, failure to project from the lumen of the stomach, and nodularity of the surrounding mass. Occasionally a benign ulcer surrounded by a large ulcer mound may simulate an ulcerating carcinoma.

(Ref. Grainger diagnostic Radiology, 4th Edition, Pg. 1043, 1057)

35. **(C). Periampullary carcinoma**

Ampullary carcinoma

Malignant epithelial neoplasm arising from ampulla of Vater

Patients present with jaundice, abdominal pain and weight loss with typical history of passing silvery stools

Classic imaging appearance:

Lobulated soft tissue mass arising from ampulla of Vater

"Double duct sign" with obstruction of PD.

(Ref. Bailey & Love, 25th Edition, Pg. 1148-1152)

36. **(A).** Pancreatic infiltration

On barium meal, the loop of duodenum is widened also k/a Pad Sign in cases of carcinoma head of pancreas.

(Ref. Das manual on Clinical Surgery, 5th Edition, Pg. 368)

37. **(C). ''Tooth paste' appearance of ileum**

Intestinal TB:

The main types of intestinal TB are ulcerative form (most frequent), hypertrophic form and mixed form.

Location: Ileocaecal region > ascending colon > jejunum > appendix > duodenum > stomach > sigmoid > rectum > esophagus.

i. Ileocaecal area:
- Stierlin sign → rapid emptying of narrowed terminal ileum into shortened rigid obliterated caecum on barium examination.
- Thickened Ileocaecal valve
- Fleischner's sign (inverted umbrella defect) → wide gaping patulous ileocaecal immediately adjacent terminal ileum
- Deep fissures + large shallow linear/stellate ulcers with characteristic elevated margins.
- Symmetric annular 'napkin ring' stenosis
- Widened IC angle (Normal is 90^{o}) → it becomes obtuse

ii. Colon:
- Segmental colonic involvement
- Diffuse ulcerating colitis + pseudopolyps
- Amputated/ Coned/ Contracted caecum

iii. Gastroduodenal:
- Simultaneous involvement of pylorus + duodenum → 'Linitus plastica' appearance.
- Linitus plastic may also be a feature of gastric lymphoma and Scirrhous carcinoma, eosinophilic gastritis

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 1087, 1134)

38. **(D). Colovesical fistula**

Ulcerative colitis
- Inflammatory bowel disease
- Rectum is always involved
- Bloody diarrhea is the most common presentation

Double Contrast Barium Enema (DCBE) is the radiological examination of choice to show disease extent and severity

Instant enema → In UC the large bowel is inflammed and contains no fecal matter, and hence enema study can be done without bowel preparation.

Acute changes:
1. *Earliest radiological change* on DCBE is blurring of mucosal lining and a fine mucosal granularity (enface) due to edema.
2. Colorectal narrowing and incomplete filling due to spasm and irritability
3. Scalloping of the edges of colon, especially the sigmoid colon
4. Mucosal stippling due to crypt abscesses (continuous; not transmural)
5. 'Collar button' ulcers
6. Toxic megacolon
7. Pseudopolyps

Chronic changes:

1. Shortening and narrowing of colon
2. 'Lead pipe' colon
3. Loss of haustrations
4. Backwash ileitis
5. Thickened rectal valve

6. Widening of Presacral space (normally 1.5 cm at S_4 vertebral level)
7. Benign stricture
8. Carcinoma of colon/rectum

(Ref. Sutton's Radiology, 7th Edition, Pg. 647, 648)

39. **(C). USG**

Barium enemas although have added advantage of chances of reduction of **Intussusception,** but there occurs ionizing radiation dose exposure.

Ultrasonography can promptly diagnose **Intussusception,** without risk of radiation hazard and if required under image guidance hydrostatic saline reduction can be attempted.

(Ref. Harrison's Principles of Internal Medicine, 17th Edition, Vol – II, Pg. 1904)

40. **(D). Pneumoperitoneum**

Pneumoperitoneum is characterized by free gas under the domes of diaphragm.

Signs of Pneumoperitonium on supine film are:

- Football sign (air dome)
- **Rigler's double wall sign** (visualization of both sides of bowel wall)
- Saddlebag/mustache Cupola sign (air trapped below the central tendon of diaphragm)
- Doge's cap sign (triangular collection of gas in Morrison's pouch)
- Lucent liver sign
- Inverted 'V' sign (medial and lateral umbilical ligament visualization)
- Visualization of falciform ligament
- Urachus sign
- Right upper quadrant gas (perihepatic, subhepatic, Morrison's pouch)
- Gas in scrotum (in children)
- Tell-tale triangle sign (air seen between bowel loops) on lateral horizontal beam film

(Ref. Grainger's Diagnostic Radiology, 4th Edition, Pg. 991)

41. **(A). Carolis disease**

Caroli's disease is a rare, congenital cystic dilatation involving intrahepatic bile ducts. The term Caroli's syndrome is used if the above anomaly is associated with congenital hepatic fibrosis. These entities belong to the group of hepatic fibropolycystic diseases, which are usually associated with renal polycystic disease. We report a case of Caroli's syndrome presenting as portal hypertension with medullary sponge kidneys. The classical "**central dot sign**" described on CT is well **demonstrated easily on ultrasound**. Awareness of this finding is highlighted

Caroli's disease is characterized by congenital, segmental, nonobstructive, saccular dilatation of intrahepatic bile ducts without other hepatic abnormalities. It was presumed to be autosomal recessive in character. Two forms of the disease have been described. The rare, so called pure form described by Jacqui Caroli is characterized by segmental saccular communicating intrahepatic bile duct dilatation, frequently present with stone formation, recurrent cholangitis and hepatic abscess. The liver involvement can be diffuse, lobar or segmental. It usually presents in childhood and about 75% of affected patients are boys. Cholangiocarcinoma can develop in 7% of patients. Caroli's syndrome is another form that is more common and is associated with congenital hepatic fibrosis. The dilatation of intrahepatic biliary ducts in usually less prominent. Both the conditions result from malformation of the embryonic ductal plate at different levels of the biliary tree http://www.ijri.org/article.asp?issn=0971-3026;year=2000;volume=10;issue=3;spage=173;epage=174;aulast=Moorthy - ref3#ref3. These patients present with features of portal hypertension. This ductal plate malformation of the interlobar bile ducts results in malformed and abnormally shaped branch bile ducts, around the portal tracts. Some of the bile ducts contain bile. There is no inflammation or regeneration of nodules. Choledochal cysts may be

associated. Portal hypertension is caused by hypoplasia or fibrous compression of portal vein radicles in the fibrous bands surrounding the nodules. These dilated sacculi or cystic spaces appear as anechoic areas on ultrasound and are hypodense on CT. The fibrovascular bundles containing portal vein radicals and a branch of the hepatic artery bridging the saccule appears as a central dot or a linear structure on CT, enhancing with contrast. This "central dot sign" described on CT can be easily seen on ultrasound as demonstrated in our case. Awareness of this finding on ultrasound can result in proper diagnosis and can avoid invasive tests for confirmation. The dilated cysts communicate with bile ducts. On color flow Doppler imaging, flow can be demonstrated within the linear strands. Cholangiography shows diverticulum-like sacculi of intrahepatic bile ducts of varying sizes, shapes and distribution. Calculi are common. The common bile duct is normal. Hepatic scintigraphy with 99 mTc diethyl IDA shows the typical "beaded" appearance of dilated intrahepatic bile ducts. In Caroli's syndrome both CT and ultrasound show focal mild dilatation of intrahepatic bile ducts (2-3 mm). The liver shows changes of portal hypertension (shrunken liver, splenomegaly, splenic and esophageal varices and ascitis). Intrahepatic biliary calculi are absent. Cholangiography shows typical findings of focal segmental dilatation. The MRCP findings in Caroli's disease are similar to ERCP [8]. Caroli's disease may be associated with choledochal cysts, medullary sponge kidney, infantile and adult polycystic kidney disease and cystic renal dysplasia. Cholangiocarcinoma may be a complication. Cirrhosis of liver mimics this condition and can be differentiated by biopsy where there will be hepatocellular dysfunction. Caroli's disease is sometimes included in the classification of choledochal cyst, which is not appropriate since choledochal cysts occur in extra hepatic bile ducts and there is no renal involvement.

(Ref. http://www.ijri.org/article.asp?iss, Pg.0971-3026; year=2000; Volume=10; Issue=3; Pg. 173; Pg. 174; aulast=Moorthy)

42. **(A). USG abdomen**

Benign strictures of the biliary tree have a variety of causes including traumatic, chronic pancreatitis, gallstones, infection, and other rare causes. Surgical injury is by far the most common and accounts for 95% of cases.

At cholangiography, benign strictures are typically focal, smooth areas of narrowing with proximal biliary dilatation.

CT and ultrasonography typically show only the duct dilatation with a gradual tapering of the duct diameter, without a surrounding mass present.

Postcholecystectomy strictures usually occur in the mid common duct near the junction with the cystic duct, although if instrumentation of the duct is performed, strictures can occur more distally as well. Distal strictures at the sphincter of Oddi may be difficult to diagnose at cholangiography, since the duct normally terminates in this region. An elongated or rigid ampullary segment and failure of the CBD to drain contrast material at 45-minute delay filming is highly suggestive of stricture.

ERCP has become **primary method** of direct cholangiography and additionally it offers the ability to examine upper GIT, the papilla of Vater and the pancreatic duct.

It has developed considerable therapeutic potential and guided biopsies are possible. Post cholecystectomy biliary stricture is important to identify and if ultrasound or other studies suggest that obstruction is low, ERCP is investigation of choice.

(Ref. Sutton's Radiology 6th Edition, Pg. 963, 971, 972);

43. **(B). CECT**

CECT is investigation of choice for Acute pancreatitis.

CT also is useful to predict the severity of the case.

Scoring system for severity of Acute Pancreatitis by CT is called CT severity Index/CTSI and is as follows:

CT features	Score
I. Grade	
Normal gland	0
Focal / diffuse enlargement	1
Peripancreatic inflammatory changes	2
Single Peripancreatic fluid collection	3
2 or more fluid collections or abscess	4
II.Necrosis	
None	0
< 33%	2
33-50%	4
> 50%	6

Total CTSI (0-10) = Balthazar grade (0-4) + CT scoring (0-6)

Score	Morbidity	Mortality
0-3	8%	3%
4-6	35%	6%
7-10	92%	17%

(Ref. Bailey & Love, 25th Edition, Pg. 1140-1141)

44. **(C). Focal nodular hyperplasia**

Liver parenchyma is primarily made up of two type of cells :

1. Hepatocytes → Perform excretory & synthetic function
2. Kupffer cells → They have Reticuloendothelial function.

Both these cells can be investigated with Tc labeled cells. Two types of Radionucleotide imaging procedure are used in liver.

A. Hepatocytes based imaging (IDA imaging)

IDA compounds are taken up by functioning hepatocytes, excreted unchanged in bile & not resorbed from the gut.

It will allow imaging of liver parenchyma, trace the flow of bile, in the ducts, gall bladder & bowel.

Its uses are

a) Assessment of liver function
b) Biliary obstruction
c) In liver trauma to see bile leaks
d) Choledochal cyst
e) Demonstration of G. B. Function

B. Colloid Scintigraphy

They demonstrate the functioning tissue by targeting the reticuloendothelial cells of liver.

Interpretation is :

Non functioning area → Mass lesion which do not contain functioning RE cells

Hot spots → Mass lesions which contain functioning RE cells (Kupffer cells)

Focal Nodular hyperplasia →

Only liver tumour which consistently contains functioning RE cells & shows uptake of labelled colloids.

FNH also contains functioning hepatocytes and takes up IDA compound.

Histology typically shows presence of bile ductules within FNH but ducts do not communicate with biliary tree so there is no excretory pathway.

This explains why FNH lesions characteristically show prolonged retention of IDA on delayed images.

Hepatic Adenoma

This Benign tumour contains little functioning RE cells so colloid scan will show non functioning area.

IDA scan will show normal Hepatocytes

Hepatic carcinoma

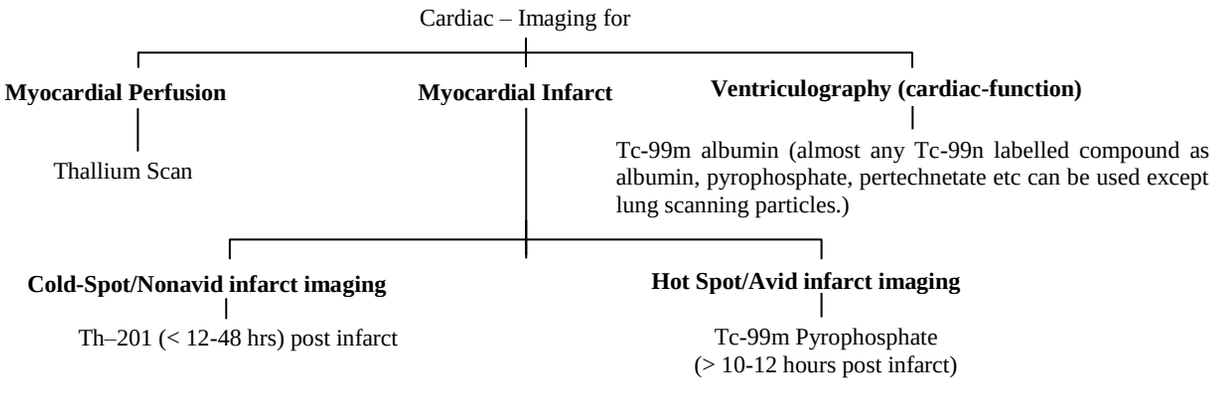
Contain little or no functioning liver tissue. Both the colloid and IDA uptake is very low.

(Ref. Sabiston, 16th Edition, Pg. 1015-1016; Bailey & Love, 24th Edition, Pg. 1068)

45. **(B). Thallium-201 scan**

- For myocardial perfusion imaging agent of choice is Thallium-201-chloride.
- Interpretation of stress thallium image

Immediate Image	Delayed Image	Diagnosis
Normal	Normal	Normal
Defect	Fill-in	Reversible/Excretional
Defect	Defect	Ischemia
Defect	persist	Myocardial-scar
	Partial fill-in	Scar + Persistent Ischemia



(Ref. Braunwald Heart Disease, 6th Edition, Pg. 279; Wofgang, 5th Edition, Pg. 1102; Harrison, 15th Edition, Pg. 1276)

46. **(D) Pulmonary venous hypertension**

There is dialation of upper lobe pulmonary veins and constriction (l/t oligemia) of lower lobe veins causing inverted moustache sign, in mitral stenosis.

In mitral stenosis there is increase in PCW pressure which cause radiological changes.

PCWP (mm hg)	Finding
5 -12	Normal
12-17	Cephalization of pulmonary vessels (only in chronic conditions)
17-20	Kerley lines, subpleural effusion
> 25	Alveolar flooding edema

Radiographic changes of mitral valve disease (mainly rheumatic)

1. Left atrial enlargement seen as straightening of left border to bulge immediately below left bronchus.
2. Upper lobe blood diversion seen as distension of upper lobe veins and constriction of lower lobe veins.
3. Interstitial Edema seen as Kerley's septal costophrenic B lines and central A lines.
4. Alveolar edema seen as perihilar confluent shadows.
5. Pulmonary hemosiderosis seen as fine punctuate densities through out lung (miliary shadow) usually after years and in MS
6. Pulmonary ossified nodules seen as discrete calcified densities at the lung base, is d/t PAH in long standing MS.
7. Pulmonary arterial hypertension seen as enlargement of main pulmonary artery and central pulmonary vessels with peripheral vessels pruning.

(Ref. Grainger, 4th Edition, Pg. 833/ 877; Harrison)

47. **(C). Echocardiography**

Pericardial Effusion		
X-Ray	Investigation of choice	Best investigation
Water bottle / Pear shaped heart	Echocardiography	CT / MRI Used when echo is equivocal or if epicardial fat is present

(Ref. Branwald – heart disease, 6th Edition, Pg. 1839)

48. **(C). Gating is not required with 1.5T MRI machines.**

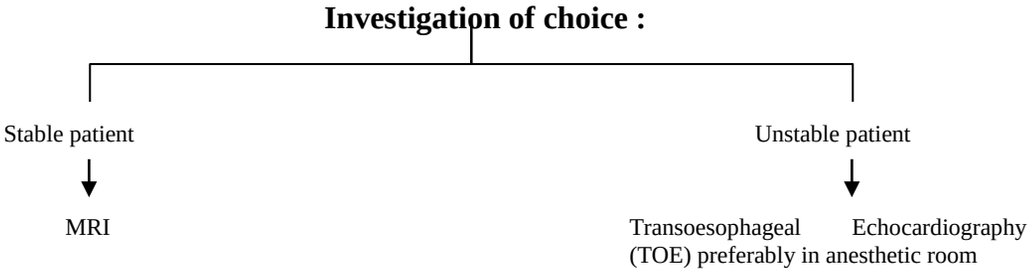
Echocardiography often displays the tumor as a mass adjacent to the heart, but CT or MRI can only show the exact localization of the tumor and its relationship to the pericardium. In patients with suspected pericardial or paracardiac tumors, MRI has advantages over CT because it is a multiplanar modality. Coronal or sagittal images may more clearly demonstrate the relationship of tumor, pericardium, and other cardiac structures.

(Ref. Radiology by David Sutton, 7th Edition, Pg. 349)

49. **(C). MRI**

- Most patients are in 50-70 years age group presents with very sudden onset pain often accompanied by tearing sensation. It is usually felt in the precordium and substernal region but may be in back between scapula. These patients are usually misdiagnosed as having cardiac ischemia, which increases risk of complications.
- Dialation and dissection in Marphan Syndrome are probably caused by a failure to resist shearing stress in media. In Ehlers-Danlos collagen molecule abnormalities predispose to dilation and saccular aneurysms but not to dissection these patients have normal resistance to shearing stress.
- Stanford classifies it into two types as Type A (involving ascending aorta) – which is more common and carry high probability to complications and mortality; and Type B (not involving ascending aorta).

Investigation of choice :



- Aortography is the gold standard

(Ref. Grainger, 4th Edition, Pg. 956-58)

50. **(B). Fracture of dens**
- MRI is the investigation of choice for imaging traumatic spine and parenchymal disesase.
- CT is second best investigation.

(Ref. Maheshwari, 3rd Edition, Pg. 154)

51. **(C). Pyle's disease**

Wormian bones can be seen in:
- Normal infants (up to 6 months of age)
- Down's syndrome
- Cleidocranial dysostosis
- Hypothyroidism
- Hypophosphatasia
- Healing phase of Rickets
- Osteogenesis imperfecta
- Otopalatodigital syndrome
- Kinky hair syndrome
- Progeria
- Pachydermoperiostitis
- Pyknodysostosis

(Ref. Grainger Diagnostic Radiology, 4th Edition, Pg. 1949)

52. **(D).** It is 6 times more common in males.

Developmental dysplasia of the hip (DDH)

- The hip is a ball and socket joint with the ball (called the femoral head) coming from the top part of the femur (thigh bone) and the socket (called the acetabulum) coming from the pelvis.
- The cause is unknown, but genetic factors may play a role.
- Problems resulting from very mild developmental dysplasia of the hip may not become apparent until the person is in their 30's or 40's.
- One or both hips may be involved.
- Risk factors include being the first child, being female, a breech delivery, and a family history of the disorder.
- A hip radiograph is helpful in older infants and children. But, ultrasound of the hip remains the most important imaging study and will demonstrate hip deformity.
- When the ossification center is in the upper outer quadrant, the hip is dislocated.

(Ref. Sutton, 6th Edition, Pg. 1105)

53. **(B).** Tuberculosis
Causes of vertebral destruction without loss of OR maintained of IVD space :
- Lymphoma
- Metastases
- Trauma
- Osteoporotic fractures

(Ref. Radiology Review Manual, 5th Edition, Pg. 182)

54. **(A). Ankylosing spondylitis**
"Iliac horns" are feature of Nail Patella syndrome.

Diagnostic radiological features of Ankylosing spondylitis are:
- Bilateral symmetrical Sacroilitis (earliest and most specific feature)
- Bamboo-spine (knobby spine, poker back or universal syndesmophytosis) is a characteristic feature of it.
- Syndesmophytes are gracile ossifications of the outer fibers of annulus fibrosis.
- Enthesitis (earliest pathological change)
- Uncommon involvement of small joints of hand and feet.

(Ref. Sutton's Textbook of Radiology, 6th Edition, Pg. , 1220)

55. **(B). Growth arrest lines**
Characteristic radiological signs in scurvy :
1. The **epiphysis** is small & sharply **marginated** by **sclerotic rim** (Wimberger sign)
2. The zone of provisional calcification at the growing metaphysis is dense, giving a white line **(Frankel's line)**
3. Beneath this is a lucent zone due to lack of mineralization of osteoid (Trumerfeld zone)
4. As this area is weakened, it is prone to fractures which manifest themselves at the cortical margin, giving rise to **(Pelkan's) spurs**.
5. Periosteal elevation due to subperiosteal hemorrhages and subsequent new bone formation particularly following treatment.

(Ref. Textbook of Radiology & Imaging, Sutton, 7th Edition, Pg. 1356)

56. **(D). Magnetic Resonance Imaging (MRI)**
Perthe's disease is a type of aseptic necrosis of bone that occurs in the femoral head. It has numerous causes like trauma, hemolytic anaemia, diabetes, etc.
MRI is best imaging modality for showing early change of Perthe's disease such as bone marrow oedema & surrounding soft tissue changes. These are signs that are evident before any bone change like reduced bone density.
CT will show early bone changes like devascularisation but is not able to shows marrow changes. X ray changes take much longer.

(Ref. Sutton 6th edition. Pg.68-70)

57. **(C). Osteopetrosis**
In osteopetrosis there is reduced osteoclastic bone resorption resulting in diffuse symmetrical skeleton sclerosis. Also k/a marble bone disease d/t its stone like quality of bones; however the bones are abnormally brittle and fracture like a piece of chalk. It can present radiologically as
- Sclerosis of all bones more prominent at base of skull

- Sclerosis of vertebral end plate l/t characteristic sandwich or broad stripped (rugby jersey spine).
- Bone in bone appearance d/t sclerotic foci with in the bone.

(Ref. Robbin's Pathological basis of disease, 7th Edition, Pg. 1281)

58. **(A). Leprosy**

Abnormalities in the forefoot may reflect infection alone, neuropathy alone, or a combination of neuropathy, infection, and small-vessel disease. Although abnormalities in the midfoot and hindfoot are most likely to represent neuropathy, osteomyelitis of the calcaneus may arise secondary to an underlying infected plantar ulcer. Hypertrophic or atrophic neuroarthropathy may occur in the forefoot. In the atrophic type, osteolysis of the distal ends of the metatarsals combined with broadening of the bases of the proximal phalanges produce "pencil and cup" deformities that simulate those of leprosy; *"sucked candy-stick" or "sharpened pencil" deformities of the metatarsal heads* may occur. Alternatively, the metatarsal heads may become flattened or fragmented. Dorsiflexion and shortening of the toes combined with plantar subluxation of the metatarsal heads predispose to neurotrophic ulceration of the soft tissues beneath the metatarsal heads and over the proximal interphalangeal joints. Unperceived chronic trauma may lead to periosteal reaction along the shaft of a bone in the absence of infection and may evolve into sclerosis of the entire shaft. Infection may accompany the neuropathic changes and accelerate joint destruction. Neuroarthropathy is a contraindication to joint replacement because of the associated tendency to instability resulting from unrecognized trauma combined with subluxation.

(Ref. Sutton's Radiology, 6th Edition, Pg. 61, 62)

59. **(B). Chondrosarcoma**

The given clinical, radiological, and histological features are classical of chondrosarcoma.

Cartilagenous benign tumors:

- Enchondroma
- Chondroblastoma
- Chondromyxoid fibroma

Cartilagenous malignant tumor:

- Chondrosarcoma

(Ref. Apley's System of Orthopedics, 5th Edition, Pg. 171)

Topic 3 – Head, Neck & Spine, Endocrine System Obstetrics & Gynecological Radiology, Breast Imaging & Interventional Radiology

60. **(B). Eosinophilic granuloma**

Histiocytosis commonly involves the skull, particularly in Letterer- Siwe and Hand Schuller Christian disease where the typical 'geographical skull' defects may be seen. Eosinophilic granuloma may present as an isolated lesion.

(Ref. Harrison, 17th Edition, Pg. 374)

61. **(A). Helical CT scan without IV contrast**

In head trauma the imaging study of choice is CT scan.

Usually is contrast study is not needed for head injury per se.

Skull radiographs have extremely limited value as compared to CT except in evaluation of skull fractures that to depressed skull fracture/fracture base of skull.

Indications for CT include:

- **Loss of consciousness**
- **Altered mental status**
- **Focal neurologic signs**
- **Clinically suspected basilar fracture**
- **Depressed skull fracture**
- **Penetrating wound (e.g. bullet)**
- **Suspected acute SAH/EDH/SDH/ Parenchymal Hematoma.**

(Ref. RRM by Dahnert, 5th Edition, Pg. 285)

62. **(C). Crescent-shaped hyperdense lesion**

An acute subdural hematoma, i.e, within 48 hours of injury, appears on non –contrast CT scan as a **hyperdense (white), crescentic (concavoconvex) mass** along the inner table of the skull, most commonly over the frontoparietal regions or middle cranial fossa and associated with ipsilateral brain swelling. Subdural collection are generally of higher attenuation than the brain for about two weeks, and after three to four weeks are of lower attenuation, eventually approaching that of CSF.

Extradural hematomas appear as high – density, biconvex (lentiform) areas immediately subjacent to the vault.

Subacute subdural hematomas often become lens-shaped and can be confused with an epidural hematoma.

(Ref. Textbook of Radiology & Imaging, Sutton, 7th Edition, Vol.2, Pg. 790)

63. **(B). Herpes simplex encephalitis**

Herpes simplex encephalitis predominantly involves the **temporal** and **frontal** lobes and presents with fever, headache, behavioral changes, **confusion**, **focal neurological findings** and abnormal CSF findings. There are, however, no pathognomonic clinical findings and the definitive diagnosis depends upon the identification of HSV within the CSF by means of PCR or within the brain tissue by means of brain biopsy. **MRI**, which is highly sensitive to white matter changes, is the investigation of choice and reveals the lesions as **high signal (hyperintense)** on T_2 weighted images. Hemorrhage may occur as increased signal on T_1 weighted images & usually implies extensive necrosis. MRI also shows periventricular signal change not apparent on CT.

MRI in neurocysticercosis shows small rounded, cyst like structures due to the individual bladders. Small calcified foci representing the residual scolex are not identified on MRI.

Acute pyogenic meningitis does not generally produce changes in the CT or MRI, though evidence of ischemia or empyema may be seen.

Carcinomatous meningitis, on MRI, demonstrates meningeal enhancement, usually at the basal cisterns. The ventricular lining is frequently involved.

(Ref. Harrison, 17th Edition, Pg. 1088, 2625, 2630-2633, 1097-1100)

64. **(D).** Radiotherapy is treatment of choice

Angiofibroma is very vascular tumor of **teen age boys. CT scan** is the inv. of choice to see the extent of invasion.

Juvenile Nasopharyngeal Angiofibroma/ Nasopharyngeal fibroma

CT Scan with contrast enhancement	**MRI**
• **Inv. of choice** • Anterior bowing of posterior wall of maxillary sinus (antral sign) is	• When soft tissue extension is present intracranially / infratemporal fossa or into the

(Ref. P. L. Dhingra, 3rd Edition, Pg. 300)

65. (B). Meningiomas

A number of neoplastic lesions in the head and neck area are hypervascular, most commonly meningiomas and hemangioblastomas intracranially and paragangliomas and juvenile nasopharyngeal angiofibromas extra cranially.

(Ref. Radiology Review Manual, 5th Edition, Pg. 299)

66. **(D). Arteriography**

Arteriography is considered the gold standard in evaluation of **arteriovenous fistula, aneurysm and aortic dissection.**

- Aneurysm is a sac filled with blood in direct communication with the interior of an artery. A true aneurysm is due to local dilatation of the artery where as a false aneurysm is a sac with walls formed of condensed connective tissue which communicates with the lumen of the artery through its apparatus in its wall. Aneurysm may be classified into congenital, infective, degenerative, dissecting, post stenotic, post inflammatory (arteritic; necrotic), traumatic and cirsoid.
- Arteriography is the gold standard for all types of aneurysms; but in dissecting aneurysm (aortic dissection) the investigation of choice is MRI in stable patients and TOE (trans oesophageal echocardiography) in unstable patients.
- For detecting aortic dissection MRI had a **sensitivity** of 98.3%, TOE 97.7%, CT 93.8% and TTE 60% (MRI>TOE>CT>TTE). MRI had **specificity** of 97.8%, CT of 87%, TTE 83% and TOE 77% (MRI>CT>TTE>TOE). MRI and CT were more sensitive than TTE in **detecting thrombus formation** but not superior to TOE (TOE>MRI>CT>TTE). CT was not effective in detecting the entrance site or regurgitation but MRI and TOE accurately identified both.
- **Aortography (Arteriography)** is considered the **gold standard** in evaluation of aortic dissection. The diagnosis can be made by recognizing an initial flap or a double lumen, findings which are pathognomic. The indirect findings are – compression of true lumen, thickening of aortic valve, branch vessel abnormalities, aortic insufficiency or an ulcer like projection beyond the aortic intima wall.

(Ref. Wolfgang Dan hert, 5th Edition, Pg. 604-605;
Grainger and Allison's 4th Edition, Pg. 841-843, 956-958, 2379)

67. **(B).** low grade astrocytoma

Usually low grade astrocytomas do not show contrast uptake.

(Ref. Sutton, 7th Edition, Pg. 1752)

68. **(**D) Corpus callosal lipoma

Corpus callosal lipoma shows bracket clacification.

Meningiomas show the highest incidence & the density of calcification among brain tumours. It also typically causes hyperostosis of overlying skull vault. Ependymomas & medulloblastomas also calcify but to lesser extent. Plain CT scan is the most sensitive investigation for tumour calcification.

(Ref. www.emedicine.com/RADIO/topic439.htm; Harrison, 17th Edition, Pg. 2605, 2606)

69. **(B).** Neurofibromatosis

Neurofibromatosis, Ankylosing spondylitis, ependymoma & achondroplasia cause posterior scalloping.

Causes of anterior scalloping of vertebrae :

a) Aortic aneurysm
b) Lymphadenopathy
c) Multiple myeloma
d) Tuberculosis

(Ref. Textbook of Radiology & Imaging – David Sutton, 7th Edition)

70. **(A). White matter**

Disease related changes are detected by MRI in more than 90% of patients who otherwise meet diagnostic criteria for definite multiple sclerosis. On inversion-recovery of T_1-weighted imaging sequences, the brain may appear normal or show darkened (hypodense) punctuate foci in the white matter.

Characteristic changes of MS are best appreciated with spin-echo (T_2 weighted) and proton density sequences, in which abnormal hyperintense areas stand out brightly from the surrounding brain substance.

Some foci that are hyperintense on T_2 weighted image may appear to extend outward from the ventricular surface, corresponding to a pattern of perivenous demyelination that is pathologically observed in MS (Dawson's fingers) Lesions are also commonly found within the brain stem, cerebellum and spinal cord.

Multiple sclerosis (MS) is characterized by a triad of inflammation, demyelination, and gliosis (scaring). For diagnosis of **(MS)** involvement must reflect predominantly disease of white matter long tracts, usually including (a) pyramidal pathway (b) cerebellar pathway (c) medial longitudinal fasciculus (d) optic nerve (e) posterior columns :

- Lesions in the anterior corpus callosum are helpful diagnostically because this site is usually spared in cerebrovascular disease.

(Ref. Harrison, 17th Edition, Vol. II, Pg. 2074, 2611)

71. **(B). Amyotrophic lateral sclerosis**

Amyotrophic lateral sclerosis

It is characterized by progressive muscle weakness, limb and truncal atrophy and bulbar signs and symptoms. Mean age at diagnosis at 57 years. Disease progression is relentless; half the patients are dead within 3 years and 90% have died by 6 years following symptom onset.

Non-tau inclusions and degeneration in spinal motor neurons and pyramidal tracts (Corticospinal tracts) usually produce no specific sign on MRI except for occasional signal changes on T2WI. T2WI disclose high signal areas along the large myelinated pyramidal tract fibers in the posterior limb of the internal capsule and cerebral peduncles in about 25% cases.

(Ref. Annie Osborn Diagnostic Neuroradiology, Pg. 778)

72. **(B). Oligodendroglioma**

Intradural metastases (drop metastasis) are a frequent complication of intracranial medulloblastoma, ependymomoblastoma, and pineal germinomas and are less commonly associated with high-grade astrocytomas, mature ependymomas, malignant choroid plexus papillomas, and angioblastic meningiomas.

Patients with intracranial medulloblastoma, ependymomoblastoma, and pineal germinomas are routinely surveyed by gadolinium- enhanced spinal MRI for evidence of CSF dissemination and drop metastases, and CSF cytology remains the definitive analysis for drop metastases.

(Ref. Sutton, 6th Edition, Pg. 1602, 1474, 1611, 1600-2)

73. **(B). Ultrasound**

Hydrocephalus

Obstetric ultrasound study is one of the best methods for antenatal diagnosis of hydrocephalus as it is noninvasive and hazard-free not only to fetus but also to mother.

However, assessment prior to GA of 20 weeks may be difficult, as ventricles constitute a large portion of cranial vault.

Signs suggestive of fetal hydrocephalus on obstetric USG study are:

- Atrial size > 10 mm
- Dangling "choroid plexus" sign
- Banana sign
- Lemon sign
- BPD > 95th percentile
- ± Polyhydramnios

(Ref. Sutton Radiology, 6th Edition, Pg. 1586)

74. **(A). Cavernous hemangioma**

Extraaxial cavernous hemangiomas: Rare and very rarely arise in the cavernous sinus. Although this malformation is categorized as a vascular malformation and has well-defined histologic characteristics, it sometimes presents tumor like behavior, including mass effects, enclosure of neurovascular structures, and proliferation during pregnancy.

The lesions are found predominately among women.

The onset of symptoms is usually insidious, and symptoms are caused by the large size of the lesions.

Patients usually present with headaches and dysfunction of the cranial nerves passing through the cavernous sinus, manifesting particularly as ptosis and diplopia. MRI reveals well-defined masses that are **Hypointense** or **isointense** on t1-weighted images and **markedly hyper intense on t2-weighted** images, which indicates the relationship between the lesion and the intracavernous ICA.

The marked hyper-intensity on t2-weighted images and homogenous enhancement seem to distinguish these lesions from other types. **Meningiomas often similar signal intensity** to gray matter **on both t1- and t2-weighted images**.

Schwannomas tend to give **lower signal intensity than gray matter on t1-weighted** images and **almost uniformly give higher** signal intensity **on t2-weighted** images.

Both Schwannomas and meningiomas show **prominent contrast enhancement**, which tends to be a **slightly heterogeneous pattern**.

(Ref. Characteristic MR Imaging Findings of Cavernous Hemangiomas in the Cavernous Sinus. American Journal of Neuroradiology 24:1148-1151)

75. **(D). Odontoid view**

Jafferson's Fracture

- It is most common type of atlas fracture. It is cause by axial compression force (with or with out extension force), resulting from a fall on the head from a height or mass falling on head. This mechanism of injury results in a burst fracture of ring of atlas (C1) vertebrae, that occurs secondary to the occipital condyles being driven into the interior portions of the ring of atlas and driving the lateral masses outwards.
- Lateral displacement of C1 lateral mass lateral the outer cortex of the C2 lateral mass raises concerns for the structural integrity of the transverse Atlantal ligament (TAL). The stability of atlas depends on TAL.
- Due to outward movement of lateral masses, there is no encroachment on the neural canal and, usually, no neurological damage.
- Classical Jafferson's fracture (as described by Jafferson in 1920) was four part fracture of ring of atlas (2 part # of anterior ring & 2 part # of posterior ring). However more common are two part or three part fractures.

- It is typically diagnosed on plain radiographs
  - Open mouth (odontoid) view may show asymmetry of the lateral masses of C1 on C2 with overhang.
  - A bilateral overhang > 6.9 mm suggests disruption of transverse ligament and potential late instability.
  - On lateral radiograph presumptive evidence of transverse ligament disruption is >4mm atlanto-dents interval.
- Coronal CT reformation provides the best method of evaluating important atlas fracture characteristics.

(Ref. Apley's System of Orthopaedics & Fractures, 8th Edition, Pg. 650-51;Current Diagnosis & Treatment in Orthopaedics, 3rd Edition, Pg. 271-72)

76. **(B).** 'Mercedes Benz' sign

'Mercedes Benz' sign is seen in gallstones (tri-radiate).

77. **(B). Myelomalacia**

Both cord edema and myelomalacia appear as On T1 – III defined hypointense area On T2 – Hyperintense area		
	Cord Edema	**Myelomalacia / Cord atrophy**
Etiology	Reflects focal accumulation of intracellular & interstitial fluid in response to injury	In end stage of cord trauma and result of trauma, ischemia and release of vasoactive substances & cellular enzyme
MRI T1WI T2WI	• III defined hypointense area • Focus of hyperintensity	• Poorly marginated hypointense area • Hyperintense cord parenchyma

(Ref. MRI of Brain & Spine by Scott W. Atlas, 3rd Edition, Pg. 1802, 1810)

78. **(A). Hyperechoic**

Virtually all thyroids Ca are poorly echogenic and majority will show invasion into thyroid stroma and thyroid capsule whereas thyroid adenoma are hypoechoic compared to normal thyroid tissue.

(Ref. Text book of Radiology, D. Sutton, 6th Edition, Pg. 1293-1294)

79. **(C). Radio nucleotide scan**

Neuroendocrinal tumors (NET) are derived from diffuse neuroendocrine system of gastrointestinal (GD) tract, which is composed of amine and acid producing cells with different hormonal profiles depending on the site of origin.

Net refers to two types of tumors

Name	Biologically active peptide secreted
I. Carcinoid Tumor	**Serotonin**, possibly tachykinin, ,pilin, Prostaglandin
II. Pancreatic Endocrinal Tumor (PET)	
– Zollinger-Ellison Syndrome	**Gastrin**
– Insulinoma	Insulin
– Glucagonoma	Glucagons
– Somatostatinoma	Somatostatin
– GRF-oma	**Growth Hormone Releasing Hormone**
– Acth-oma	ACTH
– VIP oma (Verner Morrison Syndrome / WDHA, Pancreatic cholera)	Vasoactive intestinal peptide (VIP)
– PET causing Carcinoid syndrome	Serotonin, Tachykinin
– PET causing hypercalcemia	PTHrP

Because of its greater sensitivity than conventional imaging (CT, MRI, USG) and its ability localize tumor throughout the body at one times. **SRS (Somatostatin receptor Scintigraphy) now the imaging modality of choice for localizing both primary and metastatic NET tumors. (Except for Insulinoma).**

- **Best modality of localizing Insulinoma is endoscopic u/s**
- Somatostatin receptors are of 5 types, radiolabeled octreotide binds with highest affinity to SS_2 receptor.
- SRS is not a diagnostic investigation. Diagnosis is confirmed by detecting peptides or amines (or their metabolites) secreted by the tumors in urine or serum.

(Ref. Harrison, 15th Edition, Pg. 594-602 17th edition Pg.616)

80. (D). Posterior urethral valve

Urethral obstruction, most often occurring in males and due to posterior urethral valves, has the following sonographic findings: bilateral hydronephrosis and hydroureter, a large thick-walled bladder, and a dilated posterior urethra. Associated oligohydramnios occurs when urethral obstruction is severe.

(Ref. Sutton Radiology 7th Edition, Pg. 1017, 1061)

81. (A). Single umbilical artery

The umbilical cord normally contains three vessels: two arteries and a vein, which are protected by Wharton's jelly. It is important to document the number of vessels in the cord. *Single umbilical artery* occurs in up to 1% of cases. Ten to twenty percent of these cases have malformations including:

1. **T**risomies 13 and 18,
2. **A**nomalies of the urinary tract, central nervous system and heart,
3. **O**mphalocele,
4. **S**irenomelia, and
5. **V**ATER association.

(Ref. Ultrasonography in OBGY by Callen, 4th Edition, Pg. 44)

82. **(C). Trans vaginal US**

Best method of diagnosing unruptured ectopic pregnancy is combination of transvaginal sonography & quantitative B-HCG values

Dx of Ectopic pregnancy

Transvaginal USG (most accurate	B-HCG
• Absence of intrauterine pregnancy with positive pregnancy test • Fluid in pouch of Douglas • Adnexal mass clearly separated from ovary	• Lowest level of BHCG at which gestational sac is visible on – • B-HCG > 2000 IU/L, with empty uterine cavity on TVS • Failure to double the value of B HCG by 48 hours with empty uterus. • Lower level of B-HCG compared to gestational age

(Ref. Dutta obs., 5th Edition, Pg. 197-199, 6th Edition, Pg. 185-186)

83. **(B). 6 mm.**

The sonographic feature of pyelictasis is dilated renal pelvis with Ap diameter >/= 6mm.

(Ref. Sutton Radiology, 7th Edition, Pg. 1050)

84. (D). Ovarian tumour

The thickened omentum produced by "caking" appears as a large soft tissue mass with poorly defined edges. Fat planes are obscured.

Following diagnostic signs characterize the lesions of mesentery/omentum according to their appearance:

1) Rounded masses - NHL (most common), leukemia and ovarian tumor (rare)
2) Ill-defined masses - NHL, Carcinoma ovary (most common), Colon, pancreas, stomach (rarely)
3) Cake-like masses - Ovarian tumors, NHL and leukemia
4) Stellate pattern - All types of metastatic disease except lymphomas and leukemias.

75% ovarian neoplasms are benign, 21% are malignant, 4% are borderline malignant.

(Ref. CT and MR Imaging of Whole Body by Haaga, Pg. 1653)

85. **(C). MRI**

Ductal carcinoma-in-situ (DCIS) and lobular carcinoma-in-situ (LCIS) are confined to the ducts and acini, respectively. There are four subtypes of DCIS: comedocarcinoma, micropapillary carcinoma, cribriform carcinoma and solid carcinoma. Among these subtypes, comedocarcinoma is the most aggressive. DCIS now accounts for 20–40% of all cancers detected by screening mammography.

MRI must be able to demonstrate and characterize mammographically detected lesions (including DCIS) and, ideally, reveal mammographically occult lesions. This requires MRI to have high-resolution capabilities.

(Ref. Grainger Radiology, 4th Edition, 2269-2273)

86. **(B). CEMRI**

CEMRI (Contrast Enhanced Magnetic Resonance Imaging) is most useful investigation for the preoperative evaluation of cervical carcinoma. The normal cervix appears as two distinct zones, an inner high signal intensity zone (endocervical canal) and an outer low signal intensity zone (fibrous stroma). It may occasionally have three zones similar to those of the uterus. On axial images, the lower cervix normally is a complete, low-intensity ring. If disrupted, this may serve as an important landmark for the identification of parametrial tumor extension. MRI is quite accurate in detecting tumor involvement of the vagina, parametrium, pelvic sidewall, bladder, or rectum. However, MRI may underestimate the extent of very superficial disease and cannot detect carcinoma in situ reliably. It has similar constraints in the detection of lymph node enlargement as CT, namely, that it cannot depict microscopic tumor involvement of normal-sized nodes or differentiate benign nodal enlargement from malignant lymph node enlargement.

(Ref. Shaw's Textbook of Gynaecology, 13th Edition, Pg. 387)

87. **(B). Several internal excrescences**

USG is the initial imaging modality of choice in the evaluation of pelvic masses. It is accurate for the determination of the presence, size, location, and character of pelvic masses but is relatively nonspecific of tumor type.

The sonographic appearance of cystadenocarcinoma is cystic, with areas of solid tissue on the inner cyst wall and papillary excrescences protruding from the septa. Spokewheel-like septations suggest mucinous cystadenocarcinoma. The appearance of other malignant ovarian neoplasms may be completely solid, primarily solid with irregular cystic areas, or thick-walled with necrotic centers.

(Ref. Radiology Review Manual 5th Edition, Pg. 1001)

88. **(D). Carcinoma**

Pleomorphic microcalcification in a spiculate mass is hallmarks of Breast Ca. Females on HRT are at a high risk for breast Ca.

Cystosarcoma phylloides occurs in younger women, generally occurs bilaterally has typically finger like projections on imaging.

Fibroadenoma shows dense calcification is wider more than taller, and has smooth margins.

(Ref. Chapman, 4th Edition, Pg. 365)

89. **(B). First 10 days of Menstrual Cycle**

- Ten day Rule: Radiological investigation in a reproductive age gp. Female should be carried out with in 10 days of last Menstrual Period i.e. Ist 10 days of M. C. (i.e. within in 10 days of onset of menstruation).
- This was stated in the belief that there was then least likelihood of conception talking place (but if it did the embryo would be most sensitive to radiation) it is now believed that fetus is relatively insensitive to radiation in early stages of pregnancy any adverse effect leads to spontaneous abortion.

- The fetus is most sensitive to radiation at 8-15 weeks gestation for increased incidence of Down's syndrome and slight reduction in IQ.

(Ref. Grainger, 4th Edition, Pg. 233)

Topic 4 – Nuclear Medicine & Radiotherapy

90. **(A). CyberKnife**

CyberKnife

The CyberKnife was developed in the mid 1990s by Accuray as an innovative tool for intracranial stereotactic radiosurgery (see Section 15.2.5.3). It delivers the dose with a miniature (104 MHz) linac mounted on an industrial robotic arm, a combination that offers excellent spatial accuracy in dose delivery and allows, in comparison with isocentric linacs and tomotherapy units, a great deal of flexibility in directing the beam towards the target.

Owing to its on-line target imaging and automatic adjustment of the radiation beam direction to compensate for target motion, the CyberKnife provides a frameless alternative to conventional radiosurgical procedures. The rigid invasive stereotactic frame, the essential component of standard radio-surgical treatments used for target localization, treatment set-up and patient immobilization during treatment, is not required for treatment with the CyberKnife.

The location of the lesion is predetermined through a family of axial CT images that serves as a base for the determination of a set of digitally recon- structed radiograph (DRR) images. A set of paired orthogonal X ray imagers determines the location of the lesion in the room coordinate system and communicates these coordinates to the robotic arm, which adjusts the pointing of the linac beam to maintain alignment with the target.

The CyberKnife radiosurgery system provides an innovative approach to image guided dose delivery that is based on an on-line orthogonal pair of digital X ray imagers, a patient CT data set fused with MR and/or PET images and a miniature linac mounted on an industrial robotic arm. This new approach to highly accurate intracranial as well as extracranial delivery of high radiation doses with small radiation fields opens the field of radiosurgery to very exciting new research directions, both in basic radiation physics and clinical cancer research.

Besides the obvious advantage of dispensing with the need for a stereo- tactic frame without compromising the treatment's spatial accuracy, the CyberKnife also offers several other advantages over conventional radio- surgery, such as:

- Veritable image guided dose delivery.
- Possibility for fractionated treatment of intracranial malignant tumours.
- Possibility for treatment of extracranial spinal lesions, relying on the skeleton to provide a reference frame.
- Possibility for radiosurgical treatment of other organs such as the lung and prostate using surgically implanted fiducial markers as a reference frame.
- Capability for on-line tracking of target motion, which results either from patient motion during treatment or from organ motion within the patient during treatment.

(Ref. Radiation Onco physics By E. B. Podgorsak pg. 543)

91. **(B). I^{125}**

Choice of radionuclide for prostate implants:

The use of permanent radioactive seed implants for the treatment of early prostate cancer has gained renewed interest with the introduction of 125I and 103Pd seeds, which emit low energy (~30 keV) photons.

Gold-198 seeds, which emit medium energy photons (~400 keV), were used in the past, but the unnecessary radiation exposure hazard prevented the use of this radionuclide from gaining wide acceptance.

Palladium-103, which has a shorter half-life (17 days) than 125I (60 days), delivers a higher initial dose rate and hence has been found useful in treating fast growing high grade tumours.

(Ref. Radiation Onco physics By E. B. Podgorsak pg. 465)

92. **(C). Amifostine**

Many thiol [SH] groups of compounds like *amifostine* are used to protect normal cells from the harmful side effects of radiation. The agent amifostine is used commonly in clinical practice to protect from toxicities of chemoradiotherapy.

(Ref. Harrison, 17th Edition, Pg. 671)

93. **(B). 20 mSievert**

Recommended Dose Limit :

Effective dose : Occupation worker – 20 mSv per year

Average over defined periods of 5 years.

The effective dose should not exceed 50 mSv this in any single year.

In India, AERB permits not > 30 mSv per/year.

(Ref. Introduction to Radiation Biology, P. Uma Sevio, A. Nagarathan, Pg. 215, 216)

94. **(C). Genetic mutation**

Indeterministic/stochastic effects of radiation :

Independent of the total dose of radiation. It is an all are none phenomenon.

e.g. Genetic mutations.

Deterministic/Non stochastic effects of radiation. Depend on the total dose of radiation given.

e.g. Alopecia in the irradiated portal.

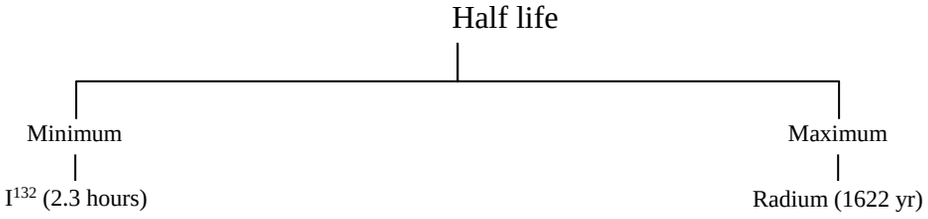
(Ref. Introduction to Radiation Biology – Uma Nagarathnam, 1st Edition, Pg. 26)

95. **(D). 1-2 years**

Transverse myelitis after radiation treatment is a spinal cord reaction similar to cerebral necrosis. The syndrome consists of progressive and irreversible leg weakness and loss of bladder function and sensation referable to a single spinal cord level. Flaccid paralysis eventually occurs. Symptoms can occur as early as 6 months after radiation treatment, but the usual time of onset is 12 to 24 months. Studies have shown that at 45 Gy, the incidence of radiation myelitis is < 0.2 %.

(Ref. http: // www. ijri.org/articles/archives/2002-12-1/major-papers-21.htm)

96. **(B). Radium**



(Ref. Harrison, 17th Edition, Pg. 1109; CMDT 2005, Pg. 199)

97. **(A). Gallium: Ideal agents for bone scan**

Diagnostically used radionuclides:

- **Technetium-99m (6 h):** Used in to image the skeleton and heart muscle in particular, but also for brain, thyroid, lungs (perfusion and ventilation), liver, spleen, kidney (structure and filtration rate), gall bladder, bone marrow, salivary and lacrimal glands, heart blood pool, infection, etc.
- **Selenium-75 (120 d):** Used as seleno-methionine to study the production of digestive enzymes.
- **Xenon-133 (5 d):** Used for pulmonary (lung) ventilation studies.
- **Gallium-67 (78 h):** Used for tumor imaging and localization of inflammatory lesions (infections).
- **Indium-111 (2.8 d):** Used for specialist studies, e.g. brain studies, infection and colon transit studies.
- **Iodine-123 (13 h):** Increasingly used for diagnosis of thyroid function, it is a gamma emitter without the beta radiation of I-131.
- **Krypton-81m (13 sec) from Rubidium-81 (4.6 h):** Kr-81m gas can yield functional images of pulmonary ventilation, e.g. in asthmatic patients, and for the early diagnosis of lung diseases and function.
- **Rubidium-82 (65 h):** Convenient PET agent in myocardial perfusion imaging.
- **Thallium-201 (73 h):** Used for diagnosis of coronary artery disease other heart conditions such as heart muscle death and for location of low-grade lymphomas.

(Ref. Harrison, 16th Edition, Pg. 232, 84, 1324, 120, 1518, 1411; 17th Edition, Pg. 517,682t, 805, 1994-1995)

98. **(B). An artificially made radioisotope**

Co-60 is an isotope of Co-59 produced artificially by bombarding its nucleus by neutrons. The target material (Co-59) is bombarded by neutrons in a nuclear reactor. The target atoms capture these neutrons and in turn emit photons (gamma-rays) or particles or both, to transform itself into the required radionuclides. This method is called "activation" since radioactivity is induced into the target material.

$$^{59}_{27}\mathrm{Co} + ^{1}_{0}\mathrm{n} \rightarrow ^{60}_{27}\mathrm{Co} + \gamma$$

Both Co-59 and Co-60 have the same atomic number, the same properties and cannot be separated chemically.

Other artificially produced radioisotopes →

$$\mathrm{Phosphorus} - 32, ^{3}_{1}\mathrm{H}, ^{4}_{2}\mathrm{He}$$

$$^{137}_{55}\mathrm{Cs}, ^{96}_{37}\mathrm{Rb}, \mathrm{etc.}$$

Positron is an elementary particle which has a unit positive charge and which exists in nature only when it is in motion. A slow moving or stationary positron quickly annihilates with an electron to give two photons.

(Ref. Fundamental Physics of Radiology, 3rd Edition, Pg. 561)

99. **(D). Plutonium**

Eye plaques

Intraocular melanoma is the most common eye tumour. An eye plaque, loaded with 125I seeds, is applied externally to the scleral (outer) surface over the tumour base. The number of seeds to be used is related to the size of the plaque, and ranges from 7 to 24 for plaque diameters of 12–20 mm. The typical activity used is 0.5–5 mCi per seed so as to achieve treatment dose rates of 0.5- 1.25 Gy/h, with a

prescription dose of 100 Gy delivered in 5–12 consecutive days.
The prescription point is defined as the tumour apex if the apical height exceeds 5 mm, and 5 mm depth from the interior sclera if the apex is less than 5 mm high. Tumour localization is usually performed using fundoscopy, fundus photography and ultrasound A and B scans. CT and magnetic resonance imaging (MRI) may also be used. Post-implant, plaque placement verification is carried out with ultrasound imaging.
A less common approach to the treatment of lesions in the eye is based on b emitting sources: 90Sr/90Y (maximum electron energy: 2.27 MeV; penetration into tissue: 12 mm) and more recently 106Ru (maximum electron energy: 3.4 MeV; penetration into tissue: 20 mm).

(Ref. Radiation onco physics By E. B. Podgorsak pg. 466)

100. **(D). Resortment**

The basis of fractionation is rooted in five primary biological factors called the five Rs of radiotherapy:

- Radiosensitivity. Mammalian cells have different radiosensitivities.
- Repair. Mammalian cells can repair radiation damage. This is a complex process that involves repair of sublethal damage by a variety of repair enzymes and pathways.
- Repopulation. Cells repopulate while receiving fractionated doses of radiation.
- Redistribution.Redistribution in proliferating cell populations throughout the cell cycle phases increases the cell kill from a fractionated treatment relative to a single session treatment.
- Reoxygenation. Reoxygenation of hypoxic cells occurs during a fractionated course of treatment, making them more radiosensitive to subsequent doses of radiation.

(Ref. CMDT, Pg. 2006-1595)

101. **(A). More skin damage**
Megavoltage x-ray therapy (> 1 mev) has following advantages over orthovoltage therapy (150 to 400 kv):

- Skin-sparing effect.
- Very low lateral scatter.
- Homogeneous distribution of the radiation energy.
- Greater deposit of the energy in the tumor, or in the target volume.

Orthovoltage therapy causes **highest skin damage.**

(Ref. Introduction to Radiotherapy by Rafla, Pg. 8)

102. **(B). Measuring the radioactivity**
A gamma camera, measures radioactivity of the substance that is taken up by specific organ or tissue of interest, by detecting gamma rays.

- Working of gamma camera

- Nuclear medicine studies require the oral or intravenous introduction of very low level radioactive material (called radio pharmaceuticals, radionuclide or radiotraces) into the body; which is taken up by a particular organ or tissue.
- The decay of radiotracer then leads to emission of γ(gamma) rays, which are measured by gamma camera with the help of its crystal detector (or scintillation crystal)

(Ref. Oxford textbook of surgery, 6th Edition, Pg. 6.7, 33.2)

103. **(C). Parathyroid adenoma**
- Tc99-sestamibi scan is for parathyroid adenoma detection
- Tc99-MIBI (methoxyisobutyl isonitrile) scan is also used for parathyroid

(Ref. Grainger and Allison's, 4th Edition, Pg. 1374, 1380, 1390)

104. **(C). Alpha particle**

IONIZING RADIATIONS

Ionizing radiation is radiation that can produce charged particles (ions) in materials that it strikes.
Types of ionizing radiation are:
- Alpha radiation (Helium ions): consist of nucleus of helium atoms positively charged with "+2", low penetrating ability, stopped by thin sheet of paper or skin. Of all the ionizing radiations alpha particles are most ionizing ones.
- Beta radiation: consist of electrons, negatively charged with "-1", more penetrating than alpha particles, and can pass through 1-2 cm of water or tissue or a few mm of aluminum.
- Gamma radiation: are electromagnetic radiation emitted from nucleus in excited state (radioactive material), are highly penetrating, can pass through the human body, and cannot be absorbed completely.
- X-rays: are electromagnetic radiation emitted when fast moving charged particles (like electrons) are stopped, have penetrating power less than gamma rays but more than alpha and beta rays, can pass through human body, and cannot be absorbed completely.

(Ref. Harrison, 17th Edition, Pg. 1358)

105. **(B). X-rays & gamma rays are the forms of radiation most commonly used to treat cancer.**
- Cobalt 60 is used as a radioactive material in Teletherapy machines.
- X-rays & Gamma rays are the forms of radiation most commonly used to treat cancer.
- Gamma rays are generated from decay of atomic nuclei in radioisotopes such as cobalt & radium.
- Tele is most often used form of radiotherapy today.
- Cobalt 60 is the most commonly used isotope, another important isotope being cesium – 137 (g rays)

(Ref. Principles and Practice of Radiation Oncology, 3rd Edition, Pg. 252)

106. **(B). Beta rays**

I-131 decays by beta particle emission and a principle gamma ray energy. Its beta emission makes it therapeutically useful. Non-malignant condition like thyrotoxicosis and well-differentiated thyroid tumors and their metastases are treated by I-131.

(Ref. Walter and Miller's Textbook of Radiotherapy, Pg. 272)

107. **(A). Iridium192**

When the radionuclide is placed on the surface of the skin, (mould or plaque) is called plesiocurietherapy. Ir 192 is most commonly used agent for mould therapy.

(Ref. Harrison, 16th Edition, Pg. 1296 (t), 17th Edition, Pg. 517)

108. **(B).** 0.4–2 Gy/h.

BRACHYTHERAPY TREATMENTS CLASSIFIED WITH RESPECT TO DOSE RATEa

Dose rate	Numerical value of the dose rate at the dose specification point(s)
Low dose rate (LDR)	0.4–2 Gy/h
Medium dose rate (MDR)	2–12 Gy/h
High dose rate (HDR)	>12 Gy/h

I^{125}, Cobalt-60 Iridium 192 all are used in brachytherapy.
Iodine-125 is used as permanent seeds in prostate cancer.
Cobalt-60 can be used for intracavitary, and Cobalt plaques are used in ophthalmic tumors.

Iridium-192 is the most common source used in interstitial brachytherapy and ICA.
I-131 is used for thyroid imaging & ablation.

(Ref. Harrison, 17th Edition, Pg. 1360, 1362)

109. **(D). All of the above**

Most IORT programmes today are based on electron beams produced by megavoltage linacs, since electrons provide several advantages over X rays for the purposes of IORT:
—The electron dose is deposited over a definite range, thus sparing tissue downstream from the target;
—Depending on the target thickness and electron energy, the dose can be deposited homogeneously throughout the target volume;
— In contrast to low energy X rays, there is not much difference between the tissue and bone absorption of megavoltage electron beams..

(Ref. Introduction to Radiation Biology, Uma Devi, Satish Rao, Pg. 126-127)

110. **(C). The location of the lesion within 10 cm from the anal canal;**

Selection criteria for endocavitary rectal irradiation are as follows:

- A biopsy proven, well or moderately well differentiated rectal adeno- carcinoma;
- A mobile lesion with a maximum diameter of 3 cm;
- The location of the lesion within 10 cm from the anal canal;
- No evidence of lymph node or distant metastases.

Postoperative chemotherapy has established role in colon.

(Ref. Schwartz, 7th Edition, Pg. 336; Bailey & Love, 25th Edition, Pg. 1179-1184)

111. **(B). Hyperfractionation RT**

- Hyperfractionation RT:
  1. It means, Multiple daily fractions, usually two with doses per fraction of ≤180–200 cGy, usually 100–120 cGy, separated by 4–8 hours, to total doses higher than those given with “standard” fractionation.
  2. Suitable for haedand neck and Lung tumors.

  Accelerated fractionation reduces the overall treatment time, minimizing tumour cell repopulation during the course of treatment.

  CHART (continuous hyperfractionated accelerated radiation therapy) is an experimental programme used with three fractions per day for 12 continuous days.

112. **(A). 8 Gy in one fraction**
Palliation of metastatic disease is a substantial component of radiation oncology, and a vital aspect of cancer patient care in general; severe pain and debilitation resulting from untreated metastases not only have a significant impact on the patients' quality of life, but on health care and economics as well. Standard treatment was 30 Gy in 10 fractions. However, there are recent trails, which have found 8 Gy in one fraction to be as effective, & this is standard today.

(Ref. Walter and Miller's Textbook of Radiotherapy, 5th Edition, Pg. 466)

113. (C) Use of Low LET beams.

Factors associated with radiation tolerance of the normal central nervous system tissues:

Factor*	**Factors for increased risk of injury**	:Tolerance increased by
Total dose	Higher total dose	Decreasing total dose , hyperfractionation, radiosensitizers.
Dose per fraction	Dose per fraction >180–200 cGy	Decreasing dose/fraction to ≤ 180–200 cGy
Volume	Increased volume, e.g.,: whole-organ radiation	Decreasing volume, e.g., partial-organ radiation
Host factors	Medical illness, e.g., hypertension, diabetes	Unknown, possibly radioprotectors
Beam quality	High LET radiation beams, e.g., neutrons	Low LET beams, e.g., photons
Adjunctive therapy	Concomitant use of CNS toxic drugs, e.g., methotrexate	Avoid concomitant use of CNS toxic

(Ref. Harrison's Medicine, 17th Edition, Pg. 560, 2607-2609, 2603)

114. **(B). Resectable local lesion**
Indications of RT in Parotid tumor:
(a) **Recurrent disease (benign or otherwise)**
(b) Residual disease left at surgery
(c) High grade lesion
(d) Those that refuse surgery
(e) Unfit for surgery
(f) Unresectable local lesion

If deep lobe is involved **total parotidectomy** is done which requires facial nerve sacrifice. Reconstruction of facial nerve trunk by a cable or sural nerve graft decreases the incidence of facial palsy post operatively.
Radiotherapy is indicated for histological malignant recurrence.

(Ref. Deretta, 6th Edition, Pg. 891)

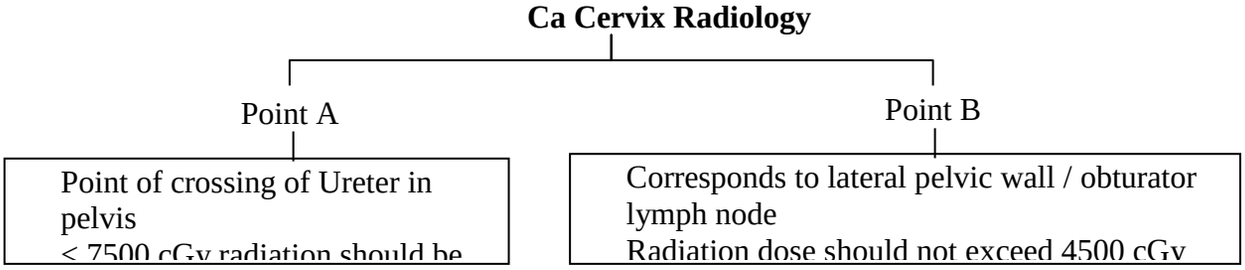
115. **(C).** Brain tumors
gamma knife Radiotherapy

It refers to sterotactic radiosurgery.
Useful in:

- Metastasis
- Meningiomas
- AVMs
- Acoustic neuromas

(Ref. Harrison's Principles of Medicine, 17th Edition, Pg. 557-561, 558t, www.blackwellsurgery.com)

116. **(B). Obturator Lymph node**



(Ref. Shaws, 13th Edition, Pg. 410)

117. (C). Mycosis fungoides.

Total Skin Electron Irradiation is a special radiotherapeutic technique that aims to irradiate the patient's whole skin with the prescribed radiation dose while sparing all other organs from any appreciable radiation dose. Since skin is a superficial organ, the choice of electron beams for the treatment of generalized skin malignancies (most commonly mycosis fungoides) is obvious, even though superficial X rays also could be, and actually were in the past, used for this purpose.

Mantle and inverted Y RT is technique of extended field irradiation for disease above and below the diaphragm respectively. The term 'Mantle technique' derives from the similarity of the treatment fields to a cloak. External beam radiation therapy, which comes from a machine outside the body, is usually used for Hodgkin's disease. Mantle radiation, which is given to the neck, chest, and lymph nodes under the arms, may also be used. Mantle radiation and radiation to the spleen and lymph nodes in the upper abdomen and pelvis is called total nodal irradiation. RT may be administered with or without chemotherapy.

(Ref. Walter and Miller's Radiotherapy, 5th Edition, Pg. 566)

118. **(B). Recurrent ovarian cancer.**

PET-CT is investigation of choice for recurrent ovarian cancer.

The main advantages of PET/CT machines are as follows:

- Earlier diagnosis of disease;
- Accurate staging and tumour localization;
- More precise treatment;

- Monitoring of response to treatment and early detection of recurrences;
- Reduction of biopsy sampling errors;
- Reduction of the number of invasive procedures required during follow-up.

(Ref. Radiation onco physics By E. B. Podgorsak pg. 547)

119. **(C) Metastable**

'm' in Tc99m stands for Metastable form of Tc99.

Tc99 is reacted with aluminium resins to get Tc99m, which is a metastable form with half life of just 6 hours.

120. Ans, C.