X- RAYS

- Are electromagnetic radiation
- Have penetrating power less than gamma rays but more than alpha and beta rays
- Can pass through human body, Cannot be absorbed completely
- Produced by Coolidge tube when **fast moving stream of electrons produced by a cathode(Tungsten filament)** strikes the anode(tungsten/ molybdenum containing copper plate)
- X-rays are most **scattered by H^+ ions.**
- Causes ionization in 3 ways: **Photoelectric effect, Compton effect & Pair production**
- Contrast can be increased by increasing the current (mA)
- Penetration can be increased by increasing the voltage (mV)
- Machine is kept at 6 feet distance form photographic plate to prevent magnification.
- Optimum distance of target film: 90-100cm
- Best chest X ray is done at: 120-150 kilovolt peak.
- **Gunson method:** X- ray of soft tissues of neck
- Cyclotron produces Gamma rays

ULTRASOUND (USG)

- Based on piezoelectric effect of crystals made up of **lead zirconate titanate**.
- **Ian Donald - father of obstetric ultrasound.** Also invented the B-mode scanner.
- **Dr. John Wild and John Reid:** invented an A-mode scanner for the detection of ovarian cancer.
- John Wild **("father of medical ultrasound")** first used ultrasound to assess the thickness of bowel tissue.
- Contains waves with frequencies>20,000 Hz.
- In medical USG frequencies commonly used are 2-10 MHz
- Frequencies used:
- Trans abdominal ultrasound: 3-5 MHz,
  - Trans-vaginal: 5-7.5MHz,
  - Breast: 15 MHz,
  - Gut wall: 7.5-20 MHz
  - Vessels: 20 MHz
- Types of image display
  - A –Mode → one dimensional picture, used only in eye scan
  - B- Mode- → two dimensional picture, commonly used
  - Real time scan → gives moving picture
  - M-Mode → motion display (e.g. in ECHO)
- USG causes delirious effect on small micro-organisms by acoustic cavitation.
- Investigation of choice for obstetric conditions

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.

CT- scan or CAT scan

- **Invented by God Frey Hounsfield in 1963, awarded Nobel Prize.**
- 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.
- Electron density of tissues in numbered as **Hounsfield number (H.N.) or Hounsfield units.**
  - Air have a value of -1000 HU
  - Fat of -120 to -200 HU
  - Water – 0 HU
  - Soft tissue of 20-60 HU
  - Blood of 50-60 HU
  - Bone of +1000 HU
- Two type of contrast agents are used
  - Ionic – water soluble iodide dyes (e.g. Na- diatrizoate, megliumine, conray, urograffin, angiografin) – may cause anaphylaxis
  - Non ionic- Safer but expensive e.g. iohexol (Omnipaque), lopamiro
- Uses of various contrast agents:

Contrast	Procedure	Contrast	Procedure
Dionosil (Tantalum)	Bronchography	**Hypaque, sodium diatrizoate**	IVP
Myodil	DSA, Myelography	**Methylene blue**	Lymphangiography
Iopanoic acid (Telepaque)	Oral cholecystography (OCG)	**Conray 280**	Aortography, cerebral angiography
Biligrafin	IV cholecystography	**Conray 280/420**	HSG
Metrizamide, Iohexol (Omnipaque)	Ventriculography	**Conray 420**	CT scan, coronary angiography
Gastrografin (Dionosil)	Oesophagoscopy	**Gadolinium**	MRI

- **Spiral CT, also known as helical or volumetric-acquisition CT:** Technique by which the volume area is scanned as the patient continuously travels through the scan field, while data is acquired along the spiral path.
- Advantages:
  - Spiral CT will produce a clearer, more defined image and provides better details.
  - Spiral CT is 8 to 10 times faster than a traditional CT scanner. This saves time and reduces radiation exposure by eliminating the need for multiple scans.
  - Spiral CT can digitally reconstruct more than one image from a single slice and allows for multiplaner reformatting (overlapping structure).
  - Spiral CT has the ability to scan **an entire region in a single breath hold, averaging about 30 seconds** or less. Shorter scan time allows coordination of peak contrast enhancement, which results in clearer images and about 1/3 less dye load.

MRI

- Based on **gyromagnetic property of protons** (or hydrogen nucleus, H^+)
- Described first by Bloch & Purchell, applied as human tool by Damadian & Lauterbeur (1972)
- It can be plain MRI or contrast MRI.
- Most common contrast agent used is i.v. **Gadolinium**.
- Proton density and relaxation time are assessed by radiofrequency pulse and the computer generates a gray scale image from this data.
- Magnetic field used in the range of **0.15-3 tesla**
- **MRI spectroscopy** provides in vivo characterization of chemical composition and metabolic activity of brain.

- Relaxation time:
  - T_1time taken to return to original axis (T_1 images are used to find out normal anatomical details)It has got high soft tissue discrimination (CSF looks black)
  - T_2: Time taken by proton to displace. Used to assess pathological processes (fluid looks white).

The induction (transmitter/receiver coil) used in MRI are **Maxwell coils**.

- Water (CSF) looks white (hyperintense) on T2.
- CSF looks hyperintense on T2 weighted image and hypointense on T1 weighed image.

MRI EVALUATION OF HEMORRHAGES

Biochemical form	Stage of haemorrhage	Time	T1	T2
Oxyhemoglobin in RBCs	Hyperacute	Immediate to first few hours	Isointense	Hyperintense
Deoxyhemoglobin in RBCs	Acute	Hours to days	Isointense to hypointense	Hypointense
Methoxyhemoglobin in RBCs	Early subacute	First several days	hyperintense	Hypointense
Extracellular metHb	Late subacute	Days to months	Hyperintense	Hypointense
Ferritin and hemosedrin	Chronic	Days to infinite time	!so to hypointense	Hypointense

Substance	T1 weighted	T2 weighted
Water/vitreous/CSF	Black	Light grey or white
Fat	White	Light grey
Muscle	Grey	Grey
Air	Black	Black
Fatty bone marrow	White	Light grey
Brain: white matter	Light grey	Grey
Brain: grey matter	Grey	Very light grey

Common Contraindications to MR Imaging

- Cardiac pacemaker or permanent pacemaker leads, Internal defibrillatory device
- Cochlear prostheses, Bone growth stimulators, Spinal cord stimulators
- Electronic infusion devices
- Intracranial aneurysm clips (some but not all)
- Ocular implants (some) or ocular metallic foreign body
- McGee stapedectomy piston prosthesis
- Duraphase penile implant
- Swan-Ganz catheter
- Magnetic stoma plugs, Magnetic dental implants
- Magnetic sphincters
- Ferromagnetic IVC filters, coils, stents—safe 6 weeks after implantation
- Tattooed eyeliner (contains ferromagnetic material and may irritate eyes)

PET

- PET produces tomographic images.
- A cyclotron is required to generate positron-emitting isotopes that can be made from compounds, such as F, C, N and O.
- Radiopharmaceuticals for PET imaging: **FDG, C methionine and $^{[18]}$ Fα-methyl tyrosine.**
- Disadvantages of PET: limited availability and high cost due to the necessity of a cyclotron
- Positron emitting radio nuclides are used:- O_2- informs 02 uptake, CO_2 - informs blood flow, 18 FDG — informs glucose utilization and is most frequently used moiety,
- **Indications:**
  - To distinguish radiation necrosis from recurrent glioblastoma
  - To evaluate transformation of brain tumor from low grade to high grade
  - To evaluate the potential for recurrence of meningioma
  - To assess tumor viability and monitor treatment response
  - **For diagnosing occult metastasis & recurrent cancers**
  - 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

SINGLE PHOTON EMISSION COMPUTED TOMOGRAPHY

- Detection of emitted gamma rays by a gamma camera.
- Requires radiopharmaceuticals that cross the blood–brain barrier.
- Radiopharmaceuticals used are ^{133}Xe, ^{123}I isopropyl iodoamphetamine (IMP), ^{99m}Tc ethyl cysteinate dimer (ECD) or ^{99m}Tc hexamethylpropylene amine oxide (HMPAO).
- Clinical applications include dementia, cerebrovascular disease, epilepsy, encephalitis, head injury, and other less common disorders that result in abnormal cerebral perfusion.
- SPECT can also be used to image uptake at neurotransmitter receptors using various radiopharmaceuticals usually labeled with ^{123}I.
- Many different SPECT radiopharmaceuticals are taken up into intracranial tumours, including ^{201}TI chloride, ^{99m}Tc MIBI, ^{123}Iα-methyl tyrosine and ^{111} In octreotide.
- Because of the requirement for lead collimation, SPECT has inherently poorer resolution than PET and absolute quantitation is not possible.
- SPECT is relatively inexpensive and has good patient acceptability.

CT and MRI Imaging Characteristics of Various Tissues:

Tissue	CT Gray Scale	MRI T1 Signal	MRI T2 Signal
Brain	Gray	Gray	Gray
Air	Black	Black	Black
CSF	Black	Black	White
Fat	Black	White	Black
Calcium	White	Black	Black
Bone	Very white	Black	Black
Extravasated blood	White	White	Black
Inflammation	Contrast enhancing	Gray, gadolinium enhancing	White
Edema	Dark gray	Gray	White
Tumor	Gray or white and contrast enhancing	Gray or white and gadolinium enhancing	White

- **FLAIR (fluid-attenuated inversion recovery)** imaging is a technique that gives a high signal for pathological lesions and a low signal for CSF.
- It is sensitive to calcium and iron within brain tissue, shows early stages of infarction, and accentuates inflammatory demyelinating lesions.

EFFECTS OF RADIATION

- Maximal permissible radiation dose: The dose of radiation which if received each year for a 50 yrs working life time would not be expected to produce any harmful effect.
- **The $LD_{50/30}$ (i.e., a dose that causes a 50% mortality rate at 30 days) is approximately 4 Gy[1 Gy=100 rad] for whole-body exposure without medical support.**
- **For most of the conditions, a min. dose of about 1000 cGy is required for whole body irradiation.**
- Whole- body exposure to doses >9-10 Gy is almost always fatal.
- In addition to the GI syndrome associated with very large exposures, patients may develop a neurovascular syndrome; the latter dominates with whole- body doses >20 Gy.
- With medical support, the LO50/30 ranges between 8 and 10 Gy.
- The **recommended occupational limit of maternal exposure to radiation from all sources is 500 mill Rads for entire 40 weeks of gestation**
- **10 days rule advices** that any x ray examination involving the abdomen of a women of child bearing age should be carried out within 10 days of menstruation.
- **Deterministic effects:** develop due to cell killing by high dose radiation.
- **Stochastic effects:** develop due to mutation effect of low dose radiation.
- Fetus is most sensitive to the effects of radiation during 8 – 15 weeks of gestation.
- **Amount of radiation received from out space = 0.1 rad/year. Additional permissible dose = < 5 rads/ year.**
- **Radiation exposure:** CT scan> Bone scan> X ray
- **No radiation hazard:** MRI & USG.

Latest ICRP recommendations for maximum permissible dose for various groups are:

- Occupational exposure(radiation workers) → 50 mSv/year
- Public (in general) → 20 mSv/year
- Pregnancy → 40.5 mSv for declared term

View (Chest- X-ray)	Structure seen
RAO (Right Anterior Oblique)	Rt lung, Lt. atrium, Gall bladder ,Mitral valve
Left Anterior Oblique	Tracheal bifurcation
Right Posterior Oblique	Right retro cardiac space
Right decubitus view	Right middle lobe of the lung
Lardotic view	Apex, Lingual lobe
Reverse lardotic view	Interlobar effusions

View	Structure seen
Cald well (Occipito-Frontal) view	• Superior orbital fissure ,foramen rotundum & superior margin of • orbit • Lamina papyracea, Maxillary sinus, ethmoid sinus, frontal sinus
Water (O-M: Occipito mental) view	• Maxillary sinus, sphenoid sinus,-frontal sinus • Intra Temporal fossa, zygoma & zygomatic arch
Basal submentovertical view	• Sphenoid, posterior ethmoid , maxillary sinus, Zygoma & zygomatic arch • Mandible along with coronoid & condyloid process

Holman Miller sign (Antral sign): anterior bowing of the posterior wall of the maxillary antrum seen on lateral skull films.

SPECIFIC VIEWS IN RADIOLOGY:

Features	View	Features	View
Supraorbital fissure	Cald well view	Patella	Skyline view
Recurrent shoulder dislocation	Strikers view	Minimal pleural effusion	Lateral Decubitus
Sella turcica	Lateral skull view	Pneumothorax	PA view in full
Scaphoid	Oblique view	Internal auditory meatus	***Periorbital view***

CARDIAC BORDERS

THE BASE OF HEART: forms the posterior surface. It is formed mainly by the **left atrium** and by small **part of right atrium.**

MEDIASTINAL/ HEART BORDER ON X-RAY:

Right Border: Formed by superior vena cava, Rt atrium, Inferior vena cava

Left Border: Formed by Aortic arch, Left ventricle, Main pulmonary artery, Left atrial appendages.

- **The left heart is formed by the main pulmonary artery and heart (left atrial appendage and left ventricle)**
- The **knob-like shadow of the aortic arch in superior mediastinum is formed by the posterior part of arch,** which is absent or deformed in coarctation of aorta.
- A small "nipple" may occasionally be seen projecting laterally from aortic knuckle or knob due to the presence of left superior intercostal vein and this normal nipple should not be misinterpreted as adenopathy (aortopulmonary window). Below the aortic knuckle or knob is a concavity, the pulmonary bay, the floor of which is formed by the main pulmonary artery beyond the pulmonary valve.
- The **pulmonary bay may be filled in by PDA.**
- Below the pulmonary bay, the left ventricle forms the left heart border.

- Just below pulmonary bay is the left atrial appendage, which is the left atrial appendage, not forming a discrete shadow unless enlarged, and below that is the level of right ventricular infundibulum, azygous vein lesion on right side and does not contribute to left heart border.
- However, a coronary artery aneurysm can cause abnormal bulging of left heart border.

RADIOLOGICAL FEATURES OF INTESTINE

Useful differentiating features B/W SI & LI includes Size & distribution of loops

- Dilated small bowel loops are numerous & arranged centrally in the abdomen
- Loops show small radius of curvature & the presence of solid feces is the only reliable sign that the loop is large bowel.
- The other signs can be misleading.

Features	Small bowel	Large bowel
Haustra	Absent	Present
Valvulae conniventes	Present in jejunum	Absent
Number of loops	Many	Few
Distribution of loops	Central	Peripheral
Diameter of loops	Small	Large
Radius of curvature of loop	30-50mm	50mm
Solid feces (only reliable sign)	Absent	May be +

RADIOLOGICAL SIGNS OF THORAX

SIGN/ SPECIFIC FEATURE	SEEN IN
Meniscus/moon/air crescent/double arch sign/combo sign/water lilly/camalotte sign/serpent sign/ rising sun sign/ empty cyst	Hydatid cyst of lung
Popcorn calcification	Hamartoma, Mediastinal nodes of histoplasmosis
Westermark sign, Hapton's hump, Palla sing Fleishner lines, Felson's sign	Pulmonary thrombo-embolism
Sail sign, Mulvay wave sign, Notch sign	Thymic enlargement
Comet tail sign	Rounded atelectasis
Golden S sign	Right Upper Lobe collapse secondary to a central
Luftsichel sign, Broncholobar sign	Left Upper Lobe collapse
Ring around artery sign Continuous diaphragm sign Tubular artery sign, Double bronchial wall sign	Pneumo-mediastinum
Deep sulcus sign, Visceral pleural line	Pneumothorax
Thumb sign	Epiglottitis
Steeple sign	Croup
Air crescent sign, Monod sign	Aspergilloma
Bulging fissure sign	Klebsiella pneumonia
Batwing sign	Pulmonary edema on CXR
Collar sign, Dependant viscera sign	Diaphragmatic rupture
Feeding vessel sign	Pulmonary septic emboli
Finger in glove sign	ABPA
Halo sing	Aspergillosis
Head cheese sign	Subacute hypersensitivity pneumonitis
Juxtaphrenic peak sign	Right Upper Lobe atelectasis
Reversed halo sign	Cryptogenic organized pneumonia
Saber sheath sign	COPD
Sandstorm lungs	Alveolar microlithiasis
Signet ring sign	Bronchiectasis
Superior triangle sign	Right Lower Lobe atelectasis
Split pleura sign	Empyema
Tree in bud sign on HRCT	Endo bronchial spread in TB

CHEST X-RAY OF ECHINOCOCCUS

- Oval mass
- Meniscus/ moon/ crescent / double arch sign
- Rising sun sign/empty cyst sign
- Water Lilly / camalotte sign
- Serpent sign/ Cumbo sign

Superior rib notching	Inferior rib notching

• Poliomyelitis, Osteogenesis imperfecta • Restrictive lung disease • Neurofibromatosis, Marfan's syndrome • Connective tissue disease- RA, SLE, Scleroderma • Sjogren's syndrome, Hyper parathyroidism	• Coarctation of Aorta (M/C cause) • Pulmonary- oligemia/ A-V malformation • Aortic thrombosis • Subclavian obstruction • Tausig Blalock operation

RADIOLOGICAL SIGNS OF CARDIOVASCULAR SYSTEM

Radiological feature	Disorder
Four bump heart	MS/ MR due to left atrial appendage enlargement
Glassy heart on ECHO	Amyloidosis
Double cardiac shadow, Double density sign, Bedford sign	Left atrial enlargement
Dock's sign, E-sign , figure of 3 sign, reversed E sign, inverted 3 sign	Coarctation of aorta
Double aortic knuckle	Aortic dissection
Jug handle appearance	Primary pulmonary hypertension
Maladie de roger effect	Small VSD
Hilar dance (pulmonary plethora)	ASD
Box shaped heart	Tricuspid Atresia
Water bottle/ flask shaped heart/ leather bottle/pear shaped/money bag heart/ purse like heart/ Epicardial fat pad sign	Pericardial effusion
Coeur en sabot i.e. boot shaped heart	Tetralogy of Fallot
Spade like deformity on ECHO	Atypical HOCM
Egg in cup appearance, square root sign	Constrictive pericarditis
Inverted moustache sign	Mitral stenosis
Egg on side appearance ,Egg shaped heart, Egg in string	D- Transposition of great arteries (D- TGA)
Convex left heart border	L-TGA
Ground glass ventricular septum	Hypertrophic Obstructive Cardiomyopathy (HOCM)
Straight left upper cardiac border	Ebstein's Anomaly
Concave main pulmonary segment & right aortic arch	Persistent Truncus arteriosus
Snowman sign, Figure of 8 sign, Cottage loaf sign	Total Anomalous Pulmonary Venous Connection (TAPVC) — supra cardiac variety
Goose neck sign	Atrioventricular septal defect
Tubular heart	Emphysema
Stag antler / hands up sign	CCF
Schimitar sign / Turkish sword appearance	Congenital venolobar syndrome
Sitting duck heart	Persistent truncus arteriosus
Yin yang sign	Pseudo aneurysms
Small heart sign	Tension pneumopericardium
High attenuating crescent sign	Impending rupture of abdominal aortic aneurysm
Draped aorta sign	Contained rupture of abdominal aortic aneurysm

Sign	Disease
Single Air Bubble sign	Pyloric stenosis/ obstruction
Double bubble sign	Ladd band / Malrotation, Annular pancreas
	Duodenal atresia/ stenosis/ web/ duplication cyst
Multiple air fluid level	Ileal obstruction
Triple bubble sign	Jejunal obstruction
String of beads sign, Stepladder appearance, Concertina effect,	Small bowel obstruction
Candy-cone appearance, Snake head appearance on barium study	
Gas under diaphragm, Liver edge sign, Falciform ligament sign, Gall bladder sign, Diaphragmatic muscle slip sign/ leaping dolphin sign, Luscent liver sign, Anterosuperior bubble sign Doge's cap sign, Riglers double wall sign, American footballs sign, Cupola's sign, Triangle sign, Visible transverse mesocolon sign, Visible small bowel mesentery sign, Pneumo-omentum/ pneumo-mesocolon, Urachus sign, Medial/ lateral umbilical fold sign, Inverted V sign, pneumoscrotum	Pneumoperitoneum
Birds beak appearance (barium meal), hurst phenomenon	Oesophageal Achalasia
Cork screw appearance (barium meal)	Diffuse oesophageal spasm
Beak sign, Double track or Tram track sign, Shoulder sign, string sign, diamond sign, Twinning recess, pyloric test, test sign, mushroom sign, caterpillar sign	Hypertrophic pyloric stenosis
Seagull / Mercedes Benz/ Crow feet sign	Radiolucent gall stone with gas
Multiple gas fluid level (step ladder pattern)	Intestinal obstruction
Cigar bundle appearance on X- ray, Winding highway railway tract on USG & Medusa Head colonies on CT scan	Round worm
Whirlpool sign in USG, corkscrew sign	Midgut volvulus
Coffee Bean sign, Bent tyre tube sign, Liver overlap sign, Pelvis overlap sign, Left flank overlap sign	Sigmoid volvulus
Shark mouth appearance	Ileocecal valve
Lead pipe appearance/ Stippled appearance/ Pipe stem appearance	Ulcerative colitis
String of Kantor, Bull's eye or Target lesion	Crohn's disease (regional Ileitis)
Thumb printing sign	Ischemic colitis (Also in amoebic & ulcerative colitis)
Saw tooth appearance (on barium enema)/ Champagne glass sign, Bowlers hat sign	Diverticulitis of colon
Apple core lesion & Napkins sign (on barium enema)	Ca-colon
Pincer sign, Claw sign, Coiled spring appearance, target sign, Meniscus sign, crescent in Doughnut Sign, Pseudokidney sign, Sandwich sign, Hay fork sign Hamburger sign, Signa de dance, Dance sign	**Intussusception**
Bubbly / frothy/ soap bubble/apple sauce appearance	Meconium ileus
Pulled up caecum/ obtuse ileo caecal angle/ filling defect/ incompetent ileocaecal valve Fleishner sign, Inverted umbrella defect, Steirlin sign, Amputed cecum, Goose neck deformity	Ileocaecal TB

Hamptons line	Benign gastric ulcer
Carmens meniscus sign;Kirkland complex	Malignant gastric ulcer
Apple peal appearance	Ileal atresia
Moulage sign	Coeliac sprue
Arrowhead sign, Rovsings sign	Acute appendicitis
Straight line sign	HCC
Comet-tail sign on USG	Adenomyomatosis of gall bladder
Central dot sign	Caroli's disease
Triangular cord sign	Biliary Atresia
Shaggy esophagus	Esophageal candidiasis
Accordion sign	Pseudomembranous colitis
Champagne sign	Emphysematous cholecystitis
Cluster of grapes sign	Pneumatoses cystoides coli
Corkscrew sign	Midgut volvulus
Dependant viscera sign	Diaphragmatic rupture
Fat ring sign	Mesenteric panniculitis
Molar tooth sign	Extraperitoneal bladder rupture
Ribbon bowel appearance on barium	Graft versus host disease
Spokewheel sign	Small bowel volvulus
Straight line sign on PET	Peritoneal carcinomatosis

RADIOLOGICAL SIGNS IN PANCREATIC DISORDERS

- In chronic pancreatitis, cholangio pancreatography (ERCP) is the most sensitive imaging modality.
- The positive findings are: **Chain of lakes appearance, String of pearls appearance, Beading appearance.**
- On x-ray numerous **irregular calcification are pathognomic of chronic pancreatitis.**
- String of beads sign -small bowel obstruction.
- Double bubble sign - in annular pancreas.

Disease	Pathognomic sign
Chronic pancreatitis (On ERCP)	Beaded appearance, Sting of pearls appearance, Rat tail stricture of CBD, **Chain of lakes appearance**
Acute Pancreatitis (Abdominal X-Ray)	Renal Halo sign, Gasless abdomen, Colon cut off ,Sentinel loop
Carcinoma pancreas	**Double contour of medial border of duodenal C loop, Double duct sign(ERCP) dilated/ widened Duodenal-C loop, mucosal irregularity, Rose thorning of medial wall of 2nd part of duodenum, Scramble Egg**

BLUNT TRAUMA

- **Spleen is the most commonly injured organ in blunt injury abdomen.**
- Contrast- enhanced CT is the investigation of choice for detecting splenic injuries.
- **Kehr sign** (after elevating foot end, referred pain over left shoulder d/t irritation of under surface of diaphragm by blood) is seen in splenic ruptures.
- On X- ray:
  - Fracture of left lower ribs,
  - Obliteration of splenic & psoas shadows
  - Elevation of left diaphragm
  - Indentation of stomach & presence of free fluid between coils of intestine.

- Arises from para ganglion cells of ANS.
- Most common site of origin –**adrenal medulla**
- Most common extra-adrenal site: **organ of zuckerkandl**
- **Investigation of choice for: is CT scan followed by MRI.**
- IOC for locally recurrent, metastatic, Ectopic & Extra – adrenal pheochromocytoma is **MIBG scan (Using I^{123} or I^{131})**
- Sensitivity: **MIBG > MRI > CT > USG**

RADIOLOGICAL SIGNS OF EXCRETORY SYSTEM

Radiological feature	Disease
Rim/ crescent sign & Soap bubble appearance	Hydronephrosis
Flower vase appearance of ureter	Horse shoe kidney
Yo yo phenomenon	Duplex ureter of kidney
Putty kidney, autonephrectomy, moth eaten appearance, Kerr's kink, irregular cavity, phantom calyx	TB kidney
Corkscrew ureter, beaded ureter, pipe stem ureter	TB ureter
Golf hole ureter	TB bladder
Drooping flower appearance	Ectopic ureter
Cobra head appearance/ adder head/ Spring onion appearance	Ureterocele
Egg in cup appearance, Signet ring sign on IVU Lobster claw sign on IVU, Ball on tee sign on IVU	Analgesic nephropathy causing papillary necrosis
Thimble bladder	Tubercular/ chronic cystitis
Fir tree appearance/pine cone bladder or christmas tree bladder	Neurogenic bladder
Sandy patches	Schistosomiasis of bladder
Chalice/ Bergman sign	Ureteric dilatation distal to neoplasm
Fish hook bladder	BPH
B/L spider leg appearance, Swiss- cheese/ black nephrogram,	Autosomal dominant Polycystic kidney
Sun burst nephrogram/ Patchy chaotic nephrogram	Autosomal recessive Polycystic kidney
Renal fascia sign	Acute renal artery occlusion
Bunch of flowers appearance, Paintbrush appearance	Medullary sponge kidney
Edling sign	Pseudoureterocle
Wind in the sail appearance, Keyhole appearance	Posterior urethral valves
Sunburst appearance, Bladder in bladder appearance, Molar tooth sign	Extra peritoneal bladder rupture
Nubbin sign	Reflux nephropathy involving the lower pole of a duplicated collecting system
Goblet sign, Bergmans coiled catheter sign	Ureteral transitional cell carcinoma

- **Pseudo ureterocele: malignant stricture of distal ureter.**

INVESTIGATIONS IN RENAL TUBERCULOSIS

PLAIN FILM

www.FirstRanker.com

- **Focus on calcification, which is seen in 25-45% at various stages of disease**
  - triangular in papillary necrosis
  - focal or amorphous : **putty kidney (endstage)**
- **Fluoroscopy - IVP**
- Traditional plain film IVP is quite sensitive to renal tuberculosis with only 10% of affected patients having normal imaging. Features include:
  - Parenchymal scars 50%
  - **Moth eaten calyces: early finding**
  - Irregular caliectasis
  - Phantom calyx
  - Hydronephrosis
- **Other lower urinary tract signs include:**
  - Kerr kink 3
  - Saw-tooth ureter
  - Pipe-stem ureter
  - Beaded or corkscrew ureter
  - Thimble bladder

ULTRASOUND

Sonographic appearances are non-specific and variable, depending on the stage of disease.

Early

- Normal kidney or small focal cortical lesions with poorly defined border + / - calcification.
- Progressive papillary destruction with echogenic masses near calyces.
- Distorted renal parenchyma.
- Irregular hypoechoic masses connecting to collecting system; no renal pelvic dilatation.
- Mucosal thickening + / - ureteric and bladder involvement.
- Small, fibrotic thick-walled bladder.
- Echogenic foci or calcification (granulomas) in bladder wall near ureteric orifice.
- Localised or generalised pyonephrosis.

End stage

- Small, shrunken kidney, "paper-thin" cortex and dense dystrophic calcification in collecting system.
- May resemble chronic renal disease.

Ultrasound is less sensitive than CT in detection of:

- Calyceal, pelvic or ureteral abnormalities.
- Isoechoic parenchymal masses.
- Small calcifications.
- Small cavities that communicate with collecting system.

CT

- CT is the most sensitive modality for visualizing renal calcifications.
- CT IVP is more sensitive at identifying all manifestations of renal tuberculosis.

Early

- Papillary necrosis (single or multiple) resulting in uneven caliectasis
- Progressive multifocal strictures can affect any part of the collecting system
- Generalised or focal hydro nephrosis.
- Mural thickening and enhancement
- Poorly enhancing renal parenchyma, either due to direct involvement or due to hydronephrosis

- Progressive hydronephrosis results in very thin parenchyma, mimicking multiple thin walled cysts.
- Amorphous dystrophic calcification eventually involves the entire kidney (known as **putty kidney**).

RADIOLOGICAL SIGNS IN ORTHOPEDICS

Classical radiological feature	Condition
Sunray appearance, Codman's triangle	Osteosarcoma
Onion peel appearance	Ewing's sarcoma
Soap bubble appearance	Osteoclastoma
Speckled/ Mottled/ Patchy calcification	Chondrosarcoma
Wormian bones	Osteogenesis imperfect
Trethowan's sign	Slipped capital femoral epiphysis
Aneurysmal sign	TB Spine
Honey comb appearance	Adamantinoma
Moth-eaten appearance in bone (permeative process of bone)	• Multiple myeloma • Primary lymphoma of bone (reticulum cell sarcoma) • Ewing sarcoma • Infection • Eosinophilic granuloma • Malignant fibrous histiocytoma • Metastases, especially Burkitt lymphoma • Mycosis fungoides
Driven snow appearance	Pindborg tumor

IMPORTANT FEATURES:

Sutural diastasis, copper beaten skull	Raised intracranial tension
Bracket calcification	Lipoma of corpus callosum
Dawson fingers on brain MRI	Multiple sclerosis
Tram track/ rail road track gyriform cortical calcifications	Sturge weber syndrome
Hyperdense MCA sign, Insular ribbon loss sign Light bulb sign on MR diffusion	Acute stroke
Pseudo delta sign, Cortical vein sign	SAH
Sugar icing appearance , Zuckerguss appearance	Medulloblastoma
Dural tail sign, Mother-in-law sign, Sunburst/ spoke wheel tumour vascularity	Meningioma
Geographic lytic skull, Vertebra plana	Eosinophilic Granuloma
Multiple punched out lesion in skull vault	Multiple myeloma
Hair-on-end skull vault	Thalassemia
Picture frame vertebra	Pagets disease
Fish mouth vertebra	Sickle cell anemia, Homocystienuria
Bat wing 4th ventricle	Joubert syndrome
Boxcar ventricles	Huntington's disease
Clover leaf skull	Thanatophoric dysplasia
Cord sign, Empty delta sign	Intravertebraldural sinus thrombosis
Corduroy appearance, Polka dot appearance	Intravertebral hemangioma

Eye of the tiger sign	Hallaverden syndrome
Flat tyre sign, Umbrella sign	Ruptured globe
Figure of 8 appearance	Pachygyria
Fish vertebrae	Sickle cell disease
Hot cross bun sign	Multisystem atrophy
Inverted napoleon hat sign	Spondylolisthesis
Scottie-terrier dog sign	Spondylolysis
Mount fuji sign	Tension pneumocephalus
Reversal sign	Anoxic brain injury
Salt and pepper pattern	Vascularity in glomus tumours
Sandwich vertebra	Osteopetrosis
Strawberry skull on antenatal USG	Trisomy 18
Tau sign	Persistent trigeminal artery

X-ray features of Osteosarcoma:

- Area of irregular destruction of metaphyses
- Erosion of the overlying cortex
- New bone formation in the matrix of the tumor
- Irregular periosteal reaction
- Codman's triangle
- Sun-ray appearance

Disease	**Radiological feature**
Osteosarcoma	Variable mixture of radio opacities & radiolucency **(hall mark)** Sun burst/ sun ray appearance (11nd), Codman's triangle (non specific)
Osteoclastoma Ewing's sarcoma Paget's disease	Soap bubble appearance Onion peel appearance In osteo lytic hot phase: Advancing wedge/ Blade of grass/ candle flame appearance In mixed phase: cotton ball skull, **picture frame vertebrae** In cool phase: bowing, bone density increased

Features	**Disorders**
Geographic lytic skull /Vertebrae plana	Eosinophilic granuloma/ Hans- Schuller Christian disease/Histiocytosis
Multiple punched out lesions	Multiple myeloma
Chicken wire calcification	Chondroblastoma (CODMAN'S TUMOR)
Hair on end skull vault	Thalassemia, sickle cell anemia
Erosion of dorsum Sella	Raised ICT (earliest & most common)
Salt peeper skull	Hyperparathyroidism
Silver beaten app. Of vault	Raised ICT
Sunray calcification with spicules	Meningioma

Epiphyseal dysgenesis, Punctate/ fragmented epiphysis	**Hypothyroidism**
Epiphyseal enlargement with squaring and angulation	**Juvenile chronic arthritis**

• Small epiphysis marginated by sclerotic rim (Wimberger sign) • Radiodense calcification at growing metaphyseal end **(Frankel's line),** • Radiolucent zone due to lack of mineralization of osteoid **(Trumerfeld zone),** • **Pelkan's spur & Subperiosteal hemorrhage**	**Scurvy**
Epiphyseal widening, Cupped & frayed metaphysic	**Rickets**

PUNCHED OUT LESIONS OF SKULL

- **Infectious Disorders**
  - Fungal osteomyelitis
  - Blastomycosis
  - Coccidioidomycosis
- **Granulomatous, Inflammatory Disorders**
  - Sarcoidosis
  - Hand-Schuller-Christian syndrome
- **Neoplastic Disorders**
  - Metastatic bone disease
  - Adenocarcinoma of prostate
  - Multiple myeloma
- **Metabolic, Storage Disorders**
  - Gout
  - Histiocytosis X
- **Congenital, Developmental Disorders**
  - Bony cystic angiomatosis
- **Hereditary, Familial, Genetic Disorders**
  - Ollier's enchondromatosis
- **Vegetative, Autonomic, Endocrine Disorders**
  - Primary Hyperparathyroidism
- **Reference to Organ System**
  - Systemic mastocytosis

HAIR ON END SKULL

(HINEST)

- **Hereditary spherocytosis**
- **Iron deficiency anemia**
- **Neuroblastoma**
- **Enzyme (G-6PD) deficiency**
- **Sickle cell disease**
- **Thalassemia major**

Radiological signs of vertebral diseases:

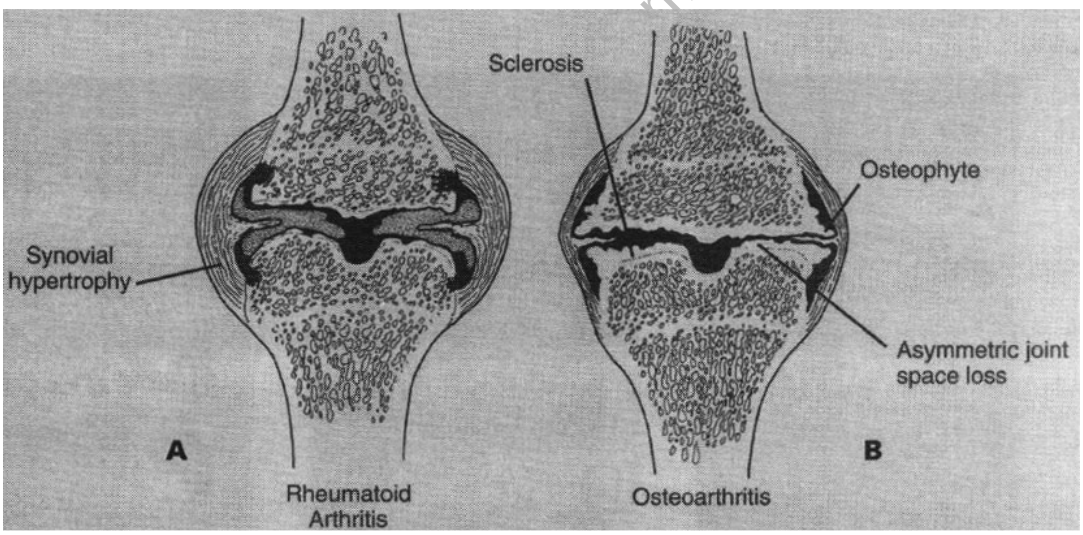
Vertebra piano	Eosinophilic Granuloma
Rugger jersey spine	Osteopetrosis, osteodystrophy due to CRF
Fish mouth vertebra	Homocystinuria, Sickle cell anemia
Cod mouth vertebra	Osteoporosis, osteomalacia & Hyperparathyroidism
Picture frame vertebra, "cotton wool," or osteoporosis circumscripta	Paget's disease
Calcification of intervertebral disc	Alkaptonuria

CAUSE OF HAIR ON END SKULL VAULT

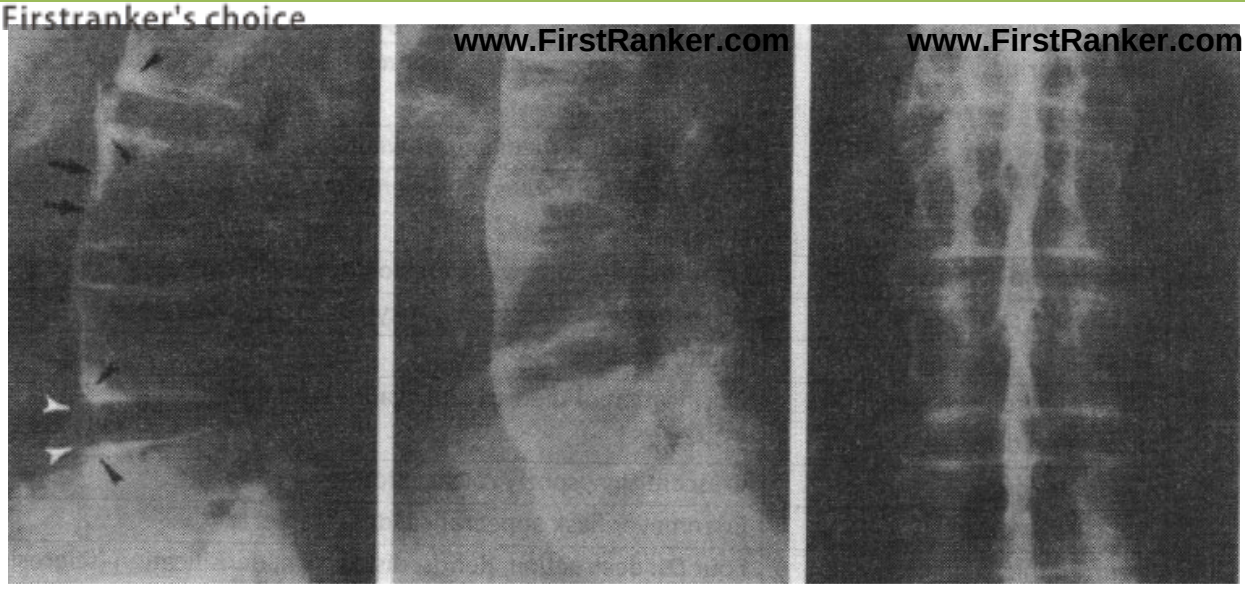
Hemolytic anemias: Thalassemia major/ Cooley's anemia (most common) & Sickle cell anemia, Neoplastic: **Hemangioma:** Meningioma; Metastasis

Others: Cyanotic heart disease; Iron deficiency anemia; Ewing's sarcoma, syphilis, infantile cortical hyperostosis (Caffey's disease).

RADIOGRAPHIC FINDINGS IN ARTHRITIS	
Disease State	**Findings in Hip or Knee**
Osteoarthritis	Joint space narrowing, subchondral sclerosis, osteophytes, subchondral cysts
	Hip: Superior or medial narrowing
	Knee: Early narrowing on Rosenberg views; flattening of femoral condyles
Rheumatoid arthritis or SLE	Uniform joint narrowing, erosion near joint capsule
Ankylosing spondylitis	Osteopenia, Osteophytes, ankylosis of sacroiliac joints
Gout	Tophi, erosions
Calcium pyrophosphate deposition disease	Calcification of menisci and hyaline cartilage
Osteonecrosis	Crescent sign, spotty calcification
Gaucher disease	Erlenmeyer flask appearance, distal femora
Neuropathic joint	Four Ds: destruction, debris, dislocation, densification (sclerosis, hypertrophy)
Hemophilic arthropathy	Epiphyseal widening, sclerosis, cysts, joint space narrowing



- **Erosive osteoarthritis: gull's wing/ angel wing appearance.**



A B C

FIG: BAMBOO SPINE APPEARANCE OF ANKYLOSING SPONDYLITIS

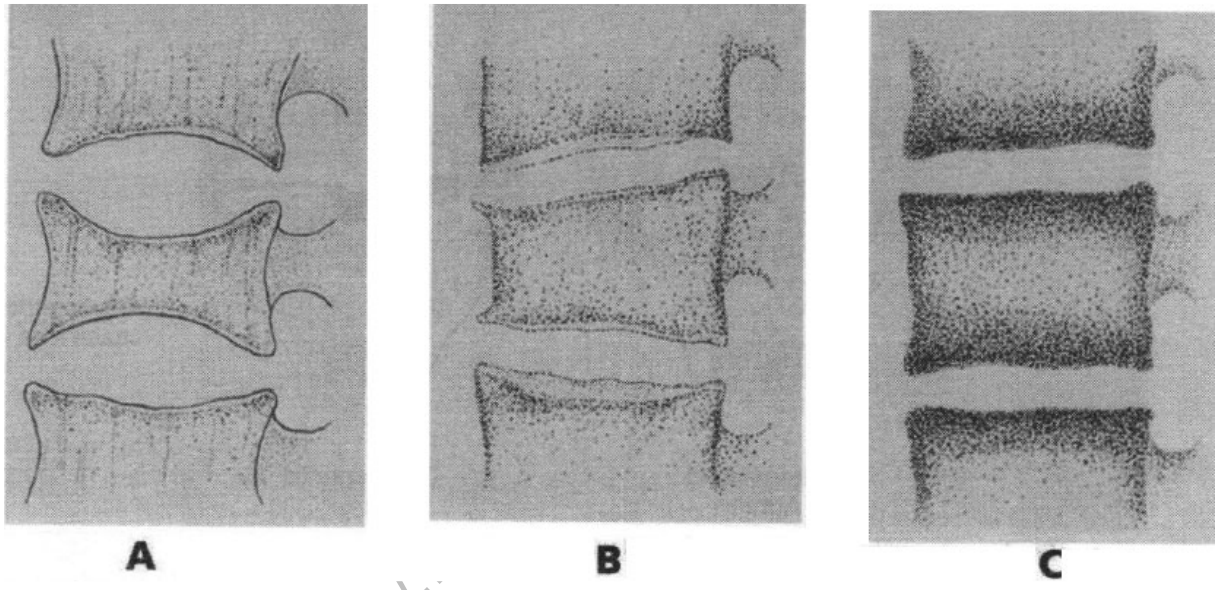


Figure: The characteristic differences between osteoporosis, osteomalacia, and hyperparathyroidism in the spine.

(A) Osteoporosis manifests as a biconcave vertebral body with prominent vertical trabeculae.

(B) Osteomalacia manifests as uniform deossification with a loss of trabecular detail and anterior wedge-shaped compression fractures.

(C) The "rugger jersey" spine of secondary hyperparathyroidism manifests as increased density adjacent to the vertebral end plates.

Shiny corner sign	Ankylosing spondylitis
Pseudo shiny corner sign	Degenerative spondylosis
Waldenstrom sign	Osteoarthritis hip
Patellar tooth sign	Patella-femoral joint OA
Movie sign	Chondromalacia patellae

Licked candy stick appearance, Jigsaw pattern Tumbling building block spine	Atrophic neuropathic arthropathy
Migrating mouse sign Apple core deformity of hip	Synovio-chondro-metaplasia
Cocktail sausage digit, spindle digit, ivory phalanx, Pencil in cup/ pestle and mortar/ mushroom and stem/ balancing pagoda/ cup in saucer appearance, opera glass hand, whittling effect, mouse ears sign	Psoriatic arthropathy
Bone in bone appearance, Sandwich vertebra, Rugger-jersey spine Erlenmeyer flask deformity	Osteopetrosis
Flowing candlewax appearance	Melorrhosteosis
Hot cross bun skull	Cliedo-cranial dysplasia
Paired posterior iliac horns	nail patella syndrome
Elephant ears, Mickey mouse ears, Clinodactyly	Downs syndrome
Bare orbit, Empty orbit sign	Neurofibromatosis-1
Hook shaped vertebral bodies, Cut corner sign	MPS I/ hurler syndrome
Central beaking of vertebrae, Ape like pelvis	MPS IV/ morquio syndrome
Gull wing sign	Erosive OA
Steinberg sign	Marfan syndrome
Pelkan spur/ Pencil thin cortex/ Corner sign of Parke Trummerfield zone of rarefaction/ White line of Frankel/ Wimberger sign	Scurvy
Looser zone/ lines, Milkmans fracture, Osteoid seams Increment fracture, Umbau zones	Osteomalacia
Rugger jersey spine/ Brown tumours/ Pepper pot skull/ Subperiosteal resorption of phalanges	Hyperparathyroidism
Cotton wool appearance, Candle flame/ blade of grass lysis Picture frame vertebra	Pagets disease
Penumbra sign	Brodies abscess
Inverted napoleon hat sign, Gendarme's cap sign Bowline of Brailsford, Broken collar/ neck of scotty dog, Scottish terrier sign	Spondylolisthesis
Button sequestrum, Floating teeth sign, Hole with hole appearance	Histiocytosis-X
Swan neck deformity, Boutonniere deformity, Hitch hiker thumb Hammer toes	RA
Trident hand, Tomb stone iliac bone, Cheuron sign	Achondroplasia
Intervertebral disc calcification	Alkaptonuria
Pear shaped vertebra	Spondylo-epiphyseal dysplasia
Hump shaped vertebra, Heaped up vertebra	Spondylo-epiphyseal dysplasia
Inferiorly beaked vertebra	MPS I/ hurler syndrome
Centrally beaked vertebra	MPS IV/ hunter syndrome
Biconcave lens vertebra	Osteogenesis imperfecta
Spool shaped vertebra	Pyknodysostosis
Bullet nose vertebra	Achondroplasia
Vertebra with central anterior tongues	Pseudochondroplasia
H shaped vertebra	Thanatophoric dwarfism

Extradural	Subdural	Subarachnoid: (SAH)
• Biconvex (Lens shaped/ lenticular) • Hyper dense in acute cases. • Hypo dense in Chronic cases	• Crescent (Concavo-Convex) • Hyper dense (<2 weeks) • Isodense (2-4 wks) • Hypo dense (> 4 wks)	• **Non- contrast CT** is investigation of choice for diagnosing the hematoma. • **Four vessels (both carotids & both vertebra's) Digital subtraction angiography (DSA)** is the investigation of choice for determining etiology. • **The hallmark of SAH is** blood in CSF detected by lumbar puncture. • Lysis of blood in CSF causes **Xanthochromia** which is peak at 48 hours.

- Most common intracranial lesion after head injury is subdural hematoma.
- Most common cause of SAH is head trauma.
- Investigation of choice for SAH is **Non- contrast CT**
- M.C. cause of spontaneous SAH is ruptured saccular aneurysm.

Diffuse axonal injury (DAI)

- It is caused by shearing of the white matter, often at the gray-white junction.
- May be due to the differing tissue density or fixation between two structures in differing response to rotation, acceleration, and deceleration.
- Detection is often associated with changes in the lobar white matter, brainstem, and corpus callosum with ovoid or elongated regions of decreased density.
- Patients usually present with severe impairment of consciousness from the moment of impact.
- **MRI (FLAIR or T2 weighted) - most useful in defining the extent of axonal shearing and non-hemorrhagic injury.**
- **CT** results -often negative, but acute areas of petechial hemorrhage & cerebral edema have been seen in early stages.

IMPORTANT SIGNS IN RADIOLOGY

- Puff of smoke sign: Moyamoya disease
- Polka dot sign: vertebral hemangioma
- Dripping candle wax sign: melorheostosis
- Accordion sign: pseudomembranous colitis
- Air crescent sign: aspergilloma
- Angelwing sign: pulmonary edema [bat wing sign]
- Air bronchogram sign: pneumonia
- Anteater's nose sign: tarsal coalition
- Apple core appearance: Ca Colon
- Blade of grass sign [Flame sign]: Paget's disease
- Bevelled edge appearance: eosinophilic granuloma
- Bowler hat sign, Mexican hat sign: colonic polyp
- Black pleura sign: alveolar microlithiasis
- Bird of prey sign: sigmoid volvulus
- Bone within bone appearance: osteopetrosis
- Breast within breast appearance: hamartoma of breast
- Bear paw sign: xanthogranulomatous Pyelonephritis
- Pelvic brim sign: Paget's disease
- Bite sign, crescent sign: avascular necrosis of femur

- Bulging fissure sign: Klebsiella pneumonia
- Banana sign/ lemon sign: neural tube defect
- Carman meniscus sign: Ca stomach
- Cotton wool appearance: Paget disease
- Cobra head appearance: Ureterocele
- Coblestone appearance: Crohn's disease
- C sign: tarsal coalition
- Coffee bean sign: sigmoid volvulus
- Colon cut off sign: acute pancreatitis
- Comb sign: Crohn's disease
- Comet tail sign: round atelectasis
- Comet sign: pelvic phlebolith
- Continuous diaphragm sign: pneumomediastinum
- Corduroy sign: vertebral hemangioma
- Corkscrew oesophagus: diffuse esophageal spasm
- Crazy paving sign: pulmonary alveolar proteinosis
- Champagne glass pelvis: Achondroplasia
- Celary stalk sign: rubella, osteopathia striata, anterior cruciate ligament degeneration
- Corkscrew sign: midgut volvulus
- Cottage loaf sign: diaphragmatic rupture
- Codfish vertebra: sickle cell disease
- Jerry Thomas sign: scapho lunate dislocation
- Dense MCA sign: hyperacute stroke(CT sign)
- Double bubble sign: duodenal atresia, annular pancreas
- Double density sign: enlarged left atrium (mitral stenosis)
- Doughnut sign: testicular torsion(nuclear scan)
- Draping aorta sign: leaking abdominal aortic aneurysm
- Deep sulcus sign: pneumothorax
- Double duct sign: periampullary, pancreatic Ca
- Erlenmeyer flask deformity: Gaucher's disease, thalassemia, osteopetrosis, pyle's disease
- Fat pad sign: pericardial effusion
- Foot ball/ falciform ligament sign: Pneumoperitoneum (infant)
- Fallen lung sign: fracture bronchus
- Fishhook ureter: BPH
- Flat waist sign: left lower lobe collapse
- Gloved finger sign: allergic bronchopulmonary aspergillosis
- Gull wing sign: erosive osteoarthritis
- Goose neck sign: endocardial cushion defect
- Hampton line: benign gastric ulcer
- Hampton hump: pulmonary infarction
- Honda sign: sacral insufficiency fracture
- Hide bound appearance: scleroderma
- Hair on end appearance: hemolytic anemia
- Hot nose sign: brain death
- Holly leaf appearance: asbestosis
- Hot cross bun sign: multi system atrophy-C
- Half moon/ light bulb sign: posterior shoulder dislocation
- Head cheese sign: hypersensitivity pneumonitis
- Ivory vertebra: osteoblastic vertebral metastasis
- Insular ribbon sign: acute cerebral infarct

- Ivory phalanx: psoriasis
- Molar tooth sign: extra peritoneal bladder rupture
- Mercedes Benz sign: gall stone
- Micky mouse sign: Paget's disease
- Napoleon hat sign: spondylolisthesis
- 1-2-3 sign: Sarcoidosis
- Pie in the sky sign: urethral injury
- Pyloric teat, pyloric beak, caterpillar sign, double triple track sign, string sign: hypertrophic pyloric stenosis
- Rugger Jersey spine: secondary hyperparathyroidism
- Rigler sign: Pneumoperitoneum
- Rice grain calcification: cysticercosis
- Ring sign: renal papillary necrosis
- Sandwich sign: lymphoma
- Spine sign: lower lobe pneumonia
- String of beads sign: mechanical small bowel obstruction
- Stack of coins: scleroderma
- Trough sign: posterior shoulder dislocation
- Westermark sign: pulmonary embolism
- Yin yang sign: partly thrombosed aneurysm
- Wimberger's sign: congenital syphilis

IMPORTANT FACTS

- **FARADAY CAGE:** prevent the passage of electromagnetic waves. Contain **Mu-copper foils** which can be applied as wall papers.
- **Contrast used in CT: lohexol (non ionic),Metrizamide- not used now**
- **Dye of choice for myelography: lopamidol**
- **Pindborg tumor:** calcifying Epithelial Odontogenic Tumor **(CEOT)**
- **M/C cause of intra cranial calcification:** Pineal body calcification
- **M/c endocrine abnormality following intracranial radiotherapy: Growth hormone deficiency**
- **M/C calcifying brain tumor in child:** Craniopharyngioma followed by oligodendroglioma
- **Suprasellar calcification with cystic appearance:** Craniopharyngioma
- **M/C solid renal neoplasm in neonates: Mesoblastic nephroma**
- **M/C malignant abdominal neoplasm in children: Wilm's tumor (nephroblastoma)**
- **M/C malignancy in children: Leukemia > Brain tumors > Nephroblastoma**
- **M/C renal mass in childhood: Hydronephrosis > multicystic dysplastic kidney> Nephroblastoma**
- **Hyperparathyroidism:** Brown's tumor (m/c in mandible), Subperiosteal erosion (Hallmark), Salt pepper appearance & basket work appearance.
- **Williams syndrome/ Idiopathic hypercalcemia of malignancy:** Supravalvular aortic stenosis, Mental retardation & Elfin facies(round faces with full cheeks & lips)
- **Emergency radiotherapy given in:**
  - Neoplastic cardiac tamponade
  - Acute epidural spinal cord compression
  - Tumor lysis syndrome
  - Severe hypercalcemia
  - SVC syndrome.
- M/C radiation induced secondary cancer: Leukemia
- M/C radiation induced secondary cancer following treatment for head & neck cancers: Thyroid cancer
- **Neutron beams are more effective in treating salivary gland tumors.**
- Soap bubble appearance in abdominal x-ray -Meconium ileus
- Soap bubble appearance in head CT-Cryptococcal meningitis

- Soap bubble calcification in x-ray-Osteosarcoma
- Puffed rice appearance on CT-Scan head-neurocysticercosis
- Soap bubble cerebral calcification in head CT-Toxoplasmosis (Congenital)

COMMON CAUSES OF EGG SHELL CALCIFICATION OF NODES

- Egg shell calcification means peripheral rim calcification of lymph nodes.
- **Pneumoconiosis (M.C):** Silicosis (M.C), Coal workers pneumoconiosis: **not seen in** Asbestosis, berylliosis, baritosis, talcosis.
- **Sarcoidosis & Lymphoma following radiotherapy**
- **Rare causes are:** Fibrosing mediastinitis, Fungal + Bacterial infections: histoplasmosis, Coccidiodomycosis, Blastomycosis, Tuberculosis, Amyloidosis

TYPES OF CALCIFICATIONS:

Popcorn calcification	Pulmonary hamartoma, Mediastinal nodes in acute histoplasmosis, fibroadenoma
Pericardial calcification	Constrictive pericarditis
Cardiac calcification	Carcinoid syndrome
Basal ganglia calcification	Idiopathic(M/C), Hypoparathyroidism
Egg shell calcification	Silicosis, Sarcoidosis, TB, lymphoma after radiation
Rice grain calcification	Cysticercosis
Tram track(rail road)calcification	Sturge Weber syndrome
Calcification of menisci	Pseudogout
Adrenal & ear pinna calcification	Addison's disease
Cardiac wall calcification	Endomyocardial fibrosis

Most common primary CNS neoplasm	**Glioblastoma multiforme**
2nd most common primary CNS neoplasm	Meningioma
Most common intracranial germ cell tomour	Germinoma
Most common mixed glioma	Oligo-astrocytoma
Most common site of schwannoma	Vestibular division on 8th nerve
Most common intracranial tumour in neonates	Teratoma
M/C primary intracranial neoplasm in sellar/ parasellar region	Pituitary adenoma
Most common intraaxial posterior fossa tumor in adults	Metastasis from extracranial sites
Most common of all primary intracranial neoplasms	Glioblastomamultiforme
Most common supretentorial neoplasm in adults	Glioblastomamultiforme
Most common intracranial tumour to calcify	Oligodendroglioma
Most common site of cellular ependymoma in brain	4th ventricle
Most common nonglial primary brain tumour	Meningioma
Most common intracranial extraaxial tumour	Meningioma
most common spinal extradural neoplasm	Metastasis
Most common benign spinal neoplasm	Vertebral hemangioma
Most common malignant extradural neoplasm	Metastasis
Most common spinal intramedullary tumour in adults	Ependymoma

Most common spinal intramedullary tumour in adult	Ependymoma

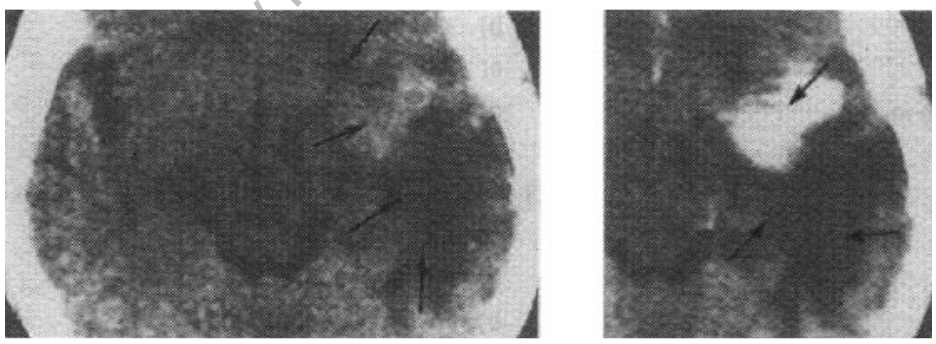
CEREBRAL RING ENHANCING LESIONS

DR MAGIC LNT

- Demyelinating disease
- Radiation
- Metastasis (2nd m/c)
- Abscess
- Glioblastoma multiforme (m/c cause)
- Infarct
- Contusion
- Lymphoma
- Neurocysticercosis
- Tuberculoma
- Toxoplasmosis
- Syphilis
- Behcet disease

A **B**

Cysticercosis; contrast-enhanced CT. Sections at the levels of the third ventricle (A) and the lateral ventricles (B). Lesions are at different stages of development: homogeneously enhancing ring with calcified scolex; some are associated with vasogenic oedema.



A **B**

Tuberculoma: CT. Axial sections before (A) and after (B) IV contrast medium: a superficial mass slightly denser than brain is surrounded by vasogenic oedema in the frontal and temporal lobes; it shows marked contrast enhancement.

RADIO NUCLIDE IMAGING

- **$^{99}T_c$ is** the most commonly used radiopharmaceutical, for imaging in nuclear medicine; it is used with different ligands for imaging of different sites.

Radio nuclide	Uses
Tc 99^m labeled serum albumin	Detection of pulmonary embolism
Tc 99^m labeled RBC's	Spleen imaging
Tc 99^m labeled DMSA	Renal morphology
Tc 99^m labeled DTPA	Measures GFR
Tc 99^m labeled HIDA/ PIPIDA	Functions of hepato biliary tree
Tc 99^m labeled MAG-3	Diagnostic of transplant rejection
Thallium 201 chloride	Cardiac imaging (cold spots in myocardial studies)
Ga-67 nitrate	To detect tumours, inflammation, abscess cavities

COLD NODULE

- **Area of decreased radio isotope intake.**
- 15 — 20 % of cold nodules may be malignant.
- Multiple cold nodules with interfering regions of increased uptake indicates a multi nodular gland with low incidence of associated malignancy.

HOT NODULE

- **Area of increased radio-isotope uptake**
- Almost never harbors malignancy, represent a benign condition
- Represents either autonomous or hypertrophic area

Exception: Warthin's tumor & oncocytoma- malignant tumour showing hot nodule on radionuclide scan

TECHNETIUM-99M BONE SCAN

- The bone scan labels the osteoblast activity with the radioactive tracer, technetium-99.
- An increase in osteoblastic activity results in the incorporation of more of the diphosphonate molecule into the mineral matrix of bone, causing it to appear **"hot" or "dark";**
- Absence of osteoblastic activity produces **a "cold" or photopenic ("photon poor") area,** due to decreased radiotracer localization and photon emission.

INDICATIONS:

- **Malignant Tumors : Primary and Metastatic**
- **Benign Bone Tumors: Osteoid Osteoma**
- **Trauma: Occult Fractures, Domestic Violence/Abuse**
- **Infection: Osteomyelitis, Arthritis**
- **Metabolic diseases: Paget's , Bone (Avascular) Necrosis**
- **Soft Tissue diseases: Myositis Ossificans**
- **Unexplained bone Pain**

"HOT" BONE SCAN:

- Seen in any disorder that results in increased bone formation.
- Areas of active bone metabolism, such as the epiphyseal growth plate, most metastatic bone lesions, osteoarthritis and osteomyelitis.

- In normal cases, **the "hottest" areas are those undergoing the most rapid growth, including the distal femur, the proximal tibia, and the proximal humerus. In the adult, greater activity is seen in the axial skeleton than in the appendicular skeleton**
- **Regional Hyperactivity may be due to:**
  - Normal bone growth and remodeling
  - Increased blood flow(trauma, heterotopic ossification)
  - Reactive osteoblastic activity (**active infections,** tumors)
  - Reparative bone process(**healing fractures**, tumors, infections)
  - Hyper-metabolic activity(metabolic disorders)
- Lesions that appear hot on bone scan include healing fractures and osteoblastic tumors, such as osteogenic sarcoma.

COLD BONE SCAN:

- A loss of blood flow to the bone, or a bone infarction, can cause this type of spot.
- When a person suffers a bone infarction, the part of the bone that no longer receives blood can die, leading it to collapse.
- **Multiple myeloma may not show up on a bone scan because only osteoclastic activity is involved in the majority of lesions.**
- **Malignant Tumors**
  - Lung (2-4%)
  - Breast (5%)
  - Renal (10%)
  - Neuroblastomas (bone marrow metastasis)
  - Thyroid (most cases)
  - Multiple Myeloma (most cases)
- **Bone Abscesses (they are surrounded by activity)**
- **Bone ischemia (AVN, sickle cell, etc.)**
- **Hemangiomas(normal or decreased activity)**

BONE SCAN IN METASTATIC LESIONS:

- Most sensitive routine imaging modality to try and identify both sclerotic and lytic lesions.
- In most cases they demonstrate increased uptake (hot spot) although occasionally **(in very aggressive purely lytic lesions) a photopaenic defect (cold spot)** may be visible.

SUPERSCAN:

- Greater than normal activity in the kidneys is most commonly due to urinary tract obstruction, and bilaterally **decreased activity most often reflects renal failure.**
- An important exception to the latter is the absence of renal activity in the so-called **superscan**, in which diffuse skeletal uptake is so avid that renal uptake is undercut.
- A common condition producing **a superscan is diffusely metastatic prostate carcinoma.**

INVESTIGATION OF CHOICE

USG	CT-Scan	HRCT	MRI	PET/SPECT
Cystic lesions, fluid accumulation	Adrenals, pancreas, mediastinum, calcification, cerebral hemorrhage	Lung pathology like bronchiectasis, interstitial lung disease	Posterior fossa, spine CNS, muscle, soft tissue, joints, etc.,	Occult metastasis

INVESTIGATION OF CHOICE IN CARDIAC CONDITIONS

Cardiac conditions	Investigation of choice
Aortic dissection: Stable patient Unstable patient	MRI Trans esophageal Echo with CT scan
Pericardial effusion	Echo (Investigation of choice), CT/MRI (second choice)
Valvular disease	Trans esophageal echo cardiogram
Constrictive pericarditis	MRI
Coarctation of aorta	Gadolinium-enhanced 3D MRA
Myocardial function	Tc-Albumin scan
Cardiac tamponade/ Cardiomyopathy	Echo cardiogram

- Gold standard test for ventricular function in heart: MRI.

INVESTIGATION OF CHOICE IN RESPIRATORY CONDITIONS

- Pleural effusion- lateral decubitus
- Pneumothorax - CXR PA view on full expiration.
- Bronchiectasis in ILD: HRCT

INVESTIGATION OF CHOICE FOR OTHER CONDITIONS

- Single Bone Metastasis — CT
- Multiple Bone Metastasis — Bone scan
- Spine Metastasis — MRI
- Avascular necrosis- MRI
- Bone Density/Osteoporosis- DEXA (Dual energy x ray absorptiometry)
- Aneurysm/ AV Fistula- Angiography
- Dissecting Aneurysm (Stable) - MRI (Unstable)-Trans oesophageal USG
- Pericardial Effusion- Echocardiography
- Lobulated pericardial effusion- MRI > CT
- Minimum Pericardial Effusion- Echocardiography
- Ventricular Function- Echocardiography
- Radiotherapy/Chemotherapy induced cardiotoxicity- Endomyocardial Biopsy
- Pulmonary Embolism- CECT> Pulmonary Angiography > V/Q Scan
- Interstitial lung disease(Sarcoidosis)- HRCT
- Bronchiectasis- HRCT scan
- Solitary Pulmonary Nodule- High resolution CT (HRCT)
- Posterior Mediastinal Tumor- MRI
- Pancoast Tumor (Superior Sulcus Tumor) — MRI
- Minimum Ascites/Pericardial effusion/Pleural effusion — USG
- Traumatic Paraplegia- MRI
- Posterior Cranial Fossa — MRI
- Acute Haemorrhage- CT
- Chronic Haemorrhage- MRI
- Intracranial Space Occupying Lesion- MRI
- Primary brain tumour- contrast MRI (Gold standard however remains to be biopsy)
- Metastatic brain tumor- (Gadolinium) contrast enhanced MRI
- Temporal Bone-CT
- SAH Diagnosis- unenhanced CT
- SAH aetiology- 4 vessel MR Angiography > CT Angiography > DSA
- **Nasopharyngeal angiofibroma- CECT scan**
- Acoustic neuroma- Gadolinium DTPA enhanced MRI
- Obstetrics- USG

- Calcifications- CT
- Blunt abdominal Trauma- CT
- Acute Pancreatitis- CT
- GERD- pH manometer > endoscopy
- Dysphagia- Endoscopy
- Congenital hypertrophic pyloric stenosis- USG
- Extrahepatic biliary atresia- perioperative cholangiogram
- Obstructive Jaundice/GB Stones- USG
- Diverticulosis — barium enema
- Diverticulitis — CT scan
- Renal TB (early) —IVP (Late)- CT
- Posterior Urethral Valve- MCU
- Ureteric stone- non contrast CT
- Renal Artery Stenosis- Percutaneous Angiography
- Extraintestinal Amoebiasis- ELISA
- Discrete swelling(solitary nodule) of thyroid- FNAC
- MRI is the investigation of choice for imaging traumatic spine (ex paraplegia). CT is second best investigation.
- The most important imaging modality in suspected or known acute head trauma is the noncontrast CT. CT is superior to MRI for the detection of acute blood and fractures,

Small intestinal tumor	CT contrast
Early renal TB	IVP
Advanced renal TB	CT> IVP> USG
Pregnant lady with abdominal mass	MRI
Dental & TM joint pathology	Ortho pantomography [OPG]

Meckel's diverticulum

- Most common type of omphalomesenteric duct remnant.
- Results from failure of the yolk sac to close during fetal life
- Present in 0.5-3% of the population.
- Occur 30-90 cm from the ileocaecal valve and range in size from 0.5 to 13 cm in diameter.
- About 20-40% cause symptoms.
- **Complications:** ulceration, bleeding, perforation, inflammation, intussusception, internal hernia, volvulus, and adhesions.
- **Ectopic gastric mucosa** is present in the diverticulum in about 20% of all patients who present with bleeding and in 95% of children who bleed.
- **Radionuclide imaging with ^{99m}technetium pertechnetate is more accurate (sensitivity-85%)** in the paediatric age group than in adults.
- Meckel's diverticula which haemorrhage contain ectopic gastric mucosa in 95% of cases and ^{99m}Tc scintigraphy is useful in this subset of patients.
- A characteristic **angiographic feature:** demonstration of a persistent vitellointestinal artery in who present with chronic gastrointestinal bleeding.

FOREIGN BODIES

- IOC: conventional film-screen radiography
- Glass objects: plain radiography, xeroradiography, CT and MRI.
- Gravel: all methods except MRI where ferromagnetic streak artefacts may obscure visualization. Plastic: easily detected by MRI.
- Wooden foreign bodies, especially when wet, are only seen by CT and MRI.
- Xeroradiography does not have any benefit over plain radiography in identifying foreign bodies.

- FB in children: USG

GOLD STANDARD METHODS

For diagnosis of breast cancer	Mammography
For staging of breast cancer	Axillary lymph node dissection
For evaluation of a stable patient with suspected vascular injury	Angiography
For diagnosis of GERD	Ambulatory 24 hr pH monitoring
For the diagnosis of GI perforation	Finding pneumoperitoneum
For diagnosis of Zollinger-Ellison syndrome	Serum gastrin levels(most patients have serum gastrin levels above 1000pennl)
For diagnosis of colonic mucosal disease	Colonoscopy
For diagnosis of steatorrhoea	Timed quantitative stool fat determination
For treatment of incontinence with an isolated sphincter defect	Overlapping sphincteroplasty
For diagnosis and method of management of acute arterial occlusion	Laparotomy
For confirmation of mesentric arterial occlusion	Mesentric angiography
For diagnosis of celiac disease	Small intestine biopsy
For identifying choledocholithiasis	ERCP
For diagnosis of primary sclerosing cholangitis	ERCP
For diagnosis of hepatitis C	HCV RNA assay
For diagnosis of invasive amoebiasis	ELISA
Of diagnosis of Klatskin tumor	Cholangiography
For assessment of function of sphincter of Oddi	Manometry
For assessing degree of liver injury and fibrosis	Liver biopsy
For diagnosis of intraluminal bile duct abnormalities	ERCP
For estimating resting energy expenditure	Indirect calorimetry
For diagnosis of iron deficiency anemia	Estimation of serum ferritin
For proving that the life span of red cell is decreased (useful in hemolytic anemia)	Red cell survival study
For evaluation of stem cell transplantation therapy	Hemopoietic stem cell transplantation
For diagnosis of acute pharyngitis	Throat culture
For diagnosis of pertussis	Culture of nasopharyngeal secretions
For diagnosis of DVT	Contrast venography
For differentiating allograft rejection and reactivation of disease after heart transplantation	Endo-myocardial biopsy
For diagnosis of otitis externa caused by p. Aeruginosa	Technetium99 bone scan
For diagnosis of acoustic neuroma	Gadolinium MRI
Investigation for diagnosis of shigella infection	Isolation and identification of pathogen from fecal material
For diagnosis of tuberculous meningitis	Culture of CSF
For diagnosis of HSV encephalitis	Brain biopsy (CSF PCR largely replaced brain biopsy in recent times)
For diagnosis of histoplasmosis	Fungal culture
For diagnosis of hypertrophic cardiomypathy and atrial myxoma	Echocardiogram

For imaging heart valves and valve motion abnormalities	2D echocardiography
For assessment of myocardial viability (identification of ischemic or hibernating myocardium)	PET
For assessment of LV mass and volume	MRI
For evaluation of renal arteries and identification of renal artery lesions	Contrast arteriography
For evaluation of respiratory gas exchange	ABG
For assessment of albuminuria	24 hr urine collection
For diagnosis of PNH	Flow cytometry
For diagnosis of ATTR and other AF mutations	DNA sequencing
For identifying and quantifying atherosclerosis in cerebral arteries	X-ray cerebral angiography
For evaluating anatomy of arterio-venous malformation	X-ray angiography
For diagnosis and classification of ataxia	Genotype
For diagnosis of lung infection (radiotherapy induced) in a cancer patient	Open-lung biopsy
For assessment of visual impairment	Snellen's chart
For bacterial stain analysis	Pulse-field gel electrophoresis
For resection of anterior and middle mediastinal masses	Median or lateral thoracotomy
Of treatment of coarctation of aorta	Surgical repair
For evaluation of coronary artery disease	Cardiac catheterization
For culture of v. Cholerae o139	Conventional culture method
To determine cut-off titer of widal test for diagnosis of typhoid fever	Nested PCR
For diagnosis of chronic arterial mesentric ischemia	Angiography
For evaluation of imaging modalities for liver tumors	Intraoperative ultrasonography
For diagnosis of common bile duct stones	Endoscopic cholangiography
For measurement of GFR	Inulin clearance
For diagnosis and treatment of ventilator associated pneumonia (VAP)	Broncho alveolar lavage
To differentiate follicular and papillary carcinoma of thyroid gland	Histology

Radiopharmaceuticals currently used and their common clinical applications

Organ system	***Clinical application***	***Radiopharmaceuticals***	***Biological behaviour***
Cardiovascular system			
Myocardial perfusion	Detection of ischaemia, infarction, and viability assessment	^{201}TI (thallous chloride)	K+ analogue extracted in proportion to bloodflow
		^{99m}Tc isonitriles	Cationic complexes taken up by myocytes in
		^{99m}Tc teboroxime	Lipophilic compound which accumulates by diffusion

		^{99m}Tc-diphosphonate	Uptake proportional to blood flow
Myocardial metabolism	Viability assessment	^{123}I fatty acids	Enters primary metabolic pathway in viable cells: limited catabolism
		^{18}F-deoxyglucose	Enter metabolic pathway in viable cells demonstrates secondary shift to anaerobic glycolysis
Cardiac ventriculography	Quantification of right and left ventricular function at rest and with exercise	^{99m}Tc-red blood cells	Characterization of cardiac chambers motion, localization of red cells within cardiac chambers
	Detection of wall motion abnormalities	^{99m}Tc-albumin	
	Quantification and detection of shunts (and valvar regurgitation)		
Cellular blood components			
Red blood cells	Detection of haemangioma	^{99m}Tc-labelled red blood cells	Red cell pooling
	Cardiac ventriculography		
	Gastrointestinal bleeding		Red cell extravasation
	Red cell survival	^{51}Cr (sodium chromate)	Red cell disappearance from the blood
White blood cells	Localization of sites of infection or inflammation	^{99m}Tc-mln-labelled cells	Cellular diapedesis
		^{99m}Tc-labelled antigranulocyte antibody	
Platelets	Platelet survival	^{111}In-labelled platelets	Platelet sequestration and degradation
	Localization of sites of active thrombosis		
Central nervous system			
Cerebral blood flow	Blood flow distribution	^{99m}Tc-HMPAO	Diffusion through the blood–brain barrier (BBB) and brain extraction
	Tumours	^{99m}Tc-ECD	
	seizure disorders		
	Dementia		

	brain death studies		
	Regional blood flow at rest and upon activation	$H2^{15}O$	BBB diffusible flow tracer
Cerebral metabolism	Functional and regional mapping of neuronal activity at rest	^{18}F-deoxyglucose	Enter metabolic pathway in viable cells
	at rest		
	upon activation		
	during seizure		
	in the interictal state		
	Staging of brain tumour	^{18}F-deoxyglucose	
	Follow-up of therapy	^{201}TI	
Cerebrospinal fluid	CSF shunt patency	^{111}In-DTPA	Follows cerebral spinal fluid (CSF) flow dynamics
	Localization of CSF leaks		
	Differentiation of normal pressure hydrocephaly from atrophy		
Gastrointestinal system			
Liver—spleen imaging	Space-occupying lesions, organ sizing, RES function	^{99m}Tc-sulphur colloid	Phagocytosis by reticulo-endothelial cells
Spleen imaging	Detection of ectopic splenic tissue	Heat-damaged ^{99m}Tc-labelled red blood	Splenic trapping of damaged cells
Hepatobiliary imaging	Assessment of biliary ducts patency	^{99m}Tc-iminodiacetic acid derivatives	Active uptake—follows bilirubin conjugation and excretion pathway
	Evaluation of gallbladder contractility		
	Diagnosis of acute vs chronic cholecystitis		

	Differentiation between biliary atresia and neonatal hepatitis		
Bowel transit studies	Oesophageal transit and reflux	^{99m}Tc-sulphur colloid	Transit of labelled material
	Gastric emptying and antral motility	^{99m}Tc-sulphur colloid	Compartmental localization of labelled material
		^{111}In-DTPA	
	Gastric emptying	^{13or14}TC-labelled substrates	Detection in breath of exhaled 13°'14CO2 metabolite
	Duodenogastric reflux	^{99m}Tc-iminodiacetic acid derivatives	Bile detection and localization
	Small bowel and colon transit	^{111}In-DTPA	Transit of labelled material
		$^{13\text{ or }14}$C-labelled substrates	Detection in breath of exhaled $^{13\text{ or }14}CO_2$ metabolite
Helicobacter pylori (HP) infection	Detection of HP Urease production	$^{13\text{ or }14}$C-labelled urea	Detection in breath of exhaled $^{13\text{ or }14}CO_2$ metabolite
Gastrointestinal bleeding	Acute and chronic bleeding	^{99m}Tc-sulphur ^{99m}Tc-labelled RBC's	Extravasation in the bowel
Peritoneovenous shunts	Determination of shunt patency	^{99m}Tc-sulphur colloid	Compartmental localization
Salivary glands	Evaluation of salivary function and ducts	^{99m}Tc-pertechnetate	Active uptake and secretion
Gastric mucosa	Detection and localization of a Meckel's diverticulurn containing gastric mucosa	^{99m}Tc-pertechnetate	Active uptake by gastric mucosa
Genitourinary system			
Renal perfusion	Evaluation of arterial blood flow	^{99m}Tc-DTPA	Early intravascular localization
	Diagnosis of transplant rejection	^{99m}Tc-MAG3	
		^{99m}Tc-DTPA	

Renal function	GFR measurement	^{51}Cr-EDTA	Clearance by glomerular filtration
	Measurement of effective renal plasma flow; tubular function		Tubular uptake
		^{99m}Tc-MAG3	
Renal morphology	Detection of renal infarct	^{99m}Tc-DMSA	Retention in renal cortex
	Global renal morphology		
Bladder	Quantitation of bladder residual vesicoureteral reflux	^{99m}Tc-DTPA	Compartmental localization
Scrotum	Differentiation between acute	^{99m}Tc-pertechnetate	Early intravascular localization
Pulmonary system			
Ventilation scan	Evaluation of regional ventilation	^{133}Xe gas	Distributes in lungs in proportion to regional
		^{81}Kr^{m} gas	
		^{99m}Tc aerosols	
Perfusion scan	Detection of pulmonary emboli, right to left shunts; preoperative and transplant evaluation of relative lung perfusion	^{99m}Tc albumin macroaggregates	Pulmonary capillary blockade
Parenchymal tissue	Interstitial lung disease staging and therapeutic evaluation	^{67}Ga	Binds to transferrin in the intravascular compartment,
Musculoskeletal system	Detection of soft tissue vs primary bone disorders during Phases I and II of study Detection of benign, alignant, and infectious bone lesions	^{99m}Tc-polyphosphate compounds	Intravascular and early soft tissue distribution (Phase I and II)
			Fixed to hydroxyapatite crystals (Phase III)
Thyroid-parathyroid			

Thyroid	Evaluation of gland size, morphology and function (uptake).	Iodine-123	Active uptake (^{123}I) and organification (^{123}I)
		^{99m}Tc- ertechnetate	
	Determination of functional status of nodules		
	Detection of thyroid cancer and metastases, thyroid cancer treatment	Iodine-131	Active uptake and organification
Parathyroid	Localization of parathyroid adenoma and carcinoma	^{99m}Tc-M IBI	Cationic complexes taken up in proportion to blood flow and trapped in mitochondria
Tumour markers			
Neuroendocrine tissue	Somatostatin receptor positive tumours	^{111}In-pentetreotide (Octecotide®)	Binds to somatostatin receptors
Lymphopoietic tissue	Staging and localization of lymphoma	^{67}Ga (gallium citrate)	Binds to transferrin in the intra-vascular compartment, taken up by cancer cells, binds to lactoferrin and ferritin, and concentrates in lysosomes
Brain neoplasia	Brain tumour staging and therapeutic follow up	^{201}TI (thallous chloride)	Concentrates in tumour cells following BBB damage
Adenocarcinoma	Tumour detection and staging	^{111}In-Satumomab pendetide	Antigen-antibody recognition
Miscellaneous neoplasia	Tumour detection and staging	^{18}F-deoxyglucose	Uptake proportional to tumour

GOLD STANDARD METHODS

- Gold standard for treatment of organ confined, muscle invasive, bladder cancer is – Radical cystoprostatectomy in men and anterior pelvic exenteration in woman
- Gold standard method for management of hydatid disease – Surgery
- Gold standard method for management of blunt hepatic trauma – Non-operative management
- Gold standard for treatment of femoral shaft fractures – Reamed locked intramedullary nailing
- Gold standard method in case of difficult intubation – Flexible fibreoptic intubation scope
- Gold standard treatment of hyperparathyroidism – Surgery
- Gold standard procedure for thymectomy – Trans cervical mediastinoscopy and surgery
- Gold standard for treatment of adrenal tumors – Laparoscopic adrenalectomy
- Gold standard method for treatment of GERD – Laparoscopic Nissens fundoplication

- Gold standard for evaluating cure rate in duodenal ulcer patients – Vagotomy
- Gold standard method of treatment of Symptomatic cholelitiasis – Lap cholecystectomy

MAMMOGRAPHY

- Diagnostic accuracy – 90 – 95 %
- 45% of breast cancers can be seen on mammography before they are palpable.

Indications:

- Coarse nodular breast, Fibro adenosis, Woman, aged 40yrs with family H/o cancer

FEATURES	BENIGN	MALIGNANT
Opacity	-Smooth margin -Low Density, Homogenous -Thin Halo	Ill defined margin(Spiculated) High density, Wide halo
Calcification	-**macro calcification** (>0.5mm in diameter) -egg shell curvilinear, -Popcorn(Fibro adenoma), -Floating calcification, -Tramline/ tortuous calcification, -Rod like Wide spread calcification	**Micro calcification** (<0.5mm in diameter)
Skin	Normal	Thickened
Nipple/ Areola	±retracted	±retracted
Duct	Normal	Focal dilatation
Subcutaneous retro mammary space	Normal	Obliterated
Surrounding parenchyma	Normal	Disrupted

BARIUM STUDIES

Study of GIT by instillation/ ingestion of barium suspension made from pure **barium sulphate.**

Procedure	Organ studied
Barium swallow	Oesophagus
Barium meal	From stomach to proximal jejunum
Barium follow through	From stomach to ileocaecal junction
Barium enema	Large intestine (administration of contrast via rectum)
Small bowel enema (Enteroclysis)	From jejunum to ileocaecal junction

DTPA (Reno gram)	DMSA (Isotope scanning)
• DTPA is useful for evaluating perfusion and function • of each kidney • Indications: 1. Measurement of relative renal function in each kidney. 2. Urinary tract obstruction 3. Diagnosis of renovascular cause of hypertension 4. Investigation of renal transplant	• T_c 99 DMSA is used for Renal morphological imaging • This compound gets fixed in renal tubules & images may be obtained after 1-2 hours of injection- Lesions such as tumors & benign lesions as show filling defect • Used to assess cortical function of kidney

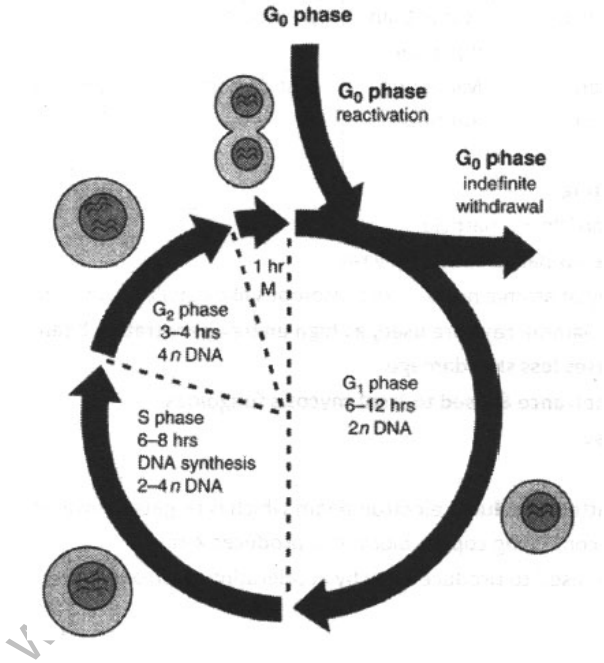
- MCU is the most accurate method of demonstrating vesicoureteric reflux, and as this is important in children with urinary tract infection and reflux nephropathy.
- The ascending urethrogram gives excellent anatomical information concerning the distal urethra as far as the distal sphincter mechanism.
- Ultrasound and CT are the investigations of choice in the diagnosis and staging of renal tumours.
- Dynamic CT is more accurate than angiography in detecting a small neoplasm.
- Antegrade pyelography is an accurate method of demonstrating precisely the site of an obstruction to the upper urinary tract.

V. RADIOTHERAPY

- Radioactivity was discovered by Henry Becquerel in 1896.
- J.J. Thompson- discovered electrons
- W.K.Roentgen- discovered X Rays in 1895.
- Madam Marie Curie- discovered radioactive substances radium, uranium etc.
- Rutherford- discovered nucleus, alpha & beta rays
- Chadwick- discovered neutrons
- Maxwell- discovered electromagnetic waves

Radiotherapy is treatment of malignant tumor with ionizing radiation, most commonly by using y rays; which causes excitation or ionization of electron (ejection of electron from orbit) and kills tumor cells by producing double strand breaks in DNA (direct) or free radicals (indirect).

- **The DNA molecules present along the chromosomes are the critical targets for radiation damage.**
- Chromosomal abnormalities occur in cells irradiated in G_1 phase before doubling of genetic material.
- Chromatid aberration occurs in cells irradiated in G_2 phase.
- **Most sensitive phase to radiation is M> G_2M interphase**
- **Most resistant phase is end of S phase.**



- Lymphocyte analysis provides evidence of recent total body exposure.
- A typical course of radiation therapy should be described as 4500 cGy delivered to a particular target (e.g., mediastinum) over 5 weeks in 180-cGy fractions.
- Most curative radiation treatment programs are delivered once a day, 5 days a week in 150- to 200cGy fractions.
- Therapeutic radiation is delivered in three ways:
  - **Teletherapy**, with beams of radiation generated at a distance and aimed at the tumor within the patient
  - **Brachytherapy**, with encapsulated sources of radiation implanted directly into/adjacent to tumor tissues
  - **Systemic therapy**, with radionuclides targeted in some fashion to a site of tumor.
- **Teletherapy is the most commonly used form of radiation therapy.**

- X-rays and gamma rays are the forms of radiation most commonly used to treat cancer.

Radiation	Content	Penetrating power	Ionizing power	Damaging power	Sources
α- Particle	Helium nuclei (i.e. 2 protons & 2 neutrons	Poorest	Maximum	Most damaging	Uranium, Plutonium
β-Particle	Either high energy electron or antimatter counterpart positron	Greater than α -particle (100)	Lesser than α particle	< α particle	Phosphorous-32,strontium-89,samarium-132,1-131
X-Ray	Low energy photons	More than β-particles	Lesser than B particle	<β Particle	
Y-Radiation	Very high Energy photons	More than X-Rays 10000 i.e., **Most penetrating**	Minimum ionizing	Least damaging	Co-60, radium -126.

Penetration power: y- ray > x ray > β particle > α particle
Ionizing & Damaging Power: α- particle> β-particle> x-ray > y ray

- Gamma rays are produced by decay of atomic nuclei in radioisotopes like cobalt & caesium.
- **For deep seated tumors, X rays & Gamma rays are used, as high energy penetrating beam deliver a less intense superficial dose & causes less skin damage.**
- **Electron beams have very low penetrance & used to treat mycosis fungoides.**
- **I-131:** emits both beta & gamma rays.
- **Californium:** emits neutron.
- Heating of tungsten filament by battery **produces electron beam** which is targeted towards positive charged tungsten or molybdenum containing copper block; this produces X-rays
- Linear accelerator and betatron are used to produce x-ray by accelerating electrons.

Neutrons

- Uncharged particulate radiation.
- Present in nuclear reactors and at high altitudes.
- Have highest penetrating power.
- Water and paraffin wax are effective in absorbing it.
- Predominant neutron emitter: **californium**.

BRACHYTHERAPY

- First proposed by Forssell in 1931.
- Delivered by two methods:
  - Intra cavitatory therapy: Eg: **Manchester system for Rx of Ca. cervix**
  - Interstitial implantation: Eg. **HDR therapy for Ca. Bronchus & ca. Oesophagus.**
- Radionuclides used in brachytherapy:
  - Caesium 137, Cobalt 60, Iridium 192, Iodine 125, Radium 226, Radon 222, Strontium 90, Samarium 145, Palladium 103, Gold 198, Yetrium 169.
- The characteristic features of Brachytherapy are:
  - Maximum radiation effect can be obtained in diseased tissue.
  - Minimum risk of to the normal tissue.
  - It requires trained personnel & Invasive

- It is often used in brain tumours and liver scans.

UNITS OF RADIATION

Feature	S.I. Unit	Non S.I. Unit
Radioactivity	**Becquerel (Bq)**	**Curie**
Absorbed dose	**Gray (Gy)**	**Rad**
Dose equivalent	**Sievert (Sv)**	**Rem**
Exposure	**Coulombs/ kg**	**Roentgen**

ISOTOPES USED IN MEDICINE

Reactor Radioisotopes (half-life indicated in brackets):

- **Molybdenum-99 (66 h):** Used as the 'parent' in a generator to produce technetium-99m.
- **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 and numerous specialized medical studies.
- **Uses of Technetium 99 tagged RBC's:**
  - Commonly indicated in Acute Lower Gastrointestinal Bleeding.
  - Relatively sensitive & very specific imaging method for noninvasive diagnosis of liver hemangioma.
  - Measurement of left ventricular ejection fraction. Assessment of regional wall motion (left and right ventricles).
- **Chromium-51 (28 d):** Used to label RBC's and quantify gastro-intestinal protein loss.
- **Cobalt-60 (10.5 months):** Formerly used for external beam radiotherapy.
- **Copper-64 (13 h):** To study genetic diseases affecting copper metabolism. Eg: Wilson's and Menke's diseases.
- **Dysprosium-165 (2 h):** Used as an aggregated hydroxide for synovectomy treatment of arthritis.
- **Erbium-169 (9.4 d):** Use for relieving arthritis pain in synovial joints.
- **Holmium-166 (26 h):** Being developed for diagnosis and treatment of liver tumours.
- **Iodine-125 (60 d):** Used in brachytherapy (prostate and brain), to evaluate the filtration rate of kidneys and to diagnose DVT in the leg. It is also used in radioimmuno-assays to show the presence of hormones in tiny quantities.
- **Iodine-131 (8 d):** Used in treating thyroid cancer, imaging the thyroid; in diagnosis of abnormal liver function, renal (kidney) blood flow and urinary tract obstruction. A strong gamma emitter, but used for beta therapy.
- **Iridium-192 (74 d):** Supplied in wire form for use as an internal radiotherapy source for cancer treatment
- **Iron-59 (46 d):** Used in studies of iron metabolism in the spleen.
- **Lutetium-177 (6.7 d):** emits just enough gammas for imaging while the beta radiation does the therapy on small (eg endocrine) tumours. Its half-life is long enough to allow sophisticated preparation for use.
- **Palladium-103 (17 d):** Used to make brachytherapy permanent implant seeds for early stage prostate cancer.
- **Phosphorus-32 (14 d):** Used in the treatment of polycythemia vera (excess red blood cells). Beta emitter.
- **Potassium-42 (12 h):** Used for the determination of exchangeable potassium in coronary blood flow.
- **Rhenium-186 (3.8 d):** Used for pain relief in bone cancer. Beta emitter with weak gamma for imaging.
- **Rhenium-188 (17 h):** Used to beta irradiate coronary arteries from an angioplasty balloon.
- **Samarium-153 (47 h):** Sm-153 is very effective in relieving the pain of secondary cancers lodged in the bone, sold as Quadramet. Also very effective for prostate and breast cancer. Beta emitter.
- **Selenium-75 (120 d):** Used as seleno-methionine to study the production of digestive enzymes.
- **Sodium-24 (15 h):** For studies of electrolytes within the body.
- **Strontium-89 (50 d):** Very effective in reducing the pain of prostate & bone cancer. Beta emitter.
- **Xenon-133 (5 d):** Used for pulmonary (lung) ventilation studies.
- **Ytterbium-169 (32 d):** Used for cerebrospinal fluid studies in the brain.

- **Ytterbium-177 (1.9 h):** Progenitor of Lu-177.
- **Yttrium-90 (64 h):** for brachytherapy and as silicate colloid for relieving pain of arthritis. Pure beta emitter.
- Radioisotopes of **caesium, gold and ruthenium** are also used in brachytherapy.

Cyclotron Radioisotopes:

- Carbon-11, Nitrogen-13, Oxygen-15, Fluorine-18: positron emitters used in PET.
- **F-18 in FDG** in detection of cancers and the monitoring of progress in their treatment, using PET.
- **Cobalt-57 (272 d):** Used as a marker to estimate organ size and for in-vitro diagnostic kits.
- **Gallium-67 (78 h):** For tumour imaging & localization of inflammatory lesions (infections).
- **Indium-111 (2.8 d):** Used for specialist diagnostic studies, eg brain studies, infection and colon transit studies.
- **Iodine-123 (13 h):** Used for diagnosis of thyroid function, a gamma emitter without the beta radiation of 1-131.
- **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.
- **Strontium-92 (25 d):** Used as the 'parent' in a generator to produce Rb-82.
- **Thallium-201 (73 h):** for diagnosis of coronary artery disease, other heart conditions such as heart muscle death and for location of low-grade lymphomas.

$T_{1/2}$ in hours	$T_{1/2}$ in days	$T_{1/2}$ in years
I^{132}-2.3 hours Tc^{99}-6 hours I^{123}-13 hours	I^{131}- 8 days; Gold- 2.7 days Thallium-3.2 days; Radon-3.8 days Xenon-5.2 days; P^{32}- 14 days I^{125}- 60 days	Co^{60}- 5.2 years Tritium- 12 years St ^{90}- 28 years ; Cs^{132}- 30 years Ra- 1622 years; U– 701 x 10^8 yrs

Co- 60 has the following features:

- Naturally occurring isotope
- Atomic. No. 27
- Atomic. Wt. 58.93
- Half- life 5.3 years
- Emits β and y- rays
- Used in both brachy & Teletherapy

Internal Contaminant Radionuclides: Properties and Treatment

Isotope Name	Symbol	Common Usage	Radiation Type, t% Radiologic $t_{1/2}$ Biologic, days	Exposure Type	Focal Accumulation in Body	Treatment
Manganese	Mn-56	Reactors, research laboratories	β, y, 2.6 h 5.7	External, internal	Liver	N/A

Cobalt	Co-60	Medical radiotherapy devices, commercial food irradiators	β, γ, 5.27 y 9.5	External, internal	Liver	Gastric lavage, purgatives; penicillamine in severe cases
Strontium	Sr-90	Fission product of uranium	β, 28 y 18,000	Internal	Bones—similar to calcium	Strontium, calcium, Ammonium chloride
Molybdenum	Mo-99	Hospitals—scans	β, γ, 66.7 h 3	External, internal	Kidneys	N/A
Technetium	Tc-99m	Hospitals—scans	β, γ, 6.049 h 1	External, internal	Kidneys, total body	Potassium perchlorate to reduce thyroid dose
Cesium	Cs-137	Medical radiotherapy devices	β, γ„ 30 y 70	External, internal	Renal excretion	Ion-exchange resins, Prussian blue
Gadolinium	Gd-153	Hospitals	β, γ, 242 d 1000	External, internal	N/A	N/A
Iridium	Ir-192	Commercial radiography	0, γ, 74 d 50	External, internal	Spleen	N/A
Radium	Ra-226	Instrument illumination, industrial applications, old medical equipment, former Soviet Union military equipment	α, β, γ, 1602 y 16,400	External, internal	Bones	MgSO4 lavage, ammonium chloride, calcium alginates
Tritium	H-3	Luminescent gun sights, muzzle-velocity detectors, nuclear weapons	β, 12.5 y 12	Internal	Total body	Dilution with controlled water intake, diuretics
Iodine-131	^{131}I	Reactor accidents, thyroid ablators	β, γ, 8.1 d 138	Internal	Thyroid	Potassium/sodium iodide, propylthiouracil, methimazole
Uranium	U-235	Depleted uranium, natural uranium, fuel rods, weapons-grade material	α, β, γ, 10^8 y 15	Internal	Kidneys, bones	$NaHCO_3$, chelation with EDTA

Plutonium	Pu-239	Produced from uranium in reactors, nuclear weapons	α, 2.1 x 10^4y 73,000	Internal	Lungs, bones, bone marrow, liver, gonads	Chelating with DTPA or EDTA
Americium	Am-241	Smoke detectors, nuclear weapon detonation fallout	α, 458 y 73,000	Internal	Lungs, liver, bones, bone marrow	Chelating with DTPA or EDTA
Polonium	Po-210	Calibration source	α, 138.4 d 60	Internal	Spleen, kidneys	Lavage, dimercaprol
Thorium	Th-232	Calibration source	α, 1.41 x 10^{10}y 73,000	Internal	N/A	N/A
Phosphorus	P-32	Research laboratories, medical facilities	B,14.3 d 1155	Internal	Bones, bone marrow, rapidly replicating cells	Lavage, aluminum hydroxide

CRANIOSPINAL IRRADIATION

Craniospinal irradiation is used for patients who have, or are at risk for, disseminated disease throughout the CNS that is not sufficiently responsive to chemotherapy (typically methotrexate).

Aim is to irradiate the entire sub arachnoid space,

Indications:

- Medulloblastoma
- PNET (pineoblastoma, ependymoblastomas, unclassified).
- Germ Cell tumour with CSF and/or MRI positive for malignant cells.
- Pure germinoma.
- Non Hodgkins Lymphoma with CSF positive for malignant cells.

Total Body Irradiation (TBI)

- Used as a systemic treatment since 1900 for palliating symptoms or obtaining short term remissions.
- **Done for:** acute leukemia in adult, high grade lymphomas **(intensive cytoreductive chemo radiotherapy followed by Bone Marrow Transplant)**
- **Prophylactic Craniospinal irradiation is useful in CNS malignancy which disseminates via CSF or any malignancy with high risk of CNS spread.**
- **They are:** Medulloblastoma, Glioblastoma, Germinoma, Small cell lung Carcinoma, ALL, Non Hodgkin's lymphoma & Leptomeningeal rhabdomyosarcoma.

INDICATIONS FOR TOTAL BODY IRRADIATION	
MALIGNANT	**NON MALIGNANT**
Leukemias: ALL, AML, CML, hairy cell leukemia	**Immune disorders-** aplastic anemia
Lymphoma's: NHL, refractory Hodgkin's lymphoma, myelodysplasia, multiple myeloma, mycosis fungoides	**Genetic disorders-** osteopetrosis, Fanconi's anemia, wiskott-aldrich syndrome
Pediatric solid tumors: Ewing sarcoma, Neuroblastoma	
Adult solid tumors: testicular Ca, Small cell Ca of lung	

- The standard treatment for brain metastases has been whole brain radiotherapy (WBRT) usually administered to a total dose of 3000 cGy in 10 fractions.
- This affords rapid palliation; approximately 80% of patients improve with glucocorticoids and radiation therapy.

STEREOTACTIC RADIOSURGERY (SRS)

- Introduced by Lekshell in 1951.
- Treats brain disorders with a precise delivery of a **single, high dose of radiation in a one-day session.**
- **Ideally confined to a lesion of 3-5cm size.**
- Stereotactic radiosurgery (SRS) delivered through a variety of techniques including the gamma knife, linear accelerator, proton beam and CyberKnife can deliver highly focused doses of RT, in a single fraction.
- Focused radiation beams are delivered to a specific area of the brain.
- It does not remove the tumor or lesion, but it distorts the DNA of the tumor cells.
- The cells then lose their ability to reproduce and retain fluids.
- Most of the beams used today are 4MV or 6MV beams.
- The three basic forms of stereotactic radiosurgery are:
  - Particle beam (proton)
  - Cobalt-60 based (photon), most well-known machine is the **Gamma Knife.**
  - Linear accelerator based (linac)

Indications

• Arteriovenous Malformations • Acoustic • Neuromas • Meningiomas • Pineal and Pituitary Tumors • Glial Tumors and Astrocytomas • Low grade tumors	• Metastatic Brain Tumors • Trigeminal Neuralgia • Essential Tremor • Parkinson's Tremor/Rigidity • Current research areas include epilepsy, headaches and neuro-psycho conditions.

INTENSITY MODULATED RADIATION THERAPY (IMRT)

- High precision radiotherapy by computer controlled X-ray accelerator to deliver precise radiation doses to a malignant tumor or specific areas within the tumor.
- IMRT used in treatment of tumours of:
  - Breast, Thyroid, lung, Prostate & Gynecological cancers
  - Head & neck cancers
  - Liver & brain cancers
  - Lymphoma, sarcoma

INTRA OPERATIVE RADIOTHERAPY

- Applied with ortho voltage X —ray
- Specialized radiation technique for treating deeply located cancers with large single dose, avoiding damage to the normal tissues.
- Intra operative electron beam followed by photons via X- rays & Gamma rays is the recent regimen.
- Used in pancreatic, gastric & rectal cancers; head & neck cancers, genitor urinary & gynecological cancers, retroperitoneal sarcomas.

FAST NEUTRON RADIOTHERAPY (FNRT)

- **Uses neutrons of megaelectron volts (MeV) energy.**

- Generated by **accelerating either protons or deuterons with cyclotrons or particle accelerators and then** delivering them to appropriate target (mostly beryllium).
- Fission neutrons (1-2MeV) from nuclear reactors can also be used to treat patients.
- For neutrons of energies used in RT, about 85% of deposited energy is via a knock on reaction **(billard ball type collision)** involving the hydrogen nucleus ('H).
- **Kinetic energy release in matter (KERMA)** is larger in high hydrogen content tissue such as fat or myelin.
- It is the **higher energy transfer that gives rise to the different radiobiological properties of FNRT.**
- Fast neutrons have RBEs 3 to 3.5 in terms of most normal tissue late effects, RBEs 4 to 4.5 in terms of damage to CNS and RBEs 8 for salivary gland malignant tumors.
- **Neutron therapy is best used in the treatment of certain tumor that exhibit a resistance to standard low LET radiotherapy —** a small niche, but it remains a very important treatment option for small number of patients for whom it appears to be better than tradition forms of treatment.
- Examples.
  - Patients with inoperable or recurrent salivary gland malignant tumors or in high risk situations where there has been an incomplete surgical extirpation or
  - Where inoperable or incompletely resected sarcomas of bone, cartilage and soft tissue or locally advanced prostate cancers particularly those that are not hormonally responsive have been found.
  - May also be beneficial in metastases from melanoma & renal cell carcinoma.

Boron Neutron Capture Therapy (BNCT)

- Pure beams of very low energy neutrons do not directly deposit much energy in tissue. The basic idea is to selectively attach a nuclide with a large cross section for capturing thermal neutrons [eg boron 40(^{10}B) or gadolinium – 157 (^{157}Gd)] to the cancer cells.
- The nucleide then undergoes a nuclear reaction with the localized release of substantial amount of energy and kills the tagged cancer cells but does not damage the surrounding untagged normal cells.
- At present moderated neutron beams from nuclear reactors are used but there is ongoing work in developing high current particle accelerator to produce low energy thermal or epithermal beams for BNCT.

Californium – 252 (^{252}CF) Neutron Brachytherapy

- Beneficial for tumors in which hypoxia is thought to be a factor in limiting tumor control with standard treatment.

METHODS FOR ORGAN PRESERVATION	
QUART Technique	Breast
Intra operative Brachytherapy	Soft tissue sarcomas
Stereotactic radiosurgery	Small brain tumors
Chemo irradiation	Bladder cancer
Concurrent chemotherapy	Anal cancer
Plaque therapy	Uveal melanoma
External radiotherapy	Retinoblastoma & laryngeal cancers
External radiotherapy/ brachytherapy	Prostate, head & neck, gynecological cancers

RADIOSENSITIVITY

Very high	High	Intermediate	Low
Bone marrow (most), Testes & ovary, Growing cartilage/ growth plate/ epiphysis, Breast, Lens	Skin, growing muscles, bones, Brain, spinal cord, Pituitary, thyroid , salivary gland, Stomach, small intestine, intestine, colon, rectum, Liver, lung, heart, kidney, cornea	Adult bone, Adult cartilage, Oral mucosa, Oesophagus Urinary bladder	Pancreas, Uterus Vagina, Adrenals

M/C affected – skin (more commonly moist areas)
Most common skin manifestation- Erythema
Most sensitive blood cell – lymphocyte
Most resistant blood tissue- platelets
Most sensitive body tissue- bone marrow
Most resistant body tissue- CNS
Most sensitive cell in CNS- neuron
Most sensitive CNS part – mid brain, medulla, spinal cord
Most sensitive abdominal organ- kidney
Most sensitive hormone: growth hormone
Most sensitive mucosa – intestinal mucosa

RADOSENSITIVITY OF TUMOURS:

High	Moderate	Relatively Resistant	Highly resistant
Ewing's sarcoma Seminoma Lymphoma Wilm's tumor Multiple myeloma	Nasopharyngeal Ca Dysgerminoma, Teratoma & Ovarian Ca Medulloblastoma Small cell Ca lung Ca. breast Basal cell Ca	Renal cell Ca Rectal / colon Ca Ca Cervix	Hepatoma Pancreatic Ca Osteosarcoma Melanoma

MOST RADIOSENSITIVE TUMORS

- Ovarian tumor: **Dysgerminoma > Teratoma**
- Brain tumor: **Medulloblastoma**
- Testicular tumor: **Seminoma**
- Lung tumor: **small cell C_A**
- Kidney tumor: **Wilm's tumor**
- Bone tumor: **Ewing's Sarcoma & multiple myeloma**

RADIOSENSITIZERS	RADIOPROTECTIVE AGENTS	RADIATION POTENTIATOR
• Anti-cancer drugs: Cisplatin , 5-FU, Hydroxyurea Vincristine, Bleomycin • Metronidazole, Misonidazole, Etanidazole, Pimonidazole • Hyperbaric O_2 (**Most potent**) (not - cyclophosphamide)	• Amifostine • Sodium butyrate • IL-1 • GM-CSF	• Doxorubicin • Dactinomycin

- Amifostine reduces cisplatin-induced nephrotoxicity & also reduces xerostomia in patient with head & neck Ca.
- Sodium butyrate when given topically improves the symptoms of radiation proctitis.

RADIO IODINE THERAPY IN THYROID CANCER

- Well differentiated thyroid cancer still incorporates radio iodine, but less efficiently than normal tissue.
- Indication- For tumor that takes up iodine, I^{131} treatment can reduce or eliminate residual disease.
- Thyroid ablation + I^{133}-Treatment in:
  - Large papillary tumor
  - Lymph node involvement

- FCT
- Evidence of metastasis

WILM'S TUMOUR

- The postoperative radiotherapy in Wilm's tumour **should be started within 10 days of surgery**.
- Delay in starting RT beyond 10 days leads to tumour cell repopulation and increase in relapse rate.
- Recommended dose: 1.2 to 1.5 Gy per fraction
- Indications of RT in Wilm's tumour are:
  - Stage II, Ill, IV with unfavorable histology (UH)
  - Stage III & IV with favorable histology (FH)
  - Metastatic disease
  - Clear cell sarcoma of kidney in all stages.

MEDULLOBLASTOMAS

- **Most common malignant brain tumor of childhood**, approximately 20% of all primary CNS tumors among children.
- Arise from granule cell progenitors or from multipotent progenitors from the ventricular zone.
- **Associated syndromes:** Gorlin syndrome, Turcot's syndrome and familial adenomatous polyposis.
- **Histology:** highly cellular tumors with abundant dark staining, round nuclei, and rosette formation (Homer-Wright rosettes).
- **Features:** headache, ataxia, and signs of brainstem involvement.
- **MRI:** densely enhancing tumors in the posterior fossa, sometimes associated with hydrocephalus.
- Seeding of the CSF is common.
- **Treatment:** maximal surgical resection, craniospinal irradiation, and chemotherapy with agents such as cisplatin, lomustine, cyclophosphamide, and vincristine.

BONE SECONDARIES

Ca. Prostate produce mainly osteoblastic (Osteosclerotic) secondaries.

- **Mostly blastic: Bladder, bowel, breast, bronchial, Carcinoid, lymphoma & Prostate [4 Bees Can lick Pollen**
- **Usually lytic but frequently blastic: Breast**

Invariably lytic: Kidney/Thyroid

WEDGE ANGLE

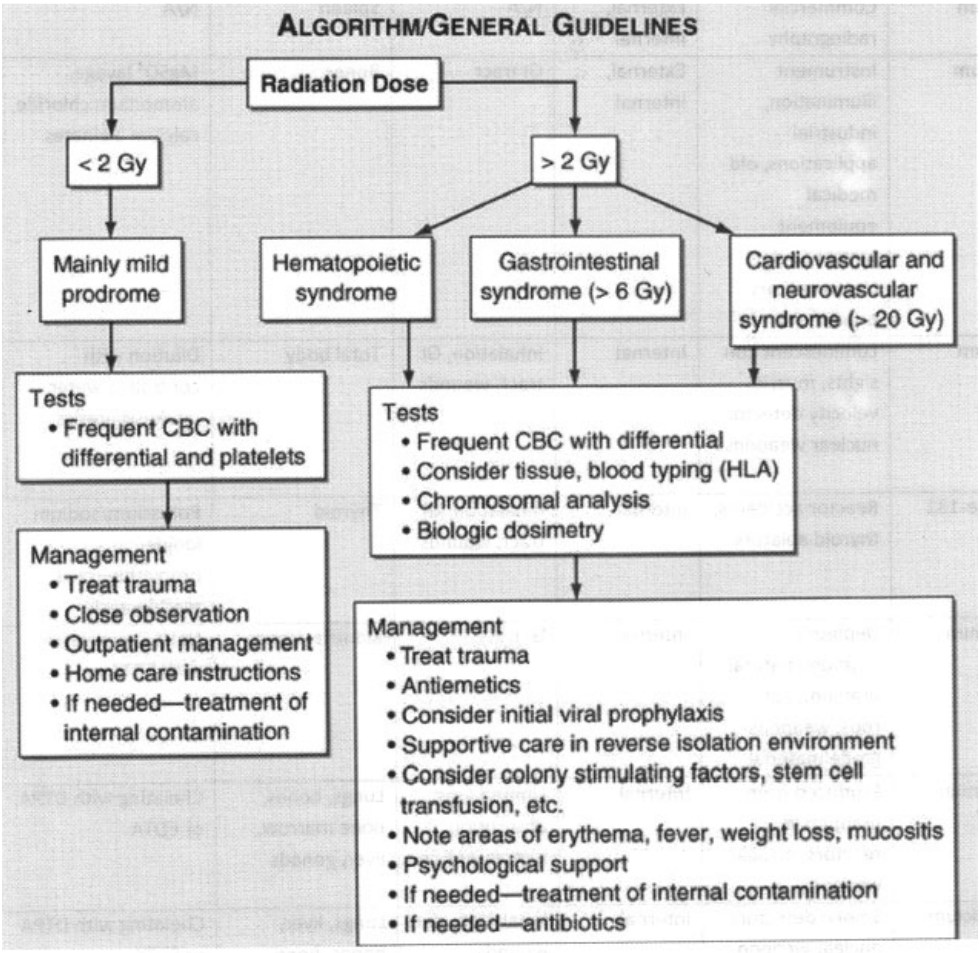
"The angle which the 50 per cent isodose curve makes with the normal to the axis or "the angle through which the 50 per cent isodose curve has been turned at the central axis"

Internal Contaminant Radionuclides: Properties and Treatment

Isotope	Common Usage	Exposure Type	Mode of Contamination	Focal Accumulation in	Treatment
Manganese	Reactors, research laboratories	External, internal	N/A	Liver	N/A
Cobalt	Medical radiotherapy devices, commercial food irradiators	External, internal	Lungs	Liver	Gastric lavage, purgatives; penicillamine in severe cases
Strontium	Fission product of uranium	Internal	Moderate GI tract	Bones—similar to calcium	Strontium, calcium, ammonium chloride
Molybdenum	Hospitals—scans	External, internal	N/A	Kidneys	N/A

Technetium	Hospitals—scans	External, internal	Inhalation, administration	Kidneys, total body	Potassium perchlorate to reduce thyroid dose
Cesium	Medical radiotherapy devices	External, internal	Lungs, GI tract, wounds, follows	Renal excretion	Ion-exchange resins, Prussian blue
Gadolinium	Hospitals	External, internal	N/A	N/A	N/A
Iridium	Commercial radiography	External, internal	N/A	Spleen	N/A
Radium	Instrument illumination, industrial applications, old medical equipment, former Soviet Union military equipment	External, internal	GI tract	Bones	MgSO4 lavage, ammonium chloride, calcium alginates
Tritium	Luminescent gun sights, muzzle-velocity detectors, nuclear weapons	Internal	Inhalation, GI tract, wounds	Total body	Dilution with controlled water intake, diuretics
Iodine-131	Reactor accidents, thyroid ablators	Internal	Inhalation, GI tract, wounds	Thyroid	Potassium/sodium iodide, propylthiouracil,
Uranium	Depleted uranium, natural uranium, fuel rods, weapons-grade material	Internal	GI tract	Kidneys, bones	NaHCO3, chelation with EDTA
Plutonium	Produced from uranium in reactors, nuclear weapons	Internal	Limited lung absorption, high retention	Lungs, bones, bone marrow, liver, gonads	Chelating with DTPA or EDTA
Americium	Smoke detectors, nuclear weapon detonation fallout	Internal	Inhalation, skin wounds	Lungs, liver, bones, bone marrow	Chelating with DTPA or EDTA
Polonium	Calibration source	Internal	Inhalation, wounds	Spleen, kidneys	Lavage, dimercaprol
Thorium	Calibration source	Internal	N/A	N/A	N/A
Phosphorus	Research laboratories, medical facilities	Internal	Inhalation, GI tract, wounds	Bones, bone marrow, rapidly replicating cells	Lavage, aluminum hydroxide, phosphate

Abbreviations : DTPA, diethylenetriamine pentaacetic acid; EDTA, ethylenediamine tetraacetic acid



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