DNB June 2020 - Paper 3

PART A

1. Discuss the causes and radiological features of Budd–Chiari Syndrome. Discuss the role of Interventional Radiology in treatment of Budd–Chiari Syndrome.
(7 + 3)

2. a) Imaging workup of a potential renal donor.
b) Imaging evaluation of vascular complications of a transplant kidney.
(5 + 5)

3. Enumerate various internal hernias. Discuss in detail the imaging features of any two internal hernias.
(2 + 8)

4. Describe the imaging algorithm in a suspected case of ectopic pregnancy. Describe the role of imaging in differentiating three common clinical mimics of ectopic pregnancy.
(5 + 5)

5. Discuss the classification and imaging features of cystic neoplasms of the pancreas.
(3 + 7)

PART B

6. Describe TNM staging of bladder cancer. Draw a schematic diagram of T staging of bladder tumour. Enumerate the role of ultrasound, computed tomography, and MRI in the diagnosis and staging of bladder carcinoma.
(2 + 2 + (2 + 2 + 2))

7. Describe various indications, protocol, advantages, and disadvantages of fetal MRI.
(2 + 3 + 3 + 2)

8. What are the various causes of acute mesenteric ischemia? Discuss the role of radiology in its diagnosis and management.
(3 + (5 + 2))

9. Describe briefly the segmental anatomy of the liver with a line diagram. Describe imaging (CT & MRI) features in hepatocellular carcinoma.
(4 + (3 + 3))

10.
a) Role of plain radiograph in a case of acute abdomen.
b) Role of MRI in acute pancreatitis.
(5 + 5)

Q1. A. Rotating anode x ray tube and its advantages.

B. X ray beam restricting devices and their uses.

Answer

Rotating Anode X-ray Tubes

These tubes incorporate a **disc-shaped target** mounted on a rotor, which **spins during exposure**, spreading the electron impact over a larger surface.

Structure and Components

Component	Description
Target (Focal Track)	Circular disc of **tungsten** or tungsten-rhenium alloy
Backing	**Graphite or molybdenum** for reduced weight and enhanced heat storage
Rotor	Copper-iron assembly inside the vacuum envelope, attached to the target disc
Stator	Electromagnets placed outside the envelope to induce rotor motion via electromagnetic induction
Anode Stem	Narrow **molybdenum** shaft to reduce heat conduction to bearings

Rotational Speeds

- Standard tubes: **~3400 rpm**
- High-capacity tubes (CT/IR): **up to 10,000 rpm**

Mechanism of Rotation

- Uses an **induction motor**:
    - **Stator** generates a rotating magnetic field.
    - **Rotor** follows synchronously, causing the **anode disc to spin**.

Thermal Advantages

- **Spreads heat** over a much larger area → ↑ **tube heat capacity**.
- Enables **short exposure times and high tube current (mA)** without thermal damage.

Features

Feature	Description
Focal Track Area	Larger effective area due to rotation (e.g., 1800 mm² vs 4 mm²)
Heat Dissipation	High, via **radiation, conduction**, and **convection**
Focal Spot Sizes	**Dual focal spots** via two filaments
Line-Focus Principle	Used to achieve small **effective focal spot**
Applications	**General radiography**, **CT**, **angiography**, **intervention**, **mammography** (modified versions)

Advantages

- High heat load handling (due to rotating anode & backing materials)
- Short exposure times → reduces motion blur
- Improved spatial resolution with small focal spot options
- Durable for high-volume workflows (e.g., fluoroscopy, CT, cardiac imaging)

Limitations

- Complex design → prone to **mechanical failure** (bearing wear, rotor imbalance)
- Requires **warm-up protocols** to prevent thermal cracking
- Costlier and heavier
- **Rotor failure** or **bearing damage** may lead to tube loss

Stationary vs Rotating Anode Tubes

Feature	Stationary Anode	Rotating Anode
Target Design	Fixed, embedded in copper	Rotating disc of tungsten alloy
Focal Spot Area	Small, fixed	Wide track, dynamic
Heat Dissipation	Poor; via conduction	Excellent; via rotation, conduction, radiation
Thermal Capacity	Low	High (↑ mA, ↓ exposure time)
Exposure Rate	Low	High
Applications	Dental, portable, low-demand systems	All general radiography, CT, IR, mammography
Durability	Mechanically stable, limited heat load	Prone to rotor wear and overheating
Cost	Less expensive	More expensive, heavier

Additional Features	Simpler construction	Uses induction motor, line-focus, heel effect

Beam Restricting Devices in Radiology

Purpose
Beam restriction reduces the size and shape of the primary x-ray beam to match the area of clinical interest.
Main objectives:

1. **Reduce patient dose** – by limiting unnecessary irradiation of tissues outside the region of interest.
2. **Reduce scatter radiation** – thereby improving image contrast and diagnostic quality.
3. **Improve spatial resolution** – by minimizing penumbra and unwanted exposure.

X-ray–Matter Interactions Relevant to Beam Restriction

- **Scatter radiation** is mainly produced by **Compton scattering**, where an incident photon loses energy and changes direction after interacting with loosely bound outer-shell electrons.
- **Two main factors** affecting scatter production:
  - **Volume of tissue irradiated** (field size × part thickness)
  - **kVp** (higher kVp → less absorption, more scatter energy and quantity)
- **Effect on image**: Scatter degrades radiographic contrast and adds unwanted density (fog), especially in **digital systems**, which are more sensitive to low-energy scatter.

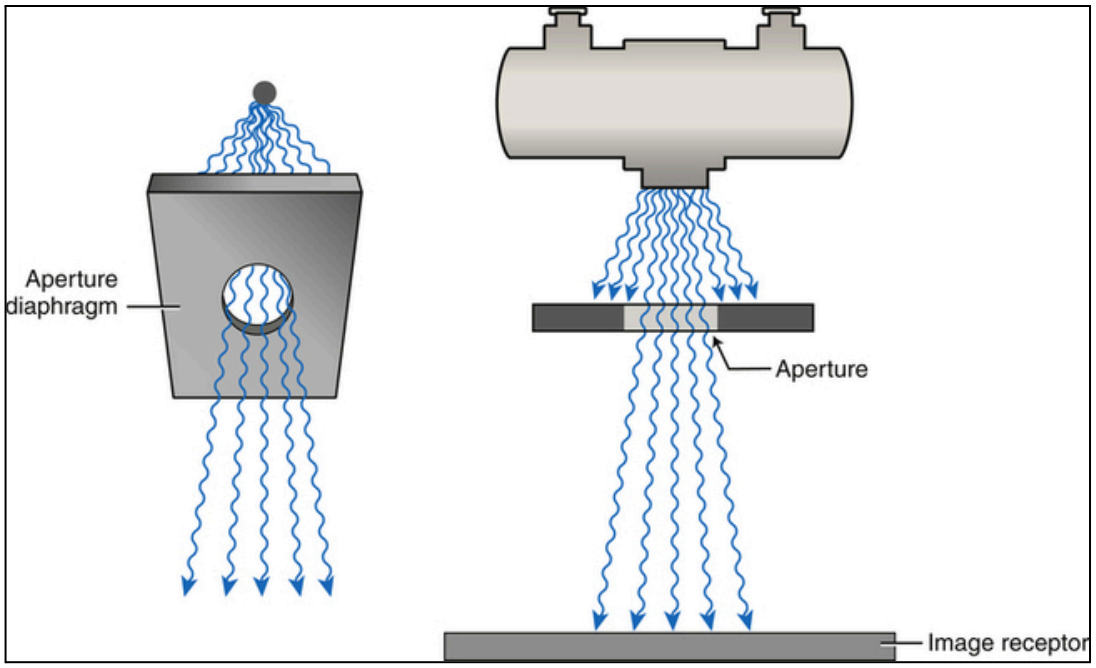
Relationship Between Collimation, Scatter, and Image Quality

- **Increasing collimation** (decreasing field size):
  - ↓ Patient dose
  - ↓ Scatter radiation
  - ↑ Radiographic contrast
  - ↓ Film-screen density (may require mAs increase)
  - ↑ Digital quantum noise if exposure not compensated
- **Decreasing collimation** (increasing field size):
  - ↑ Patient dose
  - ↑ Scatter radiation
  - ↓ Radiographic contrast
  - ↑ Density (film-screen) / ↓ noise (digital)

Types of Beam Restricting Devices

1. Aperture Diaphragms

- **Design**: Flat sheet of lead (or lead-lined material) with a central hole (aperture) attached directly to the x-ray tube housing.
- **Advantages**:
  - Simple, inexpensive.
  - Lead is malleable—can be cut to custom sizes.
- **Disadvantages**:
  - Fixed field size (not adjustable).
  - Large penumbra due to proximity to the focal spot.
  - Limited versatility.
- **Uses**: Trauma units, chest radiography, dental radiography.



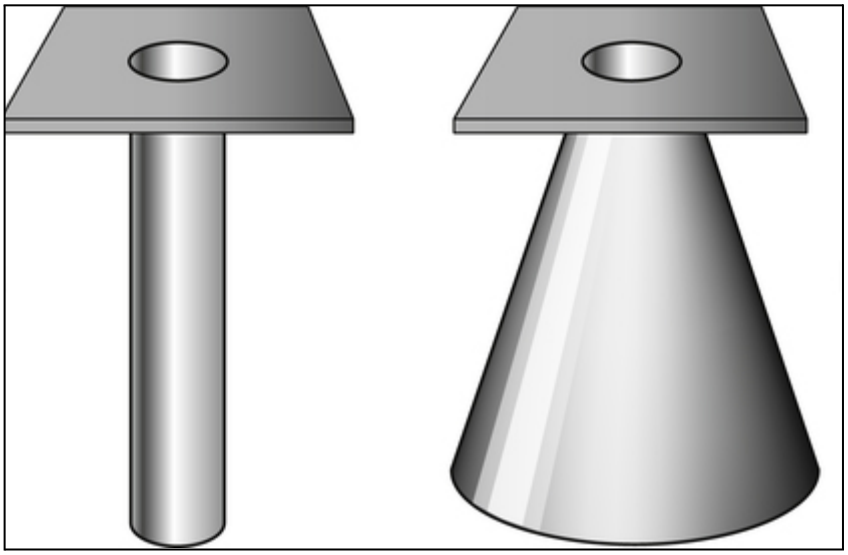
2. Cones and Cylinders

- **Design**: Metal extensions placed beyond the tube housing to limit the beam.
  - **Cylinder type**: Straight-sided beam restriction.
  - **Flared type**: Matches beam divergence.
- **Advantages**:
  - Effective beam shaping.
  - Reduces off-focus radiation.
- **Disadvantages**:
  - Can be heavy → potential tube misalignment.
  - Limited field size options.
- **Uses**: Trauma, chest, dental radiography, certain extremity imaging.

3. Collimators

- **Design**: Adjustable lead shutters that can vary beam size and shape.

    - **Manual collimators** – operator adjusts field size using light-beam alignment.
    - **Automatic/PBL (Positive Beam Limitation)** – adjusts to match image receptor size.
- **Advantages**:
    - Most efficient and commonly used device.
    - Precise control over field size.
    - Reduces scatter and improves contrast significantly.
- **Disadvantages**:
    - May require higher mAs due to smaller field size.
    - More complex and costly than diaphragms or cones.
- **Uses**: Standard in modern x-ray equipment across all body regions.



Physics & Clinical Practice

- **Beam restriction is proactive** – prevents scatter production by reducing irradiated tissue volume.
- **Grids are reactive** – remove scatter after it is produced.
- The optimal approach: **Collimate tightly + use grid when appropriate** (especially with larger body parts or higher kVp).
- **Exposure factor adjustment**: When collimating significantly, **increase mAs** to maintain image receptor exposure (do not increase kVp, as it increases scatter proportion).

Q2. Classify water soluble iodinated contrast media. Describe various adverse reactions to iodinated contrast media. Describe steps in the diagnosis and management of contrast media induced anaphylaxis

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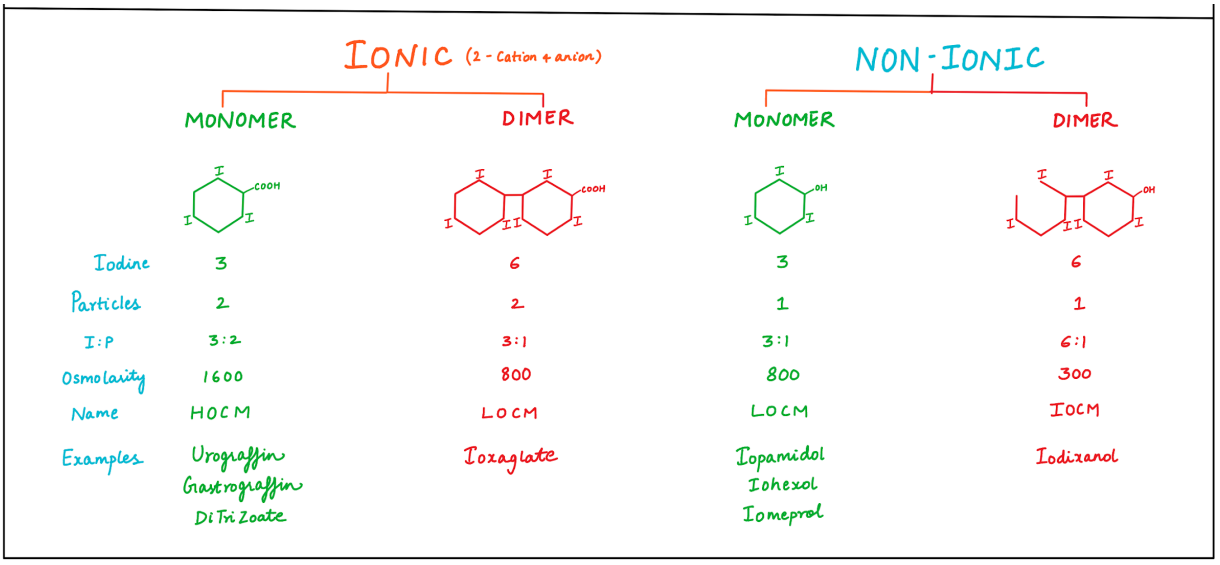
Answer

Contrast media is a substance which produces alteration in contrast in a radiographic image



Adverse reactions of iodinated contrast media –

1. Acute Allergic-like Reactions
Incidence

- Any severity: ~0.6%
- Severe: ~0.04%

Mechanism

- **IgE-mediated (classic theory)**: In predisposed individuals, contrast acts as an allergen → IgE binds → histamine & mediator release from basophils/eosinophils.
- **Alternative theory**: L-arginine → nitric oxide → complement activation.

Prevention

- If **previous history positive**:
  - Prefer alternative imaging without iodinated contrast.
  - If contrast needed:
    - **First choice**: Non-ionic dimers (e.g., *iodixanol*).
    - If unavailable: Different low-osmolality contrast.
- **If previous unknown allergic-like reaction** to same class:
  - **Elective**: 12-hour oral steroid premedication.
  - **Emergency**: Accelerated IV premedication.

Premedication Regimens

- **Elective**:
  - Prednisolone 50 mg PO at 12h, 7h, 1h pre-contrast
  - Pheniramine 25 mg IV pre-contrast
- **Emergency**:
  - Methylprednisolone 40 mg IV OR hydrocortisone 200 mg IV q4h until contrast
  - Pheniramine 50 mg PO 1h pre-contrast

Post-Contrast Monitoring

- All patients: Stay ≥30 min post-contrast, IV access in place.

Management

Presentation	**Action**
Urticaria	Often self-limiting; severe → pheniramine 25 mg IV
Diffuse erythema	Monitor vitals, O_2 6–10 L/min; if hypotensive → rapid 1000 mL IV fluid (RL/NS); if unresponsive → consider IV/IM adrenaline
Bronchospasm	O_2 6–10 L/min; β-agonist inhaler (2–3 puffs × 3); moderate-severe → consider IM/IV adrenaline; call critical care
Laryngeal oedema	O_2 6–10 L/min; α-agonist IM/IV; intubate if needed; call critical care
Hypotension + tachycardia	Legs elevated; O_2 6–10 L/min; rapid IV fluids; if poor response → IM/IV adrenaline; call critical care

2. Acute Physiologic Reactions

Mechanism

- **Non–contrast-related**: Pyrogenic, psychosomatic, vasovagal.
- **Chemotoxic**: Ion toxicity (not iodine content).
- **Hyperosmolar** (mainly HOCM): RBC/endothelium damage, BBB disruption, vasodilation.

Prevention

- Replace HOCM with LOCM.

Management

Reaction	Action
Vasovagal	O_2 6–10 L/min; elevate legs; rapid IV fluids; atropine 0.6–1 mg IV slowly (repeat if needed, max 0.04 mg/kg); call assistance
Hypertension	O_2 6–10 L/min; GTN 0.4 mg SL × up to 3 doses; if no response → labetalol 20 mg IV (then 20–80 mg q10 min, max 300 mg)
Phaeochromocytoma crisis	Phentolamine 5 mg IV (if unavailable, labetalol)
Seizures	O_2 6–10 L/min; lorazepam 2–4 mg IV; phenytoin infusion
Pulmonary oedema	O_2 6–10 L/min; head elevated; furosemide 20–40 mg IV slow push

3. Delayed Reactions

Incidence

- 0.5–15%

Timing

- 30 minutes to 1 week post-contrast.

Mechanism

- T-cell–mediated hypersensitivity (↑ in patients on IL-2 therapy).

Severity

- Mild: Rash, urticaria
- Severe: Stevens–Johnson syndrome, toxic epidermal necrolysis
- Other: Nausea, vomiting, headache, iodine mumps (salivary swelling), acute polyarthropathy

Management

- Supportive: Antihistamines, corticosteroids, antiemetics, antipyretics, fluids

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Q3. Enumerate the principles of Computed Radiography (CR) and Digital Radiography (DR). What are their advantages and disadvantages?

Answer

Computed Radiography (CR)

Principle

- Uses **conventional X-ray equipment** with a **photostimulable phosphor imaging plate** instead of film.
- Allows transition from **film-screen** to **digital radiography**.

Process

1. **Exposure**
    - **Patient exposed to X-rays → part absorbed, remainder reaches imaging plate.**
2. **Imaging Plate**
    - **Made of photostimulable phosphor (BaF:Eu; bromide:iodide ≈ 85:15) in a 0.3 mm powdered layer.**
    - **X-ray energy stored in phosphor atoms.**
    - **Protected by surface coat; plate kept in light-tight cassette.**
3. **Plate Reading**
    - **Plate inserted into CR reader.**
    - **Red laser scans plate → releases stored energy as blue light.**
4. **Light Collection**
    - **Emitted light collected by photomultiplier tube or CCD sensor.**
5. **Signal Conversion**
    - **Light → electrical signal → digital data (pixel matrix).**
6. **Image Processing**
    - **Algorithms adjust contrast, brightness, sharpness, and noise.**
7. **Display & Storage**
    - **Image displayed on monitor for viewing/interpretation.**
    - **Stored electronically (PACS).**

Advantages

- **Digital workflow** — easy storage, retrieval, sharing.
- **Post-processing** improves contrast and reduces need for retakes.
- **Lower radiation dose** than film-screen.
- **No chemical processing** — faster results.
- **Long-term savings** — no film/chemical costs.

Disadvantages

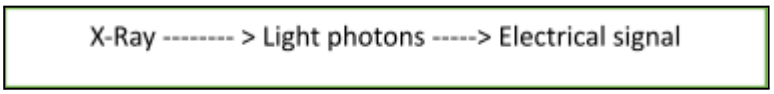
- **Workflow interruption** — extra step of plate scanning.
- **Plate damage** possible → image artifacts.
- **Limited dynamic range** vs. direct digital radiography (DDR).
- **Higher initial cost** for equipment & training.

Principle

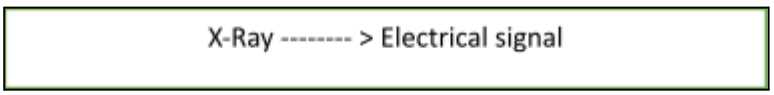
- **Direct digital imaging** without intermediate plate reading.
- Uses **flat-panel detectors** or **CCD-based detectors** that directly convert X-ray photons into electrical signals.
- Offers faster workflow compared to CR.

Detector Types

1. **Indirect Conversion**
    - **Scintillator (Cesium Iodide [CsI] or Gadolinium oxysulfide [Gd_2O_2S]) converts X-rays → light.**
    - **Photodiode array (usually amorphous silicon) converts light → electrical signal.**



2. **Direct Conversion**
    - **Amorphous selenium (a-Se) directly converts X-rays → electrical charge without light stage.**
    - **Better spatial resolution (no light spread).**



Process

1. **Exposure**
    - **Patient exposed to X-rays, which reach the detector.**
2. **Detection**
    - **Indirect DR: X-rays → light (scintillator) → electrical signal (photodiodes).**
    - **Direct DR: X-rays → electrical signal (a-Se).**
3. **Readout**
    - **Thin-film transistor (TFT) array reads the stored charge.**
4. **Signal Conversion**
    - **Electrical signal → digital image (pixel matrix).**

5. **Image Processing**
    - **Computer algorithms optimize contrast, reduce noise.**
6. **Display & Storage**
    - **Immediate image availability on workstation.**
    - **Stored in PACS for retrieval, sharing, and archiving.**

Advantages

- **Immediate images** — no cassette handling or scanning.
- **Higher workflow efficiency** — suitable for high-volume settings.
- **Better spatial resolution** (especially with direct conversion).
- **Lower repeat rates** — instant feedback on exposure/positioning.
- **No plate damage** — detector is fixed and protected.

Disadvantages

- **High initial cost** for flat-panel detectors.
- **Detector fragility** — expensive repairs if damaged.
- **Limited portability** — most systems fixed to rooms/tables (though portable DR units exist).
- **Size limitations** — detector area fixed.

Computed Radiography (CR) vs Digital Radiography (DR)

Feature	Computed Radiography (CR)	Digital Radiography (DR)
Detector Type	Photostimulable phosphor imaging plate (in cassette)	Flat panel detector (FPD) – either indirect (scintillator + photodiode) or direct (photoconductor)
Workflow	Requires cassette handling → plate is read in CR reader → image processed	Direct capture → image sent immediately to workstation, no cassette handling
Image Acquisition Time	Slower – requires multiple steps	Faster – near-instant image display
Equipment Compatibility	Can retrofit into existing X-ray rooms (uses same X-ray machine, just replace film with CR plate)	Usually requires new DR system or DR retrofit kit for older rooms
Spatial Resolution	Moderate (often 2.5–5 lp/mm)	Higher (up to 3.5–7 lp/mm depending on pixel size)

Dynamic Range	Moderate	Wider dynamic range → better performance in under- or over-exposure
Radiation Dose	Slight dose reduction compared to film, but higher than DR	Lower dose for equivalent image quality
Maintenance	Plates need regular replacement (susceptible to scratches, dust)	Flat panel detectors are durable but expensive to replace
Portability	Cassette-based → can be used in portable/mobile X-rays easily	Portable DR detectors exist but are costlier
Cost	Lower initial cost than DR	Higher initial cost, but lower running cost long term
Image Quality	Good, but some loss due to plate reading process	Better signal-to-noise ratio, sharper images
Typical Use	Transitional tech from film to digital; widely used in smaller or budget-conscious facilities	Modern hospitals, high-throughput radiology departments, trauma, ICU, ER

Q4. Describe the principle and technique of phase contrast MR angiography.

b) Discuss its advantages, limitations and clinical applications.

Answer

Phase Contrast MRA (PC-MRA) is a non-contrast MR angiographic technique that encodes **velocity-induced phase shifts** in flowing blood into image contrast. It not only produces high-quality angiographic images but also **quantifies flow velocity and volume**, making it uniquely useful in **hemodynamic evaluation**.

Basic Principle
PC-MRA is based on the fact that **moving protons** experience a **net phase shift** when exposed to magnetic field gradients, unlike stationary protons.

- **Stationary Spins**: Under a bipolar gradient (equal and opposite lobes), phase shifts cancel out → **net phase = 0°**.
- **Moving Spins**: Shift position between the two gradient lobes → **incomplete phase cancellation → net phase proportional to velocity**.

This principle is utilized to:

- **Depict vessels**: flowing spins appear bright (high phase shift).
- **Quantify flow**: velocity and volume derived from phase shifts.

Sequence Structure

- **Base Sequence**: Gradient Echo (GRE)
- **Bipolar Velocity-Encoding Gradient (VEG)** applied in one or more directions (commonly through-plane).
- **Two datasets** are acquired:
    - One with **flow encoding gradients** (velocity-sensitive).
    - One without flow encoding (reference).
- **Subtraction** of these yields a **phase-difference image** that reflects **velocity**.

<u>Key Parameter: VENC (Velocity Encoding Value)</u>

- VENC = **maximum velocity** encoded without aliasing (±180° phase shift).
- Must be tailored to target vessel:
    - **Arteries**: VENC ~ 150–300 cm/s
    - **Veins / CSF / Sinuses**: VENC ~ 20–40 cm/s
- **Low VENC**: Better sensitivity to slow flow but prone to aliasing.
- **High VENC**: Avoids aliasing in fast flow but reduces SNR for slow flow.

Advantages of PC-MRA

Advantage	Explanation
Quantitative	Measures velocity, flow volume, and pressure gradients
Sensitive to slow flow	Especially in veins, sinuses, CSF
Background suppression	Stationary tissue has net phase = 0 (dark), excellent contrast
No contrast required	Completely endogenous; safe in renal dysfunction, pregnancy
Multidirectional encoding	Can detect flow direction, multidimensional flow (x, y, z)
Flow mapping	Produces velocity vectors, flow-time curves

Limitations

Limitation	Reason
Long acquisition time	Especially if multi-directional encoding (2–4× TOF time)
Motion sensitivity	Patient or cardiac motion causes misregistration, artifacts
Turbulent flow = signal loss	Intrinsic phase dispersion → dephasing → blacked-out vessel
VENC setting critical	Incorrect value leads to aliasing or poor sensitivity
Complex post-processing	Requires flow analysis software for velocity/volume

Comparison: TOF vs PC-MRA

Feature	TOF-MRA	PC-MRA
Basis	Inflow enhancement	Velocity-induced phase shift
Flow sensitivity	High for fast flow	Best for slow flow
Quantification	No	Yes (velocity, volume)
Background suppression	Limited	Excellent
Motion artifact	Less	More (ECG gating often needed)
Turbulence	Signal dropout	Signal dropout
Scan time	Short	Long
Preferred for	Arteries (fast flow)	Veins, CSF, hemodynamics

Clinical Applications
Intracranial MRA & MRV

- Venous sinuses (e.g., transverse, sigmoid, SSS)
- Intracranial dural AVFs
- Flow direction and velocity mapping

Cardiac and Aortic Flow

- Aortic regurgitation or stenosis: quantifies flow reversal, pressure gradients
- Congenital heart disease (e.g., VSD, PDA, coarctation)
- Shunt quantification (Qp/Qs)
- Diastolic dysfunction (E/A ratio from mitral flow)

CSF Flow Studies

- Normal Pressure Hydrocephalus (NPH): Aqueductal stroke volume
- Chiari malformation: CSF pulsatility at foramen magnum

Portal and Renal Veins

- Flow assessment without contrast

Spinal Dural AVF

- Flow dynamics in spinal veins

Technical Optimization

Parameter	**Strategy**
VENC	Set close to expected peak velocity
Gating	Use **ECG** (arterial) or **respiratory** (venous) gating to reduce motion
Flow direction	Align velocity encoding gradient to vessel direction
TE	Use **short TE** to minimize intravoxel dephasing
Acquisition type	2D for quantification, 3D for angiographic projection
Signal loss from turbulence	Use flow compensation if needed

4D PC-MRA (Phase Contrast with 3D + Time)

- Encodes flow in **3 directions (x, y, z)** over **entire cardiac cycle**.
- Produces **velocity vector fields** and **streamlines**.
- Useful for:
    - **Cardiac chambers and valves**
    - **Great vessels**
    - **Aortic flow patterns**
    - **Cerebral circulation and AVMs**

Drawback: Very long scan time unless accelerated (e.g., parallel imaging, compressed sensing).

Artifacts and Pitfalls

- **Aliasing**: Low VENC → phase wrapping; corrected by phase unwrapping or raising VENC

- **Eddy currents**: Induce background phase shifts; mitigated by background correction
- **Turbulence**: Dephasing → signal loss; not accurately measured
- **Motion artifacts**: ECG/respiratory gating reduces ghosting
- **Background noise**: Use of noise masks in post-processing improves display

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Q5. Applications of dual energy CT.

b) Ultrasound artifacts.

Answer

Dual-Energy CT enables material-specific imaging by exploiting energy-dependent attenuation differences. It enhances lesion characterization, reduces artifacts, and enables functional imaging across multiple organ systems.

NON-CORONARY CLINICAL APPLICATIONS BY SYSTEM

A. NEUROIMAGING

Application	**DECT Utility**
Intracranial Hemorrhage vs Iodine	Differentiates hyperdensities on post-contrast CT; **iodine subtraction** confirms true hemorrhage
Virtual Non-Contrast (VNC)	Eliminates need for pre-contrast scan in CTA/CTP
Calcium subtraction	Helps visualize **ischemic core** in acute stroke (edema obscured by dense bone)
Post-thrombectomy artifact reduction	Metallic coil/stent artifact reduced using **high-keV VMI**

B. THORACIC IMAGING

Application	**DECT Utility**
Acute PE detection	**Pulmonary blood volume (iodine) maps** show perfusion defects; helps assess clot burden and ventilation mismatch
Chronic thromboembolic disease (CTEPH)	Mosaic perfusion on iodine maps; subsegmental vascular pruning

Oncology	Better lesion detection with **low-keV VMI**; **iodine quantification** for response assessment
Mediastinal mass characterization	Differentiates cystic vs solid components using iodine maps and VNC
Artifact reduction	Metal artifact from port or sternotomy wires suppressed using VMI (≥100 keV)

C. HEPATOBILIARY & GI IMAGING

Application	**DECT Utility**
Liver lesion detection	Low-keV VMI enhances hypervascular lesions (e.g. HCC, hemangiomas)
Post-TACE lipiodol mapping	Visualized on iodine maps; VNC helps assess tumor response
CT enterography	Iodine maps enhance mucosal hyperemia (e.g. Crohn's)
Bowel ischemia	Iodine maps show perfusion defects in bowel wall
Stone characterization	Distinguishes uric acid (radiolucent) from non-uric acid stones
Gallstones	Composition (cholesterol vs pigment stones) potentially distinguished
Pancreatitis / Necrosis	Non-enhancing areas on iodine maps indicate necrosis

D. RENAL AND GENITOURINARY IMAGING

Application	**DECT Utility**
Renal mass characterization	Iodine maps quantify enhancement (e.g. solid vs cystic mass)
Hemorrhagic cyst vs enhancing lesion	VNC + iodine overlay improves specificity
Urolithiasis	Differentiates **uric acid vs calcium stones** → medical dissolution vs intervention
Split renal function	Quantitative perfusion analysis (iodine concentration)
Virtual NC in CTU	Reduces radiation by omitting TUE (true unenhanced) phase

E. MSK & SPINE (already detailed earlier)

- Gout (urate maps)

- Bone marrow edema (VNCa)
- Occult/insufficiency fractures
- Tumor and infection detection
- Metal artifact reduction
- Joint/periprosthetic assessment

F. VASCULAR & PERIPHERAL ANGIOGRAPHY

Application	DECT Utility
Aortic dissection or aneurysm	VNC can be used to eliminate non-enhancing thrombus or calcification
Endoleak detection (post-EVAR)	Iodine maps more sensitive for slow-flow leaks (esp. type II)
Lower limb ischemia	Perfusion mapping via iodine concentration; VMI helps stent visualization
Venous thrombosis	VNC and iodine overlay detect thrombus and assess vessel patency

G. ONCOLOGIC IMAGING

Application	DECT Utility
Hypervascular metastases	Low-keV VMI improves conspicuity (liver, pancreas, kidney, thyroid)
Treatment response	Iodine quantification reflects perfusion/viability post-therapy
Bone metastases	VNCa can show **early marrow infiltration** before sclerosis
Tumor characterization	Spectral HU curves, effective Z maps help differentiate lesions

VIRTUAL NON-CONTRAST (VNC) APPLICATIONS

Body Part	Use of VNC
Brain	Avoid repeat scan post-contrast
Kidney	Characterize cysts/masses, evaluate hemorrhage
Liver	Baseline density estimation (e.g., steatosis)
Bladder	Differentiates blood vs excreted contrast
Bones	Subtract calcium to reveal marrow changes

SPECIAL APPLICATIONS

Application	DECT Utility

Adrenal adenoma	Characterized on VNC (density <10 HU) + iodine subtraction
Fatty liver diagnosis	VNC used to estimate liver attenuation; less reliable than TUE
Gastrointestinal bleeding	Iodine maps highlight extravasation; VNC confirms if hyperdensity is contrast
Bowel wall ischemia	Non-enhancing segment on iodine map indicates devascularization

ADVANTAGES OF NON-CORONARY DECT

- **Radiation dose reduction** (eliminates pre-contrast scans)
- **Improved contrast resolution** (low-keV VMI)
- **Material characterization** (iodine, urate, calcium, fat)
- **Artifact reduction** (metal/stent/bone streaks)
- **Functional imaging** (iodine perfusion)

LIMITATIONS & CHALLENGES

Limitation	**Notes**
Platform variability	Different vendors → different image quality and quantification scales
Incomplete subtraction	Residual iodine or calcium in VNC images
False positives	Artifact in perfusion maps, urate deposition (e.g., nail beds)
Motion artifacts	Affects spectral accuracy
Learning curve	Need for radiologists to understand spectral data interpretation

Ultrasound Artifacts

Artifact	**Mechanism**	**Appearance**	**Common Causes / Examples**	**Clinical Significance**
Acoustic Shadowing	High attenuation of US beam	Dark / hypoechoic area posterior to structure	Bone, calcifications, gallstones	Can obscure deeper anatomy
Acoustic Enhancement	Low attenuation → increased transmission	Bright / hyperechoic area posterior to structure	Fluid-filled cysts, bladder	Helpful in confirming cystic lesions

Reverberation	Repeated reflection between two strong reflectors	Multiple parallel equidistant lines	Needle, pleura, bladder wall	Can mimic cystic or solid structures
Comet Tail	Type of reverberation; short path length	Bright tapering tail artifact	Cholesterol crystals, gas bubbles, metallic clips	Can indicate small strong reflectors
Ring Down	Resonance from air bubbles → continuous emission	Solid echogenic band deep to reflector	Biliary gas, bowel gas	Can obscure deeper anatomy
Edge Shadowing	Refraction & reflection at curved edge	Hypoechoic lines along structure margins	Gallbladder wall, cyst edges	May be mistaken for pathology
Mirror Image	Reflection from strong interface	Duplicate/mirrored structure	Liver–diaphragm interface, pleura	Misinterpretation as duplication
Side Lobe	Off-axis beam reflections	Spurious echoes in anechoic areas	Fluid-filled bladder, cysts	Can mimic debris in fluid
Clutter	Low-level unwanted echoes	Hazy low contrast areas	Tissue motion, poor settings	Decreased image clarity
Speed Error	Incorrect depth calc. from altered sound speed	Structure misplaced/deformed	Fat, muscle, fluid mixtures	Can cause false positioning
Ghosting	Refraction due to varying tissue speed	Duplicated/wider structures	Lens effect of curved interfaces	Can mislead anatomy recognition
Volume Averaging	Beam width includes multiple tissues	Debris-like echoes in fluid	Small cysts in complex background	May mimic pathology
Spiking / Electronic Interference	Electromagnetic noise	Bands/lines across image	Poor grounding of machine	Non-anatomic – technical artifact
Speckle	Interference from closely spaced scatterers	Grainy texture	Normal tissue structure	Reduces image quality

Anisotropy	Angle-dependent reflectivity	Hypoechoic appearance in fibrous structures	Tendons, ligaments	Corrected by changing probe angle
Aliasing	Doppler shift > Nyquist limit	Wraparound of spectral waveform	High-velocity blood flow	May require PRF adjustment
Cross Talk	Doppler mirror artifact	Symmetrical spectrum across baseline	Strong reflectors near vessel	Mimics bidirectional flow
Flash Artifact	Spurious color signal	Transient color flow in stationary tissues	Probe/patient motion, respiration	Not true blood flow

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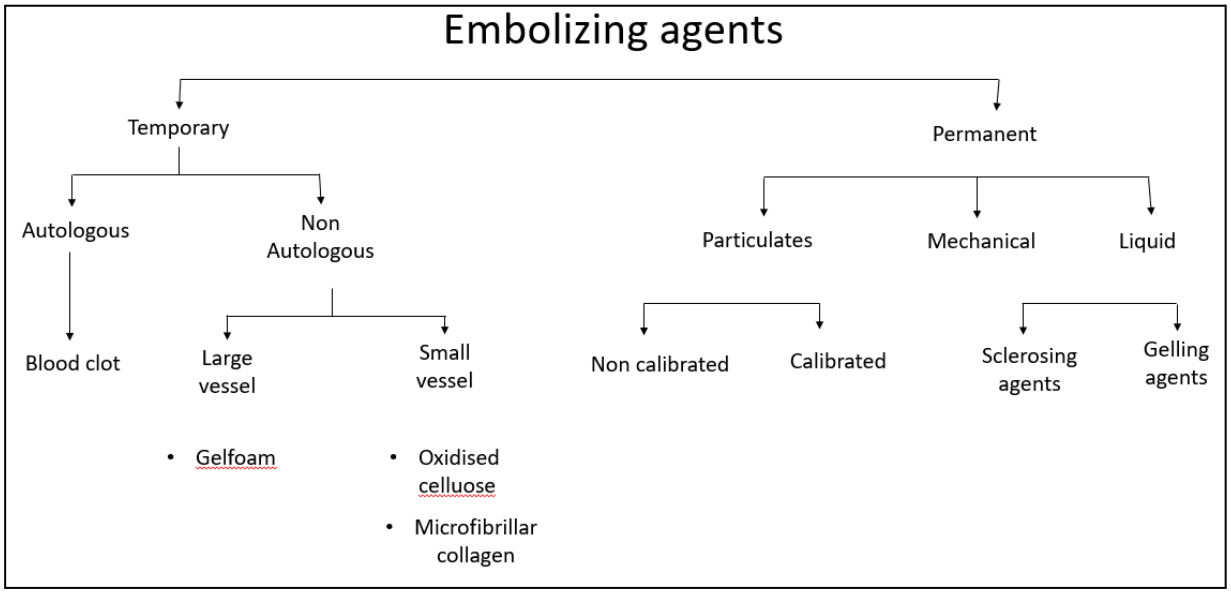
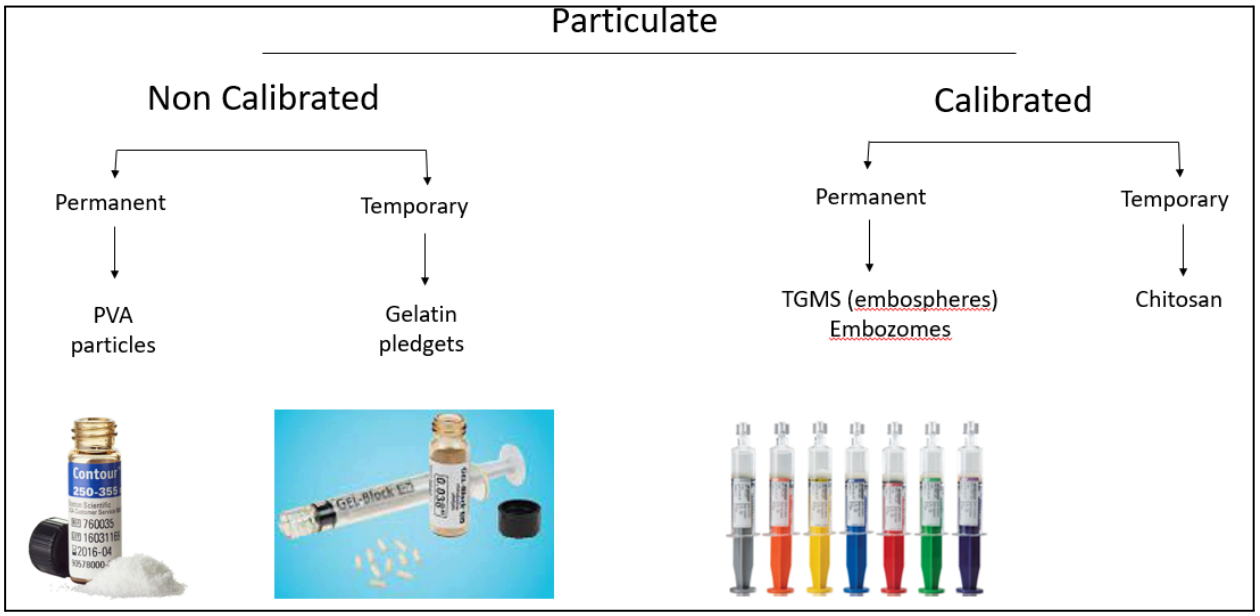
Q6. Classify the commonly used embolizing agents. Discuss their advantages, disadvantages and clinical applications.

Answer





Mechanical

Coils

Pushable

0.018 0.035

Detachable

0.018 0.035

Fibered

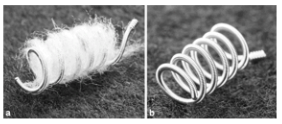
Non fibered

Hydrogel

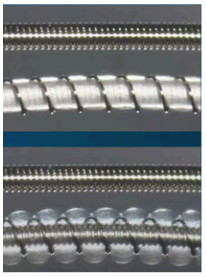
Non hydrogel

Plugs

Interlocking system



Balloons



Mechanical

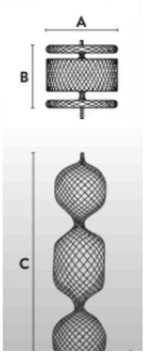
Coils

Plugs

Balloons

Uncovered plugs

Amplatzer vascular plug



30 to 50 % oversizing is recommended

Covered plugs

Microvascular plug

EOS Device

Nitinol covered by a PTFE membrane

Liquid Agents

Can penetrate deep into targets where catheters and coils cannot reach

Phase transformation is required –
Initial part – low viscosity to pass through the catheter.
Later part – becomes stiffer for vascular occlusion.

Sclerosing agents

Ethanol

Setrol

Polidocanol

Bleomycin

Gelling agents / Polymers

NBCA

EVOH (ONYX)

ONYX 18

ONYX 34

Embolic Agents

1. Gel Foam (Absorbable gelatin sponge)
Advantages: Biocompatible and well-tolerated, inexpensive, provides temporary occlusion for a few weeks, can be cut or shaped to fit, radiopaque when mixed with contrast, and easy to deliver via catheter.
Disadvantages: Short duration of occlusion (recanalization likely), non-specific embolization, risk of thromboembolism, and rare allergic or inflammatory reaction.
Clinical Uses: Temporary hemorrhage control in trauma, GI bleeding, postpartum hemorrhage, tumor embolization, AVM management, and preoperative vascular control.

2. PVA Particles (Polyvinyl alcohol)
Advantages: Permanent occlusion, predictable particle size (50–1500 μm) for controlled embolization, biocompatible, and radiopaque or mixable with contrast.
Disadvantages: Non-uniform distribution may cause incomplete occlusion, potential distal migration leading to non-target embolization, possible recanalization, rare infection or allergic reaction.
Clinical Uses: Tumor embolization (HCC, RCC, neuroendocrine tumors), AVMs, GI bleeding, uterine fibroid embolization, aneurysm management.

3. Embozene / Embospheres (Precisely calibrated microspheres)
Advantages: Accurate particle size for predictable embolization, spherical smooth surface for uniform distribution, permanent occlusion, radiopaque, and biocompatible.
Disadvantages: High cost, requires experienced technique, potential migration in high-flow vessels, risk of distal microembolization, and rare allergic reactions.
Clinical Uses: Hepatic embolization, uterine fibroid embolization, renal artery embolization, prostate artery embolization, gastric embolization.

4. Coils (Metallic occlusive devices)
Advantages: Precise and controlled vessel occlusion, permanent effect, wide variety of sizes and configurations, radiopaque, and can be combined with other embolics.
Disadvantages: Risk of thromboembolism, limited conformability in tortuous vessels, risk of coil migration or dislodgement, relatively high cost, and possible local inflammatory reaction.
Clinical Uses: Aneurysm treatment, AVM occlusion, peripheral vascular disease, GI bleeding, and uterine fibroid embolization.

5. Sclerosing Agents (Chemical sclerosants – e.g., ethanol, STS)
Advantages: Permanent occlusion, versatile (usable in veins, AVMs, tumors), minimally invasive, rapid hemostasis, and cost-effective.
Disadvantages: Can cause tissue necrosis if extravasated, pain during injection, risk of allergic reaction, potential recanalization, and risk of non-target embolization.
Clinical Uses: Varicose vein therapy, AVM management, hemorrhoid treatment, vascular tumor embolization, and control of esophageal variceal bleeding.

Q7. What is plagiarism in scientific writing? What are the various common types of plagiarism? Describe, how plagiarism can be detected in scientific writings. Briefly mention a few measures to avoid plagiarism.

Answer

Plagiarism in Scientific Writing

Plagiarism in scientific writing is the **unauthorized use of another person's intellectual output** — including text, ideas, images, graphs, or data — **without appropriate credit**.
In radiology research, this could involve:

- Copying **descriptions of imaging findings** from another publication
- Using **figures or DICOM images** from previous articles without permission
- Presenting another researcher's **study design, statistical methods, or conclusions** as your own

Plagiarism compromises **academic integrity**, **scientific credibility**, and may result in **article retraction, academic penalties, or legal consequences**.

Types of Plagiarism in Radiology Research

1. Direct Plagiarism

- **Definition:** Copying text, image captions, or results verbatim from another paper without citation.
- **Radiology example:** Copying a discussion paragraph on "MRI features of glioblastoma" from another author's work into your thesis.

2. Paraphrasing Plagiarism

- **Definition:** Restating someone else's work in your own words without attribution.
- **Radiology example:** Reading a review article on "CT findings in COVID-19 pneumonia" and summarizing it without citing the original source.

3. Mosaic Plagiarism (Patchwriting)

- **Definition:** Mixing phrases and sentences from multiple sources into new text without attribution.
- **Radiology example:** Combining text from three papers on "contrast-enhanced ultrasound in liver lesions" into one paragraph without proper citations.

4. Self-Plagiarism

- **Definition:** Reusing significant portions of your own previous work without citing it.
- **Radiology example:** Publishing similar case series data on "MRCP in choledocholithiasis" in two different journals without disclosure.

5. Unintentional Plagiarism
- **Definition:** Poor or missing citations due to lack of awareness or oversight.
- **Radiology example:** Using a colleague's unpublished PACS screenshots in your presentation without credit.

6. Citation Plagiarism
- **Definition:** Misrepresenting or selectively citing literature to support your point.
- **Radiology example:** Citing a study as evidence for "CT better than MRI for pancreatic masses" when the paper actually concluded the opposite.

7. Verbatim Copying with Minor Changes
- **Definition:** Copying with only superficial edits.
- **Radiology example:** Taking a textbook paragraph on "Diffusion-weighted imaging in stroke" and changing a few words.

8. Fabrication of Sources
- **Definition:** Inventing references to support claims.
- **Radiology example:** Citing a non-existent "2020 AJR article" to add weight to your argument.

Detection Methods in Radiology Manuscripts

1. Manual Review
- Journal editors and peer reviewers cross-check suspicious sections.
- Common in radiology when **image descriptions or protocols** appear identical to known papers.

2. Literature Cross-Referencing
- Comparing citations, captions, and methodology sections with known sources.

3. Peer Review Process
- Radiology reviewers, being domain experts, may recognize copied descriptions of **classic imaging signs** (e.g., "string of pearls" in SBO).

4. Plagiarism Detection Software
- Tools: *iThenticate*, *Turnitin*, *Crossref Similarity Check*.
- Radiology journals routinely run submissions through these tools.
- Algorithms detect:
    - **String matching** – identical word sequences

- **Lexical analysis** – synonyms and rephrased sentences
- **Fingerprinting** – unique text patterns

5. Image Plagiarism Detection

- Reverse image search (e.g., Google Images, TinEye) can identify reused radiology images.

6. Manual Verification

- Essential for distinguishing between **common radiological terminology** and true plagiarism.

Avoiding Plagiarism

1. **Cite All Sources Accurately**
   - Use consistent style (e.g., *Vancouver style* for most radiology journals).
   - Cite when describing prior imaging findings, protocols, or classifications.
2. **Use Quotation Marks for Verbatim Text**
   - Especially for definitions from WHO, ACR, or RSNA glossaries.
3. **Paraphrase Properly**
   - Rewrite in your own words and still credit the original source.
4. **Maintain a Reference Library**
   - Use *Mendeley, EndNote, Zotero* to organize citations.
5. **Acknowledge Image Sources**
   - For radiology figures, always state if an image is reused, even with permission.
6. **Run Plagiarism Checks**
   - Before submission, run your work through plagiarism software.
7. **Understand Academic Ethics**
   - Familiarize yourself with *ICMJE* and *COPE* guidelines.
8. **Obtain Permissions**
   - For any copyrighted radiology images, charts, or tables.
9. **Avoid Copying Reporting Templates**
   - Even structured reporting templates (e.g., BI-RADS wording) must be cited if adapted.

Q8. a) Predatory journals and publishing. b) Techniques of randomization of samples in a research study.

Answer

Predatory Journals

Predatory journals are **exploitative, profit-driven publications** that **bypass proper peer review and editorial standards**, thereby compromising scientific quality.
In radiology, these journals may publish **poorly designed imaging studies**, **unverified AI algorithms**, or **misleading case reports** without adequate scrutiny.

Predatory Journals in Radiology

1. Lack of Quality Control

- **Issue:** Minimal or no peer review; manuscripts are accepted regardless of scientific rigor.
- **Radiology example:** Publishing a case series on "CT findings in COVID-19" without proper patient selection criteria, ethical clearance, or statistical analysis.
- **Impact:** Unverified imaging protocols or diagnostic criteria enter the literature, potentially misleading clinicians.

2. Deceptive Practices

- **Tactics Used:**
  - **Unsolicited emails** promising rapid publication
  - False claims of **indexing in PubMed/Scopus**
  - Misuse of **renowned radiologists' names** on editorial boards without consent
- **Radiology example:** A predatory journal claiming RSNA indexing and inviting "original AI research in breast MRI" for a "special issue."

3. Low Publication Standards

- **Characteristics:**
  - Acceptance of manuscripts **without regard to novelty or validity**
  - Publication of **plagiarized or recycled figures**
  - Poor adherence to **ethical guidelines**
- **Radiology example:** Publishing plagiarized PACS images of "liver hemangioma" without source attribution.

4. Questionable Peer Review

- **Patterns:**
  - Reviews done by **unqualified individuals**

    - Requests for **author-suggested reviewers** without verification
    - "Fast-track" review for extra payment
- **Radiology example:** Manuscript on "Dual-energy CT in urolithiasis" accepted within 48 hours with no substantive reviewer comments.

Consequences for Radiology Research and Careers

- **Professional Reputation:** Association with poor-quality publications damages credibility.
- **Academic Progress:** Such papers may be **rejected in thesis evaluation**, **grant applications**, or **promotion assessments**.
- **Scientific Integrity:** Unreliable imaging data pollutes the evidence base, affecting meta-analyses and guidelines.
- **Patient Safety:** Clinicians may adopt flawed protocols based on unverified studies.

Combating Predatory Publishing in Radiology

1. Identification Criteria

- Absence of transparent **peer review policy**
- Vague **editorial board composition**
- Claims of **fake impact factors**
- Poorly written **call for papers**
- Publication fees not disclosed upfront

2. Reliable Resources

- **DOAJ** – Directory of Open Access Journals
- **COPE** – Committee on Publication Ethics
- **ICMJE Guidelines**
- **Think. Check. Submit.** campaign

3. Due Diligence Checklist for Radiologists

Before submitting a manuscript:

- Verify **indexing status** in PubMed, Scopus, or Web of Science
- Check **editorial board credentials**
- Read **recent articles** for quality
- Review **peer review policy**
- Search for the journal in known **predatory journal lists** (e.g., Cabell's Blacklist)

Predatory vs Legitimate Radiology Journals

Feature	**Predatory Journal**	**Legitimate Journal**
Peer Review	Minimal or fake	Rigorous, blinded
Editorial Board	Fake or unqualified	Established experts

Indexing	False claims	Verified databases
Publication Speed	Unrealistically fast	Reasonable timeline
Ethics	Poor or absent	Follows COPE, ICMJE
Impact Factor	Fabricated	Verified in JCR

Techniques of Randomization in Research Studies

Randomization is a cornerstone of high-quality research methodology, aiming to:

- **Reduce selection bias** in allocating patients to study arms.
- **Ensure comparable baseline characteristics** between groups.
- **Increase validity** and reliability of imaging research findings.

In radiology, randomization is particularly crucial when:

- Comparing diagnostic accuracy of different imaging modalities.
- Evaluating new image-guided interventions.
- Testing radiomics or AI algorithms in diagnostic workflows.

Techniques of Randomization

1. Simple Randomization

- **Definition:** Every participant has an **equal chance** of being allocated to any study group.
- **Methods:** Random number tables, computer random number generators, drawing lots.
- **Radiology example:** Randomly assigning patients with suspected liver lesions to undergo **MRI** or **contrast-enhanced CT** first, to compare diagnostic performance.
- **Advantage:** Easy to implement.
- **Limitation:** May cause imbalance in small sample sizes.

2. Stratified Randomization

- **Definition:** Participants are first divided into **homogeneous strata** based on important characteristics, then randomized **within each stratum**.
- **Purpose:** Ensures equal distribution of prognostic variables.
- **Radiology example:** Stratifying by **tumor stage** before randomizing patients to **3D mammography** vs **digital mammography**.
- **Advantage:** Balances key confounders.
- **Limitation:** Requires prior knowledge of prognostic factors.

3. Blocked Randomization

- **Definition:** Participants are divided into **blocks** of predetermined size, with equal allocation to each group within a block.
- **Purpose:** Maintains **balance** in group sizes during enrollment.

- **Radiology example:** In a multi-center trial comparing **low-dose vs standard-dose chest CT**, using blocks of 4 or 6 patients to ensure equal distribution in each center.
- **Advantage:** Prevents unequal group sizes.
- **Limitation:** Predictability if block size is constant and known.

4. Restricted Randomization

- **Definition:** Allocation is **restricted or adapted** based on predefined criteria.
- **Radiology example:** In a contrast agent safety study, limiting allocation so that **patients with renal impairment** are evenly distributed between **gadolinium-based** and **macrocyclic contrast** groups.
- **Advantage:** Flexibility for specific constraints.
- **Limitation:** May reduce randomness if over-restricted.

5. Cluster Randomization

- **Definition:** Groups (clusters) rather than individuals are randomized.
- **Radiology example:** Randomizing **entire hospitals** to use **AI-assisted CT lung nodule detection** vs **standard reporting**, with all patients in that hospital receiving the same approach.
- **Advantage:** Useful for logistical or contamination control reasons.
- **Limitation:** Requires larger sample size due to intra-cluster correlation.

6. Minimization

- **Definition:** Sequential allocation that **minimizes imbalance** between groups for predefined variables.
- **Radiology example:** Allocating stroke patients to **CT perfusion** or **MRI perfusion** in a way that balances **age, NIHSS score, and time from onset**.
- **Advantage:** Excellent balance even in small samples.
- **Limitation:** Not purely random — may introduce selection bias if allocation algorithm is known.

7. Adaptive Randomization

- **Definition:** Allocation probabilities are adjusted **during the trial** based on interim data.
- **Radiology example:** In a trial comparing **two PET tracers**, if one shows superior diagnostic yield early on, more patients are allocated to that tracer.
- **Advantage:** More ethical if one arm is clearly better.
- **Limitation:** Complex design; may complicate statistical analysis.

8. Response-Adaptive Randomization

- **Definition:** Allocation probabilities change **based on participant response** to interventions.

- **Radiology example:** In a neurointerventional trial, if early results show fewer complications with a new stent design under fluoroscopy, allocation shifts to favor that device.
- **Advantage:** Optimizes benefit for participants.
- **Limitation:** Requires continuous monitoring and advanced statistical planning.

Randomization in Studies

Technique	Key Feature	Radiology Example	Pros	Cons
Simple	Equal chance allocation	MRI vs CT for liver lesions	Simple	May imbalance small groups
Stratified	Balance within subgroups	Tumor stage before breast imaging modality	Balances confounders	Needs prior data
Blocked	Equal allocation in blocks	Low-dose vs standard CT in blocks	Maintains group size balance	Predictable if block size known
Restricted	Controlled allocation	Renal function balancing in contrast studies	Addresses constraints	May limit randomness
Cluster	Group allocation	Hospitals randomized to AI vs standard	Prevents contamination	Needs larger sample
Minimization	Sequential balance	Stroke imaging with balanced covariates	Good for small trials	Less random
Adaptive	Allocation changes over time	PET tracer selection based on interim yield	More ethical	Complex
Response-Adaptive	Based on treatment response	Neurointervention device safety	Optimizes benefit	Statistical complexity

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Q9. PC-PNDT Act and its applications.

b) TLD Badge: Principles and uses.

Answer

Pre-Conception and Pre-Natal Diagnostic Techniques (PC-PNDT) Act

Enacted: 1994
Implemented: 1996
Amendments: 2003, etc.

Purpose: To prevent sex selection before or after conception and stop the misuse of prenatal diagnostic techniques for sex-selective abortions.

Provisions

1. **Prohibition of Sex Selection**
    - Ban on any method to determine the sex of the fetus before or after conception.
    - Includes invasive (e.g., amniocentesis, chorionic villus sampling) and non-invasive methods (e.g., ultrasound).
2. **Regulation of Diagnostic Techniques**
    - Only for permitted medical indications (e.g., genetic disorders, chromosomal abnormalities, metabolic disorders, congenital anomalies).
    - Use limited to registered institutions with certified personnel.
3. **Registration of Facilities**
    - All genetic counseling centers, genetic labs, and ultrasound clinics must be registered.
    - Registration certificate must be prominently displayed.
4. **Record-Keeping**
    - Mandatory Form F for every case involving prenatal diagnostic procedures.
    - Records preserved for at least 2 years and available for inspection.
5. **Advisory Committees**
    - At central, state, and UT levels for policy advice and oversight.
6. **Awareness & Education**
    - Public education campaigns against gender-biased sex selection.
7. **Penal Provisions**
    - First offense: Imprisonment up to 3 years + fine up to ₹50,000.
    - Repeat offense: Imprisonment up to 5 years + fine up to ₹1,00,000.

- Suspension or cancellation of medical license.

Applications in Practice

- **Legal Enforcement:** District and state authorities inspect facilities, verify records, investigate violations.
- **Curbing Female Feticide:** Addresses skewed sex ratio by removing avenues for sex-selective abortion.
- **Ethical Medical Practice:** Ultrasound and other prenatal tests must not be used for non-medical sex determination.

Radiologist's Perspective

- Always document indication for prenatal USG.
- Ensure Form F is fully and accurately filled.
- Avoid any communication (verbal or written) regarding fetal sex.
- Comply with all display and registration norms.

Thermoluminescent Dosimeter (TLD) Badge

Purpose: Personal and environmental monitoring of ionizing radiation exposure.

Principle

1. **Thermoluminescence**
   - Uses crystals (e.g., LiF, CaF_2, $CaSO_4$) that store radiation energy.
   - On heating → trapped electrons are released → emit light.
   - Light intensity $\propto$ radiation dose received.
2. **Energy Storage**
   - Radiation excites electrons to higher energy states.
   - Electrons get trapped in lattice defects.
3. **Energy Release & Measurement**
   - Controlled heating in TLD Reader releases trapped electrons.
   - Light measured by photomultiplier tube → converted to dose using calibration curves.

Uses

1. **Personal Radiation Monitoring**
   - Worn by radiation workers (radiologists, nuclear plant staff).
   - Position: chest, waist, or ring (for extremity monitoring).
2. **Environmental/Area Monitoring**
   - Placed in rooms or facilities to monitor ambient radiation.
3. **Medical Applications**
   - Verify patient doses in radiotherapy.
   - Useful in small, irregular fields (brachytherapy, SRS).
4. **Research**
   - Dose measurement in experimental radiation studies.

Advantages

- **High Accuracy & Sensitivity** (even at low doses).
- **Reusable** after annealing.
- **Stable** for long-term dose integration.
- **Less affected** by temperature & humidity than film badges

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Q10. Artificial Intelligence in radiology.

b) PET MRI.

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1. Radiology Applications of AI

Stage	Application	Examples
Clinical Decision Support	AI recommends appropriate imaging study based on symptoms (Clinical Decision Support Systems - CDSS)	- ACR Appropriateness Criteria AI tools - IBM Watson Imaging Clinical Review
Scheduling & Workflow Management	AI prioritizes urgent scans, predicts imaging demand, automates bookings	- DeepMind AI for scheduling (UK NHS)
Image Acquisition	Automated protocol selection, real-time image optimization	- GE AIR Recon DL (deep-learning MRI recon) - AI-assisted low-dose CT
Image Reconstruction	Faster, high-quality images from raw data; noise/artifact reduction	- Siemens Deep Resolve for accelerated MRI - DLIR (Deep Learning Image Reconstruction) for CT
Image Post-processing	Segmentation, quantification, measurement automation	- AI cardiac function analysis - AI liver volumetry
Lesion Detection & Diagnosis	Detection of cancers, bleeds, fractures, infections	- AI triage for pneumothorax (FDA-approved) - Zebra Medical Vision - Brain hemorrhage detection: Aidoc, Viz.ai
Prognosis & Risk Stratification	Predict outcomes, therapy responses	- Radiomics + AI predicting glioma survival - AI coronary calcium score for CAD risk

Reporting & Natural Language Processing (NLP)	Structured reporting assistance, error detection, analytics	- Nuance PowerScribe One with AI auto-population of reports
Follow-up Recommendations	AI-based recommendations on repeat imaging	- Tracking lung nodules automatically (Lung-RADS support)
Radiation Dose Estimation	AI predicts, optimizes patient radiation exposure	- DoseWise Portal (Philips)

2. Subspecialty-wise Applications

Subspecialty	AI Applications
Neuroradiology	- Stroke detection (LVO on CTA: Viz.ai) - Brain tumor segmentation - Multiple sclerosis lesion detection - Automated ASPECTS scoring
Chest Imaging	- Lung cancer screening (nodule detection, risk prediction) - COVID-19 pneumonia severity scoring - Pulmonary embolism detection (CTPA triage)
Breast Imaging	- AI for mammogram lesion detection (Google Health algorithm) - Breast MRI segmentation - Automated density assessment
MSK Imaging	- Fracture detection (wrist, hip, spine) - Bone age estimation (FDA-cleared: BoneXpert)
Abdominal Imaging	- Liver fibrosis staging - Prostate cancer detection on mpMRI - Pancreatic lesion detection
Cardiac Imaging	- Coronary artery calcium scoring (Cleerly) - Ejection fraction estimation - AI-assisted cardiac CT plaque analysis
Vascular Imaging	- Aortic dissection triage - Carotid plaque burden evaluation
Pediatric Imaging	- AI for skeletal maturity - Congenital anomaly detection

3. Recent Global Advances in AI in Radiology

Area	Advance	Example

Foundation Models (Large AI Models)	Trained on millions of images, adaptable to many tasks	- Google's "MedPaLM" for imaging + clinical reasoning - "RadFormer" - RSNA 2024 highlighted
Self-supervised Learning	Reduces need for large annotated datasets	- Self-Supervised AI for brain MRI (Stanford)
Multimodal AI (Image + Text)	Combines imaging + EMR for diagnosis	- Pathology-radiology fusion for breast cancer
Generative AI (Synthetic Images)	GANs create synthetic MRI, CT datasets for training/testing	- NVIDIA MONAI - Medical GANs
Low-dose/Ultra-fast Imaging	AI reconstructs high-quality images from ultra-low dose CT or fast MRI	- Siemens Healthineers "Deep Resolve" MRI 5× faster
Federated Learning (Privacy-preserving AI)	Train AI across hospitals without sharing raw patient data	- NIH + Stanford federated brain tumor detection models
Explainable AI (XAI)	Improves transparency: why AI predicted a certain result	- "Attention Maps" in chest radiographs (highlight pathologies)
AI Regulatory Advances	Fast-track FDA approvals, RSNA structured validation	- FDA cleared > 500 imaging AI algorithms (2023 stats)
AI for Imaging Biomarkers (Radiomics + AI)	Quantitative feature extraction + prediction	- Radiomics for EGFR mutation prediction in lung CA
AI-Guided Interventions	AI predicts optimal biopsy site, guides IR procedures	- AI-powered ablation zone prediction in liver tumors

Key Real-World Approved AI Tools (Examples)

Company/Tool	Modality	Use
Aidoc	CT	ICH, PE, spine fracture triage
Viz.ai	CTA	LVO (stroke) detection and neurologist alert
Arterys	Cardiac MRI, CT	Ventricular function, lung nodules
Zebra Medical Vision	Chest X-ray, CT	Detection of fractures, malignancy, emphysema

ScreenPoint Transpara	Mammography	Lesion detection comparable to expert radiologists
Subtle Medical	MRI, PET	Scan acceleration, noise reduction

Challenges Ahead

Challenge	Details
Data bias	Algorithms trained on non-diverse populations risk inequity
Regulatory validation	Need standardized, independent multicenter validation
Explainability	Black-box AI still a major trust barrier
Integration with workflow	Radiologist burnout if AI poorly integrated
Ethical and medicolegal issues	Responsibility for AI errors remains a grey area

PET-MRI (Positron Emission Tomography – Magnetic Resonance Imaging)

Hybrid imaging modality combining functional **PET** data with anatomical and soft-tissue detail from **MRI** in a single session.

Components

1. **PET Scanner**
    - Detects photons from annihilation events after positron-emitting radiotracers (e.g., F-18, C-11, O-15) decay.
    - Provides metabolic & molecular imaging.
2. **MRI Scanner**
    - Uses strong magnetic fields + radiofrequency pulses to produce high-resolution anatomical and soft tissue images.
    - Superior soft tissue contrast vs. CT.
3. **Image Fusion Software**
    - Aligns PET metabolic data with MRI structural images for precise spatial correlation.

Advantages Over PET-CT

1. **Multimodal Comprehensive Imaging**
    - Combines PET's functional/metabolic data with MRI's structural/soft tissue detail.
    - Better lesion characterization and staging.
2. **Reduced Radiation**
    - No CT → significantly lower dose, especially valuable in pediatrics & oncology follow-up.
3. **Superior Soft Tissue Contrast**
    - Ideal for brain, spinal cord, liver, pelvis, head & neck.
4. **Functional + Structural Insights**
    - Detects inflammation, hypoxia, metabolism alongside anatomy.

5. **Motion Correction**
    - MRI-based motion tracking improves image sharpness in thoracic & abdominal imaging.

Clinical Applications

- **Neurology**: Brain tumors, epilepsy localization, neurodegenerative diseases (Alzheimer's, Parkinson's).
- **Oncology**: Whole-body tumor staging, treatment response monitoring, pelvic cancers (prostate, cervix), liver metastases.
- **Cardiology**: Myocardial viability, inflammation.
- **Research**: Multimodal biomarkers, metabolic-imaging studies.
