Radiology

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1 Chapter

INTRODUCTION TO RADIOLOGY

Names of scientists and discoveries

WC Roentgen	• **Father of radiology** • 8 November 1895 : Discovered X-rays • 1901 :Nobel prize for the discovery of X-rays • **International Day of Radiology**
Godfrey Hounsefield, Alan Cormark	**Discovered CT scan (Housefield unit)**
Peter Mansfield Paul Lauterbur	**Discovered MRI**
Felix Block & Purcell	**NMR : Nuclear Magnetic Resonance**
Charles Dotler	**Father of interventional radiology**
Henry Becquerel	**Father of radioactivity**
Lars Leksell	**Gamma knife**
John wide	**Father of medical ultrasound**
Ian Donald	**Father of obstetrics ultrasound**

Basic Terminologies

	Black	White
X- ray	Lucent	Opaque
CT (dense)	Hypodense	Hyperdense
MRI (intense)	Hypointense	Hyperintense
USG (echoic)	Hypoechoic	Hyperechoic
	Anechoic: Absolutely black	

Mechanism of Action of Ionizing Radiation

DNA damage ↓ ds DNA damage (most commonly)	Free radicals formation

Ionising Radiation

Rays			Particulate matter ↓
Cosmic	γ-rays	X-rays	α particles, β particles, neutrons, protons
Background radiation	• Radiotherapy • Scintigraphy • SPECT • PET	• Radiographs • Fluoroscopy • DSA • CT • Mammography • DEXA	Radiotherapy

Origin

X- rays	Gamma rays
Extranuclear origin	Nuclear origin (nuclear particle disintegration)

Non-ionising	Ionising: X-rays	Ionising: gamma rays
• MRI • USG • Thermography	• Radiograph • CT • Fluoroscopy/Contrast studies • Eg. IVP/ RGU/MCU/HSG/ERCP • DSA • Mammography • DEXA	• Scintigraphy • SPECT • PET

	Ionization power/ Linear energy transfer/ Damaging power	Penetrating power
Maximum	particle	Neutrons >γ rays
Minimum	γ rays	α particle

Effects of Radiation

Stochastic "chance"	Deterministic
No threshold	Threshold exists
Delayed	Immediate
Cancer, genetic mutations	Skin erythema (MC), cataracts epilation
↑ dose α ↑ probability	severity of side ↑ dose α ↑ severity
"All or none"	Gradation

Modality	Dose
CXR	0.02 mSv
Skull X ray	0.07 mSv
Abdomen X ray	1 mSv
Mammography	0.5-0.7 mSv
CT head	2 mSv
CT chest	5 mSv
CT abdomen	10 mSv
PET	10-12 mSv
Barium meal follow through / enema	7-8 mSv
IVP	2-3 mSv

Radiation Units

Entity	SI Unit	Conventional unit
Radioactivity	Becquerel / dps	Curie 1 Ci = 3.7×10^{10}Bq
Exposure	C/kg	Roentgen 1 R = 2.5×10^{-4} C/kg
Absorbed dose / Air kerma (ABG RAD)	Gray 1 Gy = 100 Rad	Rad
Equivalent dose (W_R)	Sv 1 Sv = 100 Rem	Rem
Effective dose (W_T)	Sv	Rem

Maximum Permissible Dose (AERB)

	Occupational exposure	Public exposure
Overall	20 mSv/year averaged over 5 consecutive years 30 mSv in any single year	1 mSv/year
Lens	150 mSv in a year	150 mSv/year
Skin extremities	500 mSv in a year	50 mSV/year
Pregnant female	2 mSv/year	1 mSv/year
Fetus	1 mSv/year	0.5 mSv/year

TLD Badge

- Personnel dosimeter
- 3 monthly [sent for measurement in india]
- Made up of: $CaSO_4$: Dysprosium [LiF can also be used]
- Worn below the lead apron at the level of the chest

Lead Apron

- Minimum thickness: 0.25 mm
- M/C thickness used: 0.5 mm

Zero Lead Aprons:

- Made of Ab, Ba, Bi (lighter than usual lead aprons)

Biohazard

Radiation hazard

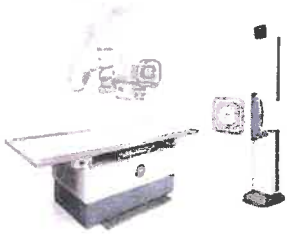
Abbreviations to know:

- PACS : Picture Archiving & communication systems
- DICOM : Digital imaging & communication in medicine
- ALARA : As low as reasonably achievable

- RFA: Radiofrequency Ablation (60-100°C)

Applications of RFA:

- HCC
- RCC
- Rx of choice in osteoid osteoma
- WPW syndrome
  - THI : Tissue harmonic imaging (used in USG)
  - HIFU : High intensity focused USG (used for ablation of fibroids)
  - POCUS : Point of care USG
  - BLUE : Bedside lung USG in emergencies
  - FALLS : Fluid administered limited by lung Sonography
  - eFAST: Extended Focussed Assessment Sonography in Trauma



X-ray machine

C-arm/Fluoroscopy

MRI

CT

USG machine

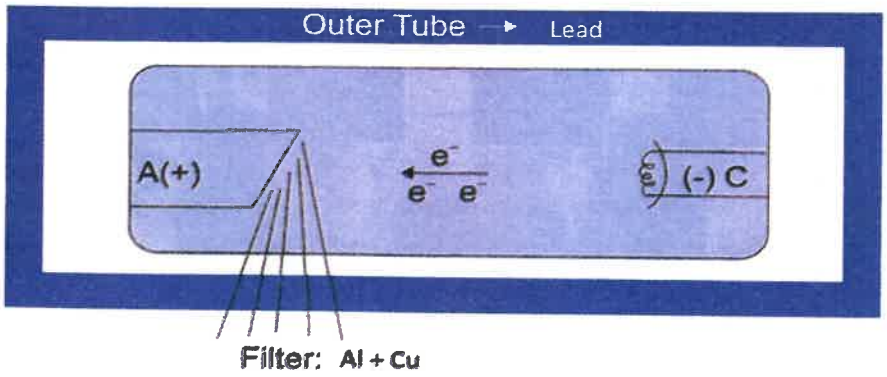
Mammography

DEXA scanner

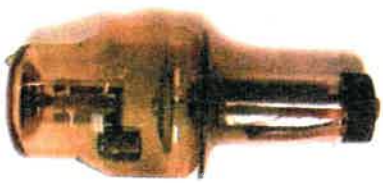
2 Chapter

X-RAY

X-RAY TUBE



Structure	Material
X-Ray tube	Pyrex glass
Cathode (-)	Tungsten + Thorium
Focusing cup	Nickel
Anode = Target (+)	Tungsten + Rhenium
Window	Glass
Filter	Al + CU
Protective housing	Lead



Rotating anode disc is used- to increase the heat dissipation of the X-ray tube

TYPES OF X-RAY TUBE

Stationary	Rotating
Portable / Ward X-rays	M/C used
Dental X-rays	Used everywhere else

Mammographic X-ray Tube vs Normal X-ray Tube

	Mammography	Radiography
Target	Molybdenum	Tungsten + Rhenium
Window	Beryllium	Glass
Filter	Molybdenum	Al + Cu

Types of Radiography:

Conventional radiography	Computed Radiography	Digital Radiography
Film is made up of silver halide (AgBr)	Photostimulable phosphor is used	Amorphous Silicone electrodes are used
Red light is the safe light for the development of these films		

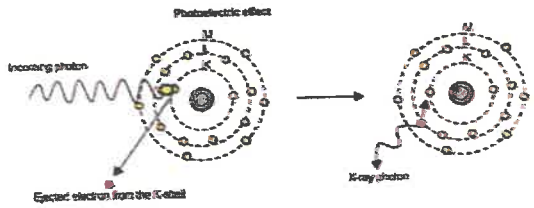
kVP and mAs

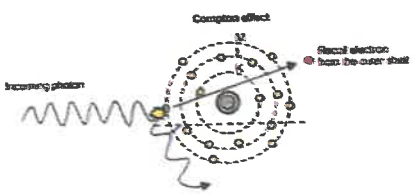
Kilo-voltage peak (kVP)	Milli-amperage second (mAs)
Regulates the velocity of electrons from cathode to anode	Regulates the number of electrons getting released from cathode
Determines the quality and quantity of X- ray	Determines only quantity of X-ray
kVP α penetration α 1 / contrast	• mAs α contrast • mAs increases blackening of films

Obese patient

kVP increase	mAs increase
Penetration increases	Contrast increases
[kVP α penetration]	[mAs α contrast]
Contrast decreases [kVP α 1 / contrast]	

Photoelectric Effect And Compton Scatter





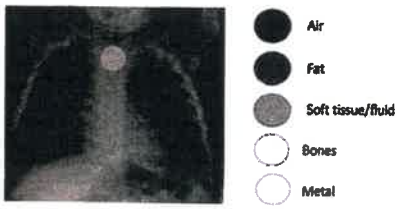
Photoelectric Effect

- Seen with low energy X-rays
- Yields diagnostic effect
- Inner shell e^- is ejected

Compton Effect

- Occurs with higher energy X-rays
- Results in non-diagnostic scatter radiation
- Outer shell e^- is ejected

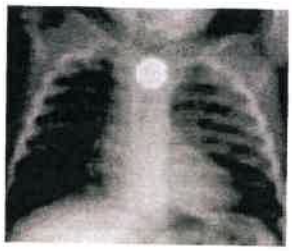
5 Radiographic Densities



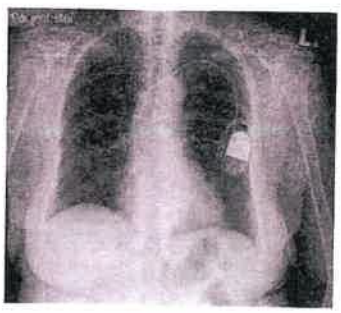
Thumb rules: X-Ray

- Initial investigation for emergencies e.g: Pneumoperitoneum, intestinal obstruction
- Initial investigation for fractures
- Initial investigation for foreign bodies
- Initial investigation for bone tumors
- IOC to know position of medical devices e.g: Position of central line,Nasogastric tube, Pacemaker

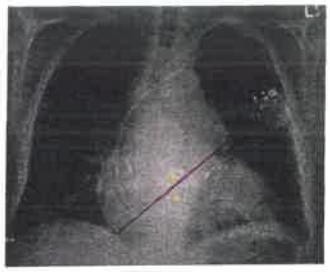
Approach to Foreign Body



In profile/ en face: Foreign body is in the Esophagus	Side profile: Foreign body is in the trachea



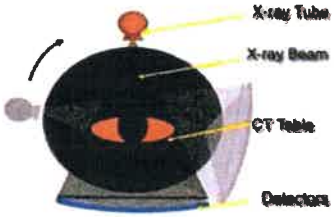
Pacemaker Leads:



Single chamber: RV
Dual chamber: RA + RV
Biventricular (3 leads): RA + RV + LV
Location of prosthetic valves on x-ray:
Draw a line from the left hilum, take it to the right CP (cardiophrenic)angle

- Above this line : Aortic valve
- Below this line : Mitral valve.

CT MACHINE



Gantry with X Ray tube and row of detectors

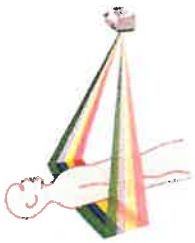
Most commonly used: 3rd generation CT scanner

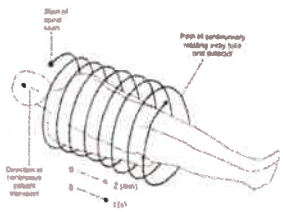
(Tube rotation with patient translational movement)

Pitch: Table movement per rotation / slice thickness

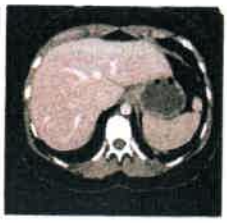
Pitch α 1 /quality

Pitch α 1/ dose





Single detector CT	Multiple detector CT (MDCT) • Higher speed • Better 3D/volumetric acquisition	Helical/ spiral CT • Higher speed • Lower dose

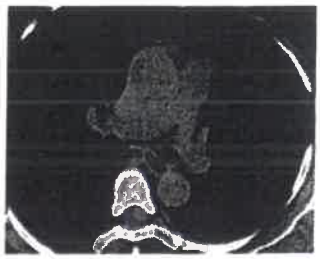


Axial / Transverse Coronal Sagittal

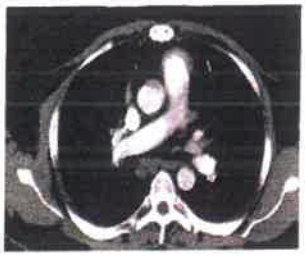
HOUNSFIELD UNIT:

Gives objective measurement of blackness / whiteness

Air -1000	Fat -10 to -100	Distilled water 0	Soft tissue 20-30	Acute hemorrhage 60-90	Iodinated contrast 100-300	Bone/Ca2+ 1000



NCCT



CECT

THUMB RULES-CT

Calcification -IOC: NCCT-

- Intracranial calcification
- Renal and ureteric calculi
- Salivary stones

Bone cortex-IOC: NCCT

- Fractures except stress fractures (MRI-IOC)
- Osteoid osteoma (Other bone tumors MRI IOC)

Foreign body:

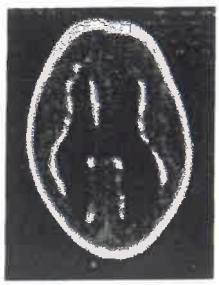
- Initial investigation: X-ray
- Best/IOC: NCCT
- Contraindicated: MRI

Acute Hemorrhage: NCCT

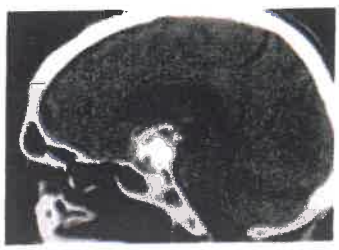
- Acute head trauma (Except DAI-MRI IOC)
- Firstline investigation in stroke

Air-IOC: CT

- Pneumoperitoneum
- Pneumothorax
- Pneumomediastinum
- Pneumocephalus
- Intestinal obstruction

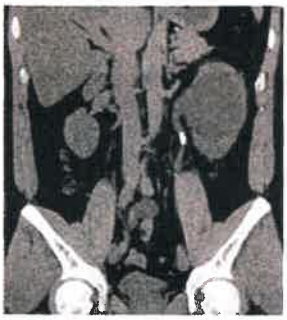


Periventricular calcification

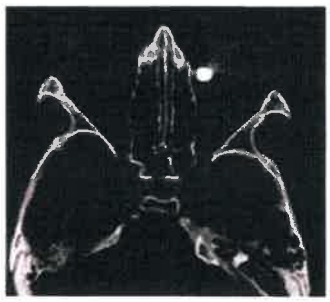


Craniopharyngioma

Peri ventricular calcification	Parenchymal Calcification	Grey-White matter junction
CMV	Toxoplasmosis	Zika virus



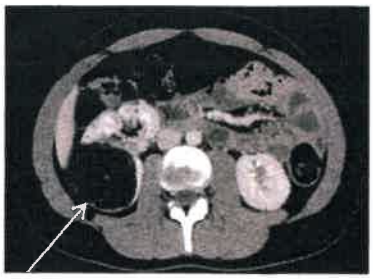
Left ureteric calculus



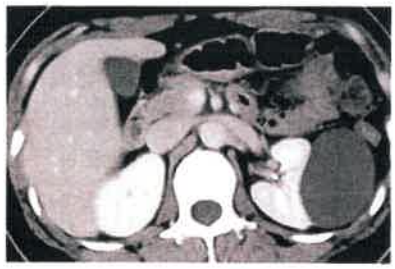
Left eye-metallic foreign body

Acute hemorrhage

(Right-EDH Left-SDH)

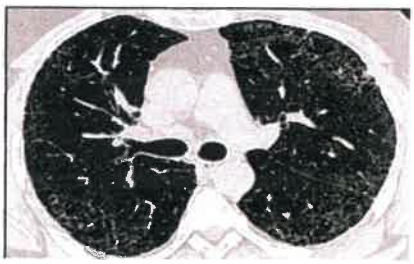


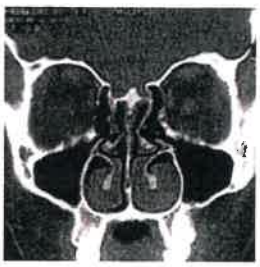
Angiomyolipoma



Renal Cyst

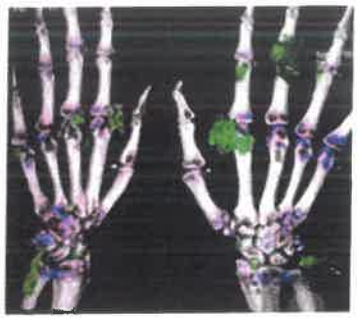
HRCT - HIGH RESOLUTION CT





Lung parenchyma HRCT (IOC) • Interstitial lung disease • Bronchiectasis • COVID - 19 evaluation	IOC for Paranasal sinus IOC for Temporal bones

Volumetric Reconstruction Technique (VRT)



Dual energy CT (DECT)

DECT

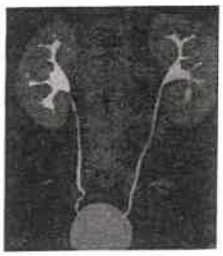
Concept: **Material decomposition**

Applications of DECT:

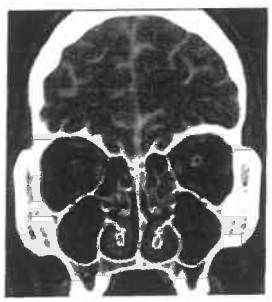
- Gout
- Renal / ureteric calculi
- Perfusion map

CT Urography

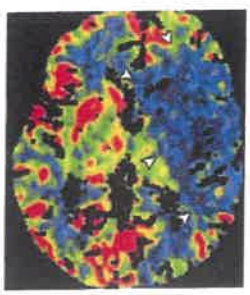
Acquired 10-15 min after injecting iv contrast to visualize renal collecting system



CT Cisternography



CT Perfusion



- Used for diagnosing **"Penumbra"**
- Physiological parameters of blood flow e.g. blood volume, mean transit time etc can be calculated

Virtual Bronchoscopy

- Virtual endoscopy can be performed
- Non-invasive
- Co2 used for virtual colonography
- Drawback: Biopsy and interventions cannot be performed

SUMMARY

NCCT
- IOC for head, spine trauma (Q)
- IOC for acute SAH (Q)
- IOC for intracranial calcification (Q)
- IOC for renal calculi
- IOC FOR IOFB
- IOC for bone cortex-Fractures, osteoid osteoma
- Initial Investigation in stroke (Q)

CECT
- Lung Tumors-Except Pancoast tumors
- Renal Tumors
- Pancreatic Carcinoma -DPCT
- Liver Tumors -TPCT
- Mediastinal Masses-except posterior
- Acute Pancreatitis-48-72 hrs

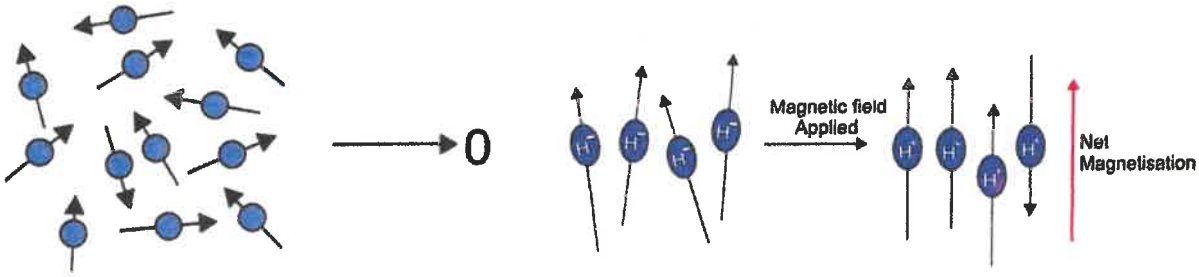
CT angiography
- Aortic dissection
- Aortic aneurysm
- Pulmonary embolism
- Mesenteric ischemia
- Sequestration

4 Chapter

- MRI = Magnetic Resonance Imaging
- No ionizing radiation is used
- Best soft tissue and contrast resolution

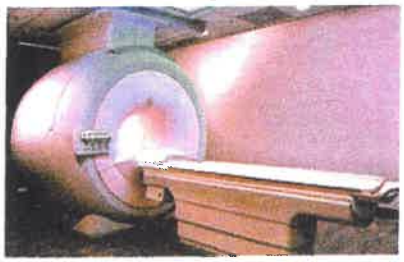
Concept

NMR - Nuclear Magnetic Resonance



Net magnetization Vector = Zero (At rest)

In the external magnetic field: NMV: along the field → Signal generated



- Primary magnetic field : 1.5 T - 3T
- RF Coils: generate the RF signal
- Gradient coil: defines the plane of image (axial / coronal / sagittal)

CT vs MRI

CT Cortex: White	MRI Cortex: Black

Calcifications, Cortex (fractures) IOC = CT	• Bone marrow • Intervertebral discs • Spinal cord pathologies • Ligaments IOC= MRI

Sequences of MRI

Sequence	T1 weighted	T2 weighted	Flair
FLUID	Hypointense	Hyperintense	CSF-Hypointense Edema-Hyperintense
GRAY MATTER	Hypointense	Hyperintense	Hyperintense
WHITE MATTER	Hyperintense	Hypointense	Hypointense
FAT	Hyperintense	Hyperintense	Hyperintense

(Remember WW2- water is white in T2)

FLAIR

To pick edema in the periventricular area

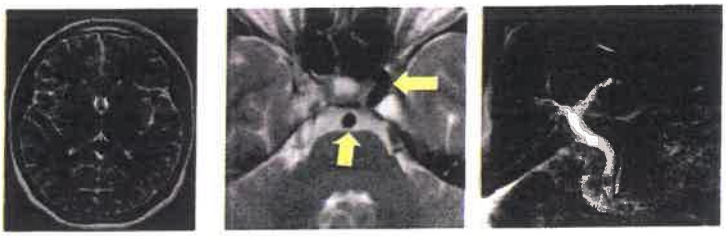
- Role in: demyelinating lesions: Multiple sclerosis (Dawson fingers)

T1 bright	T2 bright
Fat Protein rich Keratin • Cholesteatoma • Epidermoid cyst • Craniopharyngioma Posterior pituitary • Melanin • Gd (MR contrast agent) • Subacute hemorrhage	Fat Fluid (WW2)

Signal Void

Structures which are hypointense (black) on all sequences of MRI: Not able to generate any signal

- Blood vessels (arteries): Flow void
- Cortical Bone
- Air
- *Calculi*



SWI (Susceptibility Weighted Imaging)

Type of Gradient echo sequence / T2* sequence

Black dots s/o hemorrhage known as blooming

Sequence of choice for DAI (diffuse axonal injury)

STIR: Short tau inversion recovery

T2W with **fat signal suppressed.**

Sequence of choice for **Bone marrow edema**-Osteomyelitis/ Sacroilitis / Stress fracture

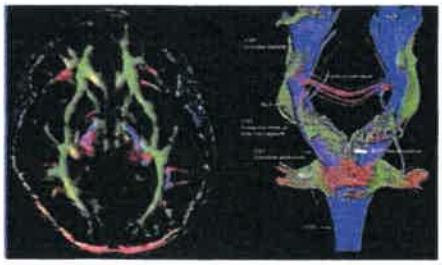
Diffusion Weighted Imaging (DWI)

DWI

ADC Map

- Relies on the concept of **Restricted Brownian motion**
- Seen in:
- Stroke / infarct-***Cytotoxic edema: Brownian motion is restricted.***
- Epidermoid cyst
- *Abscess*
- Hypercellular Tumors

DTI (Diffusion Tensor Imaging)



- Concept: ***Anisotropy***: Preferential diffusion along the neurons.
- ***Sequence of choice to study white matter tracts***
- ***Used in:***
- Preoperative planning of brain tumors
- Trauma

Tractography: 3D representation of DTI.

MRCP (Magnetic Resonance Cholangiopancreaticography)

- No contrast is needed