
Q1. Discuss in brief, the salient CT and MRI features in an acute ischemic stroke patient arriving to the hospital within 6 hours of onset. Suggest an algorithm-based approach for confirmation of diagnosis and guiding the management of such a patient.

Answer

Imaging Features in Acute Ischemic Stroke (< 6 hours)

1. Non-Contrast CT (NCCT)
Purpose: Rapid, first-line — exclude hemorrhage, detect early ischemic changes.
Early (< 6 hrs) CT Findings — often subtle:

1. **Loss of Gray–White Differentiation**:
    - **Insular ribbon sign – blurring of insular cortex.**
    - **Obscuration of lentiform nucleus (caudate/putamen indistinct).**
2. **Sulcal Effacement**:
    - **Loss of normal CSF density in sulci due to cytotoxic edema.**
3. **Hyperdense Vessel Sign**:
    - **Hyperdense MCA/basilar — intraluminal thrombus.**
4. **Subtle Hypoattenuation**:
    - **Low density in affected vascular territory; early cytotoxic edema.**
5. **ASPECTS score** (Alberta Stroke Program Early CT Score):
    - **Assesses extent of early ischemia in MCA territory.**
    - **Lower score = worse prognosis.**

2. MRI (if rapidly available, especially in stroke centers)
Purpose: More sensitive for hyperacute ischemia, detects lesions missed on CT.
Diffusion-Weighted Imaging (DWI)

- **Bright signal** in ischemic tissue within minutes of onset.
- **Restricted diffusion** → confirmed by low signal on ADC map.

Apparent Diffusion Coefficient (ADC)

- **Low ADC** in core infarct region (due to restricted water motion in cytotoxic edema).

FLAIR

- Usually **normal in first 6 hrs** ("DWI-FLAIR mismatch" suggests hyperacute stroke, useful for wake-up stroke selection).
- Mild hyperintensity may develop after ~4–6 hrs.

T2 / T2 / SWI*

- SWI may show **susceptibility vessel sign** (thrombus blooming artifact).
- Detects small hemorrhagic transformation.

MRA (TOF or contrast-enhanced)

- Shows vessel occlusion without contrast (TOF) or with contrast (CE-MRA).

Comparative Table (< 6 hrs)

Feature	CT (NCCT)	MRI (DWI/FLAIR/SWI)
Hemorrhage detection	Excellent (primary goal)	Good on GRE/SWI
Early ischemia	Loss of gray–white differentiation, sulcal effacement	DWI bright, ADC low
Intravascular thrombus	Hyperdense vessel sign	SWI blooming, TOF/MRA occlusion
Posterior fossa stroke	Poor sensitivity	Excellent (DWI)
Hyperacute infarct detection	Limited sensitivity	Highly sensitive within minutes
Perfusion assessment	Needs CTP	MRI perfusion available

Algorithm: Acute Ischemic Stroke (< 6 hrs from onset)

Step 1: Immediate Clinical Assessment

- **Confirm stroke suspicion**:
  - Sudden focal neuro deficit (FAST, NIHSS scoring).
- **Establish onset time** (or last known well).
- **Check contraindications** for thrombolysis/thrombectomy.
- **ABC stabilization**.

Step 2: Emergent Imaging

Goal — *Exclude hemorrhage, confirm ischemia, identify occlusion, assess penumbra.*

A. First-line — Non-Contrast CT (NCCT)

- **Rule out intracranial hemorrhage** (contraindication to tPA).
- **Assess early ischemic signs** → ASPECTS scoring.
- **Look for hyperdense vessel sign** (suggests thrombus).

B. Add if available immediately:

- **CT Angiography (CTA)**:
  - Detect large vessel occlusion (LVO).
  - Guide thrombectomy decision.
- **CT Perfusion (CTP)** (optional in <6 hrs, more useful in 6–24 hrs window):
  - Core vs penumbra assessment.

Step 3: MRI Pathway (if available without delay)

- **MRI-DWI + ADC**: Confirm ischemia within minutes.
- **MRA/TOF**: Show vessel occlusion.
- **SWI**: Detect thrombus & hemorrhage.
- **DWI–FLAIR mismatch**: Suggests hyperacute onset.

Step 4: Imaging-Based Decision Making

Imaging Result	**Action**
Hemorrhage on NCCT/SWI	**No tPA** → Treat as hemorrhagic stroke
No hemorrhage + ischemic changes ≤1/3 MCA territory + onset ≤4.5h	**IV tPA** candidate
Large vessel occlusion on CTA/MRA + onset ≤6h	**Direct to Mechanical Thrombectomy** (with or without tPA)
Small core, large penumbra (CTP/MR perfusion) beyond standard window	Consider **extended thrombectomy window** (up to 24h in select cases)

Step 5: Example Workflow (< 6 hrs)

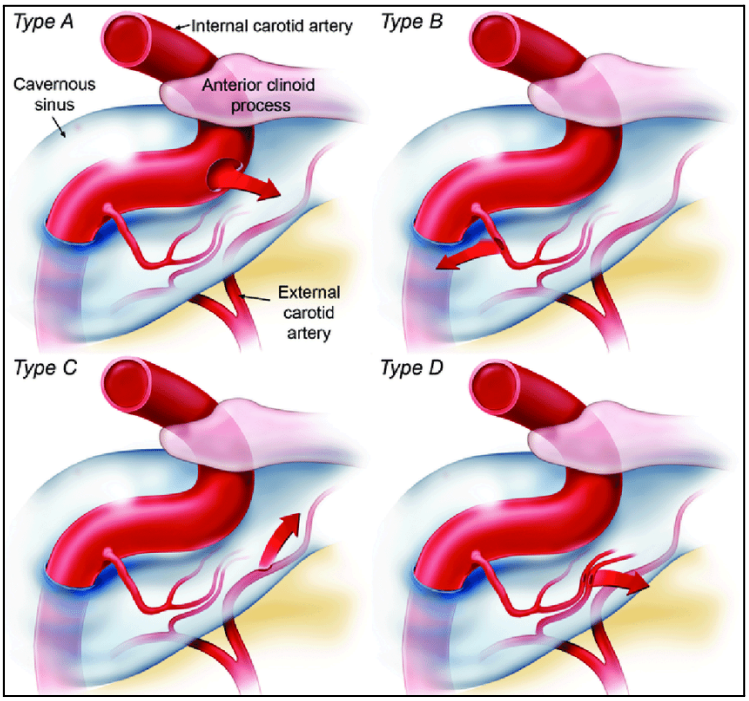
1. **Arrival & ABC** → Neuro exam + NIHSS.
2. **Immediate NCCT** (goal: <20 min door-to-scan).
3. **If no bleed**:
    - **Perform CTA (head + neck) immediately.**
    - **Consider CTP or MRI if available and rapid.**
4. **Interpret findings**:
    - **Hemorrhage → neurosurgery/ICU.**
    - **Ischemia, small core:**
        - **<4.5 hrs → IV tPA.**
        - **LVO & <6 hrs → Mechanical thrombectomy ± IV tPA.**
5. **Post-treatment**: ICU/stroke unit care.

Q2. A young adult patient has presented with unilateral pulsatile proptosis and chemosis after a road traffic accident. What is the probable aetiology and how will you confirm the diagnosis by imaging? Discuss the role of radiologic Interventions in managing such a condition.

Answer:

Probable Diagnosis
Post-traumatic Carotid–Cavernous Fistula (CCF)

- **Definition:** An abnormal communication between the carotid arterial system (usually the cavernous segment of ICA) and the cavernous sinus.
- **Etiology:** Commonly **direct type (Barrow type A)** — high-flow, post-traumatic tear of the intracavernous ICA wall.



- **Clinical hallmarks:**
  - Unilateral pulsatile proptosis
  - Chemosis
  - Orbital bruit
  - Diplopia from CN III, IV, VI palsies
  - Possible raised intraocular pressure and vision loss if untreated

Imaging in Diagnosis

1. CT & CT Angiography (CTA)

Role: Initial, rapid, non-invasive evaluation in trauma setting.

Findings:

- **Orbital signs:**
  - Proptosis
  - Dilated, tortuous **superior ophthalmic vein (SOV)** (most consistent sign)
  - Orbital fat stranding / congestion
- **Cavernous sinus signs:**
  - Enlarged cavernous sinus on affected side
  - Asymmetric early enhancement in arterial phase (arterialization of venous sinus)
- **Vascular signs:**
  - Early filling of cavernous sinus during arterial phase
  - Dilated ophthalmic and facial veins
- **Bone evaluation:** May show associated skull base fractures

2. MRI & MR Angiography (MRA)

Role: Superior soft tissue contrast, evaluates orbital and cavernous sinus structures in detail, and can non-invasively assess hemodynamics.

Findings:

- **Cavernous sinus:**
  - Asymmetric enlargement with internal **flow voids** (signal loss on spin-echo sequences from high-velocity flow)
  - Heterogeneous enhancement after gadolinium
- **Orbital findings:**
  - Proptosis
  - Dilated SOV (flow void or high T2 signal if slow flow/thrombosis)
  - Extraocular muscle enlargement (especially superior rectus and lateral rectus) due to venous congestion
  - Orbital edema and increased retrobulbar fat signal on T2
- **MRA:**
  - Direct demonstration of early filling of cavernous sinus in arterial phase
  - Can delineate fistulous point in large/direct fistulas

3. Digital Subtraction Angiography (DSA) – Gold Standard

Role:

- **Definitive diagnosis** — provides precise anatomy, hemodynamic pattern, venous drainage routes
- **Treatment planning** — immediate transition to therapeutic embolization possible

Technique:

- Catheterization of both internal carotid arteries (and external carotid if indirect fistula suspected)
- Sequential injections to evaluate cross-filling and contralateral venous drainage

Findings:

- **Direct type:** Early opacification of cavernous sinus from ICA injection in arterial phase
- **Venous drainage:** SOV, inferior ophthalmic vein, petrosal sinuses, cortical veins
- High-flow shunt with rapid venous opacification in trauma cases

Principles of Endovascular Management

- **Aim:** Obliterate the abnormal carotid–cavernous communication while **preserving the parent artery (ICA)** whenever possible.
- **Direct, high-flow (Barrow Type A)** CCFs — common after RTA — usually require urgent intervention to prevent optic nerve damage, intracranial venous hypertension, or hemorrhage.
- **Endovascular therapy is first-line**; surgery is rarely needed now.

Approach Planning

1. **Access route decision:**
    - **Transarterial approach (via ICA) → preferred for direct, high-flow CCFs.**
    - **Transvenous approach (via inferior petrosal sinus, superior ophthalmic vein, or facial vein) → preferred for indirect, low-flow CCFs or when arterial access is not feasible.**
2. **Goal:**
    - **Direct closure of the fistulous point at cavernous sinus entry.**
    - **Preservation of ICA flow (balloon test occlusion if sacrifice is contemplated).**

Interventional Radiology

1. Detachable Balloon Occlusion

- **Method:** Balloon navigated through ICA into cavernous sinus via fistula opening → inflated to block abnormal flow.
- **Advantages:**
    - Single device closure.
    - Immediate hemodynamic correction.
    - Good for large, direct fistulas.
- **Disadvantages:**
    - Risk of balloon migration/deflation.
    - Sometimes difficult to pass balloon across fistula.
- **Success rate:** High in acute trauma if anatomy favorable.

2. Coil Embolization

- **Method:** Platinum coils delivered via microcatheter into cavernous sinus to induce thrombosis.
- **Use:**
  - When balloon cannot be placed.
  - For residual leaks after balloon placement.
- **Advantages:** Precise deployment.
- **Risks:** Coil migration into ICA, incomplete closure → recurrence.

3. Stent-assisted Coil Embolization

- **Method:** Self-expanding stent placed in ICA across fistula opening → coils deployed between stent and cavernous sinus.
- **Advantages:**
  - Maintains ICA lumen.
  - Reduces coil herniation.
- **Indications:**
  - Wide-neck fistulas.
  - Complex anatomy.
- **Limitation:** Requires dual antiplatelet therapy.

4. Covered Stent Placement

- **Method:** PTFE-covered stent across ICA segment to exclude fistula.
- **Advantages:** Immediate exclusion without sacrificing ICA.
- **Risks:**
  - Rigid delivery → difficult navigation.
  - Higher thrombosis risk.

5. Liquid Embolic Agents

- **Agents:** n-BCA glue, Onyx.
- **Approach:** Either transarterial or transvenous.
- **Advantages:** Penetrates complex venous channels.
- **Risks:**
  - Non-target embolization (ophthalmic artery, cortical veins).
  - Requires precise injection control.

When ICA Sacrifice is Considered

- If preservation impossible (e.g., large tear, failed reconstruction).
- **Balloon Test Occlusion** (BTO) with hypotensive challenge performed to confirm adequate collateral circulation before permanent ICA occlusion with coils or detachable balloons.

Outcomes & Complications

- **Success rates:** >90% for direct CCF with modern techniques.
- **Complications:**
    - Cranial nerve palsies (from cavernous sinus thrombosis or coil mass effect).
    - ICA occlusion.
    - Device migration.
    - Embolic stroke.
- **Prognosis:** Early intervention → rapid resolution of bruit, chemosis, proptosis; vision improvement possible if optic nerve not irreversibly damaged.

Q3. Discuss in brief, various types of hyperparathyroidism. Describe imaging features of various types of hyperparathyroidism.

Answer

Feature	Primary HPT	Secondary HPT	Tertiary HPT
Common Cause	Parathyroid adenoma (85%), hyperplasia (10–15%), carcinoma (<1%)	CKD (most common), vitamin D deficiency, malabsorption	Long-standing SHPT → autonomous hyperplasia (often post-transplant)
Calcium	↑	↓ or low-normal	↑
Phosphate	↓	↑	↑ / normal
PTH	↑	↑	↑ (very high)
Pathophysiology	Autonomous PTH secretion	Hypocalcemia → compensatory ↑ PTH	Persistent ↑ PTH despite correction of hypocalcemia

Imaging Features in Hyperparathyroidism

Modality	Primary HPT	Secondary HPT	Tertiary HPT
Ultrasound	• Single hypoechoic, oval/bean-shaped lesion near thyroid (adenoma) • ↑ vascularity on Doppler	• Multiple symmetrically enlarged hypoechoic glands • Heterogeneous echotexture	• Multiple enlarged glands, often nodular hyperplasia • Similar to SHPT but larger/more irregular
99mTc-Sestamibi Scan	• Single persistent uptake focus (adenoma) • Early uptake in thyroid & parathyroid, delayed retention in adenoma	• Multiple foci of uptake (hyperplasia) • May be less intense than adenoma	• Multiple foci, sometimes with dominant adenoma-like lesion • Persistent uptake due to long-standing hyperplasia
CT (including 4D-CT)	• Well-defined soft tissue mass, avid enhancement with rapid washout (adenoma)	• Multiple smaller enhancing glands • Symmetric	• Multiple enlarged glands, possible dominant lesion within hyperplasia • 4D-CT helps differentiate residual

			hyperplasia vs adenoma
MRI	• T1 hypointense, T2 hyperintense, enhances with gadolinium (adenoma)	• Multiple enlarged glands, same signal characteristics	• Multiple nodular enlarged glands, possible mixed adenoma–hyperplasia appearance
Bone X-ray	• Subperiosteal bone resorption (phalanges) • “Salt-and-pepper” skull • Brown tumors	• Similar bone resorption + osteosclerosis (spine/pelvis) • More diffuse skeletal involvement	• Severe bone changes: resorption, osteitis fibrosa cystica, brown tumors, sclerosis
DXA	• ↓ cortical bone density (forearm)	• ↓ cortical bone density + renal osteodystrophy pattern	• Marked ↓ BMD with mixed lytic/sclerotic changes

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Q4. Discuss various indications, techniques, advantages and limitations of MRI in imaging of breast cancer.

Answer

MRI Acquisition

Breast MRI requires a **high-field strength scanner (≥1.5T, preferably 3T)** with a **dedicated breast coil**. The patient is positioned **prone** to:

- **Minimize motion artifacts.**
- **Optimize lesion conspicuity** by allowing the breast to be fully extended.

Breast MRI Sequences

A **multiparametric approach** using various MRI sequences enhances **lesion characterization and differentiation of benign from malignant pathology**.

Sequence	**Purpose**
T1-weighted (Pre-contrast)	Evaluates fat, hemorrhage, post-surgical changes
DCE MRI (Dynamic Contrast-Enhanced)	Detects **neoangiogenesis** using gadolinium (hallmark of malignancy)
Diffusion-Weighted Imaging (DWI)	Assesses tumor **cellularity**; **ADC maps** help in malignancy grading
T2-weighted (Fat-sat or STIR)	Differentiates **cystic vs. solid** lesions
Kinetic Curve Analysis	Time-signal intensity curve; **washout = malignancy**

Protocol

Parameter	**Value**
Gadolinium dose	0.1 mmol/kg
Rate	2 mL/sec
Slice thickness	3 mm, 2D or 3D spoiled gradient echo (SPGR)
Peak enhancement	~90 seconds post-injection
Dynamic imaging	Every 1 minute for 8 minutes (8 + 1 pre)
Total sequences	~9 (1 pre-contrast + 8 post-contrast)

Breast MRI Protocols

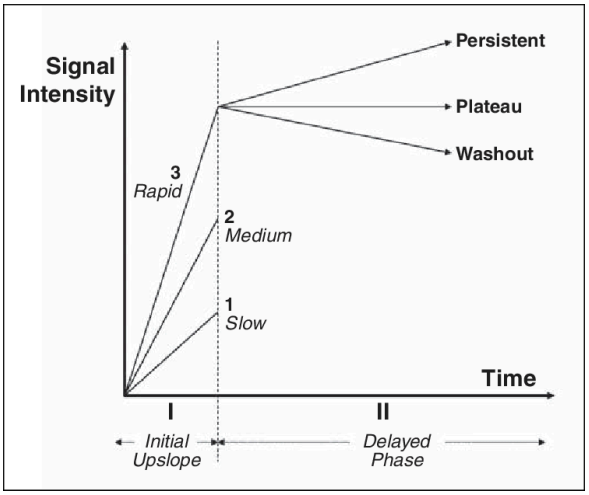
Parameter	Standard Protocol	Short Protocol	Abbreviated Protocol	Ultrafast Protocol
Total Sequences	9 (1 pre + 8 dynamic)	~3	2 (Pre + 1 Post)	2–3 rapid sequences
Pre-contrast T1	Yes	Yes	Yes	Yes
Dynamic Imaging	8 post-contrast (every 1 min till 8 min)	2 post-contrast (at 4 and 8 min)	1 post-contrast (at 4 min)	Multiple post-contrast (every 7–15 sec within 1 min)
T2-weighted / STIR	Done	Optional	Optional	❌
DWI with ADC map	Done	Optional	❌	❌
Kinetic Curve Analysis	Full curves: wash-in, wash-out, plateau)	❌	Limited: early enhancement on 1st post-contrast image)	High-resolution: early enhancement rate, time to enhancement, SER)
Scan Duration	~15–20 mins	~8–10 mins	~5–6 mins	<2–3 mins
Gadolinium Dose	0.1 mmol/kg	Same	Same	Same
Goal	Comprehensive diagnostic/staging	Efficient lesion evaluation with reduced acquisition	Screening with morphology + early enhancement info	Early lesion enhancement kinetics for rapid triage
Use Case	Diagnostic, staging, surgical planning	Intermediate centers, triage	High-throughput screening, surveillance	Rapid detection, kinetic characterization within seconds

3. Post-processing Techniques

- **Subtraction Imaging**: Removes pre-contrast background noise to highlight enhancement.
- **Maximum Intensity Projection (MIP)**: Aids in rapid detection of enhancing lesions.
- **Kinetic Curve Analysis**: Determines enhancement characteristics (persistent, plateau, washout patterns).

Kinetic Curve Analysis in DCE-MRI

Kinetic curve analysis plays a pivotal role in **differentiating benign from malignant lesions** by assessing **the pattern of contrast uptake and washout**.



Types of Enhancement Curves

Enhancement Pattern	Initial	Later	Significance
Type I	Gradual enhancement	Gradual enhancement	Suggests benign lesions (e.g., fibroadenoma, cysts, fat necrosis).
Type II	Rapid	Plateau	Indeterminate—requires further evaluation.
Type III	Rapid	Washout	Highly suspicious for malignancy.

Key Features of Malignant Lesions on DCE-MRI

- **Early, intense contrast uptake** (**peak within 90 sec**).
- **Heterogeneous or rim enhancement**.
- **Type III washout pattern** in kinetic curve analysis.

Clinical Indications for Breast MRI

Indication	Key Scenarios	Benefit
1. High-Risk Screening	• BRCA1/BRCA2 mutations • Strong family history (lifetime risk >20–25%) • Prior chest irradiation (e.g., Hodgkin's survivors)	Detects cancers earlier than mammography in high-risk women

	• Li-Fraumeni, Cowden, Bannayan-Riley-Ruvalcaba syndromes	
2. Preoperative Staging of Breast Cancer	• Assess multifocality & multicentricity • Detect contralateral cancer (~5% cases) • Define DCIS extent	Guides breast-conserving surgery vs mastectomy
3. Neoadjuvant Chemotherapy (NACT) Response	• Monitor tumor shrinkage • Differentiate fibrosis from residual tumor • Predict pathologic complete response (pCR)	Optimizes surgical planning post-NACT
4. Scar vs. Recurrence	• Post-lumpectomy or post-radiation changes • Evaluate for persistent/enhancing lesion	MRI helps confirm recurrence when enhancement persists/increases
5. Breast Implant Evaluation	• Silicone implant rupture (intracapsular / extracapsular)	MRI is gold standard for implant integrity assessment
6. Occult Primary Breast Cancer	• Axillary metastases without detectable primary on mammogram or ultrasound	MRI can identify hidden primary tumor
7. Problem-Solving Tool	• Inconclusive mammography/ultrasound findings • Suspicious nipple discharge with negative conventional imaging	Clarifies diagnosis and guides further management

Breast MRI – Advantages vs Limitations

Advantages	Limitations
Highest Sensitivity for Breast Cancer Detection (90–99%) • Detects small/occult tumors missed on mammography • Excellent in dense breasts	**Lower Specificity (High False Positives)** • Benign lesions (fibroadenomas, papillomas, fat necrosis) may enhance • Biopsy confirmation often needed
Multiparametric Functional Imaging • Combines morphology + kinetics + diffusion • Assesses vascularity, cellularity, and tissue diffusion	**Expensive & Limited Availability** • Less accessible in resource-limited settings • Higher operational cost

No Ionizing Radiation • Safe for young women & high-risk patients	**Time-Consuming** • Standard MRI: 30–45 min • Abbreviated protocols: ~10 min
Accurate Preoperative Staging • Maps tumor extent, multifocality, contralateral lesions • Reduces re-excision rates	**Requires Gadolinium Contrast** • Contraindicated in severe renal impairment (eGFR <30) • Rare NSF risk
Best for Breast Implant Evaluation • Most accurate for detecting silent ruptures	**Not a First-Line Screening Tool** • Mammography remains primary for general population

Recent Advances in Breast MRI

1. Abbreviated Breast MRI (AB-MRI)

- Shortens MRI exam time (<10 minutes).
- Retains high sensitivity while improving accessibility.
- Promising for high-risk population screening.

2. Diffusion-Weighted Imaging (DWI)

- Non-contrast technique that evaluates tumor cellularity.
- High ADC values → Benign lesion.
- Low ADC values → Malignant lesion.

3. Ultrafast Breast MRI

- Captures early contrast enhancement within 10-15 seconds.
- Helps differentiate benign vs. malignant lesions based on contrast uptake kinetics.

4. MR Spectroscopy

- Detects choline peak, a marker of malignancy.
- Reduces unnecessary biopsies.

5. Artificial Intelligence (AI) in Breast MRI

- Automated lesion detection and characterization.
- Reduces interpretation time and false positives.

Q5. Describe various morphological patterns of vertebral body injuries in thoraco-lumbar spine. Discuss role of MRI in the diagnosis and management of such vertebral body injuries.

Answer

Classification of Thoraco-Lumbar Spine Injuries

Compression Fractures	Burst Fractures	Chance Fractures	Fracture-Dislocations	Minor Vertebral Fractures
Mechanism Typically result from axial loading, often combined with flexion. **Imaging Features** 1. Wedge Compression: Anterior height loss with intact posterior wall, resulting in a wedge-shaped vertebral body. 2.Stable Fracture: No involvement of the posterior vertebral elements; spinal canal remains intact. **Clinical Implications:** Often stable; pain management and bracing are common treatments. Surgery is rarely required.	**Mechanism** High-energy axial loading causes the vertebral body to shatter, with retropulsion of bony fragments into the spinal canal. **Imaging Features** 1. Comminuted Fracture 2. Loss of Vertebral Height: Both anterior and posterior. 3.Spinal Canal Compromise 4. CT: Best modality to assess bony fragments. **Clinical Implications:** Potentially unstable; risk of neurological injury necessitates surgical intervention in many cases.	**Mechanism** Hyperflexion with distraction, often seen in seatbelt injuries in motor vehicle accidents. **Imaging Feature** 1. Horizontal Fracture Line: Extends through the vertebral body, pedicles, and spinous process. 2. CT: Clearly shows the fracture line through the posterior elements. 3. MRI: Useful for assessing ligamentous injury. **Clinical Implications:** Unstable injury; often requires surgical stabilization.	**Mechanism** High-energy trauma resulting in severe flexion, extension, rotation, or shear forces. **Imaging Features** 1. Vertebral Displacement 2. Facet Joint Disruption: Facet dislocations or perched facets. 3. Spinal Canal Compromise 4. CT and MRI: Essential for detailed assessment of bony and soft tissue damage. **Clinical Implications:** Highly unstable; immediate surgical intervention is typically required.	**Mechanism** Low-energy trauma, often in osteoporotic bones. **Imaging Features** 1. Endplate Fractures: Fractures confined to the superior or inferior endplates. 2. Compression: Minor height loss without significant displacement. **Clinical Implications:** Generally stable; managed conservatively with pain management and physical therapy.

Morphological Patterns of Vertebral Fractures

Type	Key Imaging Features	Best Modality	Notes
A. Wedge Compression Fracture	• Anterior vertebral body height loss (anterior third) • Posterior wall intact • MRI: bone marrow edema if acute	MRI (edema) CT (bony detail)	Stable unless >50% height loss or kyphotic deformity
B. Burst Fracture	• Vertebral body comminution • Interpedicular widening • Retropulsed fragments → spinal canal compromise	CT (fracture detail, retropulsion) MRI (cord/ligament injury)	Often unstable; canal compromise common
C. Flexion-Distraction (Chance) Fracture	• Horizontal fracture line through vertebral body & posterior elements • MRI: posterior ligamentous complex injury	CT (fracture plane) MRI (soft tissue)	Often unstable; seat-belt injury mechanism
D. Fracture-Dislocation	• Significant AP or lateral displacement • Facet joint dislocation/subluxation • MRI: cord compression/edema	CT (alignment) MRI (cord/ligament)	Highly unstable; high risk of neurological injury
E. Minor Vertebral Fractures	• Endplate disruption only • Non-displaced fracture lines • Minimal height loss	MRI (subtle marrow edema) CT (small fracture detail)	Usually stable; often incidental

ROLE OF MRI in Vertebral Fractures

1. **Soft Tissue Injury Assessment**
    - Ligamentous Damage: Gold standard for assessing posterior ligamentous complex (PLC) — supraspinous ligament, interspinous ligament, ligamentum flavum, posterior longitudinal ligament. Crucial for spinal stability evaluation.
    - Intervertebral Discs: Detects herniation, bulging, or annular disruption associated with fractures.
    - Muscle & Tendon Injury: Identifies paraspinal muscle tears, edema, and tendon injury that may influence management.

2. **Bone Marrow Oedema**
    - Acute Fractures: Detects bone marrow oedema not seen on X-ray or CT.
    - Chronicity Assessment: Differentiates acute, subacute, and chronic fractures based on oedema pattern.

3. **Spinal Cord & Nerve Root Involvement**
    - Cord Compression: Assesses degree of compression by retropulsed bone fragments, hematomas, or disc material.
    - Cord Signal Changes: Detects myelomalacia, contusion — important prognostic indicators.
    - Nerve Root Compression: High-resolution views reveal root impingement or injury.

4. **Infection & Tumor Evaluation**
    - Differential Diagnosis: Differentiates traumatic fractures from pathological fractures due to infection (osteomyelitis, discitis) or metastases based on marrow signal, enhancement, and soft tissue findings.

Management Role of MRI in Vertebral Fractures

1. **Surgical Planning**
    - Extent of Injury: Provides high-resolution visualization of bones, ligaments, intervertebral discs, and neural elements for comprehensive assessment.
    - Approach Selection: Guides decision on surgical approach — anterior, posterior, or combined — by showing the exact location and severity of injury.
    - Stability Assessment: MRI evaluation of PLC integrity and vertebral body damage helps determine the need for stabilization (e.g., spinal fusion, instrumentation).

2. **Non-Surgical Management**
    - Treatment Decisions: Demonstrates intact PLC and absence of major canal compromise, supporting conservative treatment with bracing and physiotherapy.
    - Monitoring Healing: Follow-up MRI detects complications such as non-union, persistent marrow oedema, or progressive kyphotic deformity, allowing timely management changes.
3. **Prognostication**
    - Neurological Recovery Prediction: Spinal cord signal changes and degree of compression provide information on potential neurological outcome.
    - Risk of Progression: Identifies patients at higher risk of deformity or instability, guiding preventive and long-term management strategies.

Q6. Enumerate various causes for unilateral painful hip in a 10-year-old child. Discuss the role of imaging in any two pathologies.

Answer

Unilateral Painful Limp in a Child (<10 years)

1. Transient Synovitis

- **Aetiology:** Often post-viral or after minor trauma.
- **Symptoms:** Sudden onset limp, hip pain, usually afebrile.
- **Diagnosis:**
    - Clinical + exclusion of serious pathology.
    - **US:** Hip joint effusion (anechoic or low-level echoes).

2. Legg-Calvé-Perthes Disease

- **Description:** Idiopathic avascular necrosis of femoral head.
- **Symptoms:** Gradual limp, hip or referred knee pain, ↓ ROM (especially abduction, internal rotation).
- **Diagnosis:**
    - **X-ray:** Increased femoral head density → fragmentation → reossification.
    - **MRI:** Early marrow changes before X-ray findings.

3. Slipped Capital Femoral Epiphysis (SCFE)

- **Description:** Posteroinferior displacement of femoral head at physis.
- **Risk Factors:** Rapid growth, obesity, endocrine disorders.
- **Symptoms:** Gradual hip/thigh/knee pain, limp, ↓ internal rotation.
- **Diagnosis:**
    - **X-ray:** Klein's line fails to intersect femoral head.
    - AP + frog-leg lateral essential.

4. Septic Arthritis

- **Description:** Pyogenic infection of hip joint (S. aureus most common).
- **Symptoms:** Acute severe pain, fever, refusal to bear weight.
- **Diagnosis:**
    - **Bloods:** ↑WBC, ESR, CRP.
    - **US:** Joint effusion (urgent aspiration for culture).
    - MRI for early detection if doubt remains.

5. Osteomyelitis

- **Description:** Bone infection, often proximal femur; hematogenous spread common.
- **Symptoms:** Gradual bone pain, fever, localized tenderness/swelling.
- **Diagnosis:**
    - **MRI:** Marrow oedema, periosteal reaction.

    - Blood culture; bone biopsy if needed.

6. Juvenile Idiopathic Arthritis (JIA)

- **Description:** Autoimmune arthritis in children <16 yrs.
- **Symptoms:** Chronic joint pain, swelling, morning stiffness.
- **Diagnosis:**
    - Clinical + exclusion of other causes.
    - **MRI/US:** Synovial thickening, joint effusion.

7. Trauma

- **Description:** Fractures or soft-tissue injury.
- **Symptoms:** Acute pain, tenderness, inability to bear weight.
- **Diagnosis:**
    - **X-ray:** Fracture/dislocation.
    - **MRI:** Occult fracture or soft-tissue injury.

8. Developmental Dysplasia of the Hip (DDH)

- **Description:** Abnormal hip joint development.
- **Symptoms:** Limp, limited abduction, leg length discrepancy.
- **Diagnosis:**
    - **Infants:** US (dynamic + static).
    - **Older child:** X-ray pelvis (Shenton's line disruption, lateral displacement).

Slipped Capital Femoral Epiphysis (SCFE) – Role of Imaging

1. X-ray (First-line, gold standard)

- **Views:**
    - **AP Pelvis**: Detects growth plate widening, irregularity, reduced epiphyseal height, and alignment changes.
    - **Frog-leg Lateral**: Most sensitive for detecting slip; "ice cream slipping off the cone" appearance.
- **Utility:**
    - Confirm diagnosis.
    - Classify severity (mild, moderate, severe slip).
- **Key Points:**
    - Compare both hips.
    - Look for **Klein's line** (on AP view – normally intersects femoral head; misses in SCFE).

2. MRI (Problem-solving / Early detection)

- **When:** X-rays inconclusive, early symptoms (pre-slip), or complications suspected.
- **Findings:**
    - Metaphyseal & physeal **T2 hyperintensity** (marrow oedema).
    - Widened, irregular physis before visible slip.

    - Associated synovitis or cartilage injury.
- **Utility:** Detects “preslip” SCFE before displacement.

3. CT (Rare, surgical planning)
- **When:** Complex slips, 3D planning for osteotomy, or atypical anatomy.
- **Findings:** Precise slip angle, deformity mapping.
- **Caution:** Radiation; not for screening.

4. Ultrasound (Minor role)
- **Findings:** Joint effusion, widened physis.
- **Utility:** Only in very early, MRI-ineligible cases.

Clinical Role of Imaging in SCFE:
- **Diagnosis**: X-ray first, MRI for early/occult cases.
- **Monitoring**: Serial X-rays for progression.
- **Surgical Planning**: CT or MRI for complex slips.
- **Follow-up**: Assess healing, avascular necrosis.

Developmental Dysplasia of the Hip (DDH) – Role of Imaging

1. Ultrasound (First-line in <6 months)
- **Why:** No radiation; femoral head is cartilaginous.
- **Techniques:**
    - **Static** (Graf method): Alpha & beta angles; classify hip maturity.
    - **Dynamic**: Barlow & Ortolani maneuvers for instability.
- **Findings:**
    - Shallow acetabulum, lateral displacement of femoral head.
    - Hip subluxation/dislocation.
- **Utility:** Screening in at-risk infants & confirmation after positive exam.

2. X-ray (>6 months, ossification started)
- **Views:**
    - AP Pelvis (standard).
    - Frog-leg lateral (sometimes supplemental).
- **Measurements & Lines:**
    - **Acetabular index** (↑ in dysplasia).
    - **Hilgenreiner’s line** (horizontal reference).
    - **Perkin’s line** (vertical reference; head should be inferomedial).
    - **Shenton’s line** (smooth arc; broken in dislocation).
- **Findings:** Delayed ossification, high-riding femoral head, shallow acetabulum.

3. MRI
- **When:** Complex cases, pre/post-operative evaluation.
- **Findings:**
    - Cartilage & labrum visualization.

    - Assess reduction success.
- **Utility:** No radiation; excellent for soft tissue anatomy.

4. CT

- **When:** Rare; for post-op position assessment or complex recurrent cases.
- **Findings:**
    - 3D acetabular & femoral head relationship.
    - Accurate post-reduction alignment.
- **Caution:** Radiation.

Clinical Role of Imaging in DDH:

- **Early diagnosis (<6 mo)**: Ultrasound screening in at-risk infants.
- **Confirmation**: US or X-ray depending on age.
- **Pre-op planning**: MRI or CT in complex cases.
- **Post-op follow-up**: MRI (cartilage), CT (bone).

Q7. a) Describe briefly various neurocutaneous syndrome.

b) Describe imaging features of von Hippel Lindau syndrome.

Answer

NEUROCUTANEOUS SYNDROMES

1. Neurofibromatosis Type 1 (NF1)

- Genetics: Autosomal dominant; mutation in the NF1 gene on chromosome 17.

- Clinical Features:

- Café-au-lait Spots: Light brown skin patches.
- Neurofibromas: Benign nerve sheath tumors that can occur anywhere in the body.
- Lisch: Iris hamartomas visible on slit-lamp examination
- Axillary/Groin Freckling: Small freckle-like spots in these areas.
- Skeletal Abnormalities: Scoliosis, pseudoarthrosis, tibial dysplasia.
- Learning Disabilities: Common, with variable severity
- Neurological Complications: Optic gliomas, seizures, and higher risk of certain cancers.

2. Neurofibromatosis Type 2 (NF2)

- Genetics: Autosomal dominant; mutation in the NF2 gene on chromosome 22.

- Clinical Features:

- Bilateral Vestibular Schwannomas: Tumors on the nerves responsible for hearing and balance.
- Meningiomas: Tumors of the meninges (brain and spinal cord covering).
- Ependymomas: Tumors of the ependymal cells lining the ventricles of the brain and the central canal of the spinal cord.
- Cataracts: Early onset posterior subcapsular cataracts.
- Skin Tumors: Less common and fewer than in NF1.

3. Tuberous Sclerosis Complex (TSC)

- Genetics: Autosomal dominant; mutations in TSC1 or TSC2 genes.

- Clinical Features:

- Skin Lesions: Facial angiofibromas, hypomelanotic macules (ash leaf spots), Shagreen patches, periungual fibromas.

- Neurological: Cortical tubers, subependymal nodules, subependymal giant cell astrocytomas (SEGA).
- Seizures: Common and often difficult to control.
- Cognitive Impairments: Ranging from learning disabilities to severe intellectual disability.
- Renal: Angiomyolipomas, cysts, and risk of renal cell carcinoma.
- Cardiac: Rhabdomyomas, which may regress with age.
- Pulmonary: Lymphangioleiomyomatosis (LAM), mainly in women.

4. Sturge-Weber Syndrome

- Genetics: Typically sporadic; associated with somatic mutation in the GNAQ gene.

- Clinical Features:

- Port-Wine Stain: Facial nevus flammeus typically following the distribution of the trigeminal nerve.
- Leptomeningeal Angiomatosis: Vascular malformations affecting the leptomeninges, often unilateral.
- Seizures: Often focal and can be difficult to control.
- Neurological: Hemiparesis, developmental delays, intellectual disability.
- Ocular: Glaucoma, choroidal hemangiomas.

5. Von Hippel-Lindau Disease (VHL)

- Genetics: Autosomal dominant; mutation in the VHL gene on chromosome 3.

- Clinical Features:

- Hemangioblastomas: Highly vascular tumors in the central nervous system, especially the cerebellum, spinal cord, and retina.
- Renal Cell Carcinoma: Increased risk.
- Pheochromocytomas: Tumors of the adrenal glands.
- Pancreatic Cysts and Tumors: Including neuroendocrine tumors.
- Endolymphatic Sac Tumors: Affecting hearing.

6. Ataxia-Telangiectasia (A-T)

- Genetics: Autosomal recessive; mutation in the ATM gene.

- Clinical Features:

- Neurological: Progressive cerebellar ataxia, oculomotor apraxia.
- Telangiectasias: Dilated blood vessels, especially in the eyes and skin.
- Immunodeficiency: Recurrent infections due to low levels of immunoglobulins.
- Increased Cancer Risk: Particularly lymphomas and leukemias.

- Endocrine: Premature aging, insulin resistance.

IMAGING FEATURES OF VON HIPPE LINDAU SYNDROME

Central Nervous System (CNS)

1. Hemangioblastomas:

- Location: Commonly found in the cerebellum, brainstem, spinal cord, and retina.

- MRI:

- T1-Weighted Images: Typically iso- to hypointense.
- T2-Weighted Images: Hyperintense.
- Post-Contrast: Strong, homogeneous enhancement of the solid component, often with an associated cystic component.

- CT Scan:

- Without Contrast: Hypodense or isodense.
- With Contrast: Marked enhancement.
- Angiography: Highly vascular tumors with prominent feeding vessels.

Retina

1. Retinal Hemangioblastomas:

- Fluorescein Angiography: Early hyperfluorescence and late leakage.

- OCT (Optical Coherence Tomography: Demonstrates the presence of retinal tumors and associated macular oedema.

Abdominal Organs

Kidneys

- Renal Cell Carcinoma (RCC):

- CT Scan:

  - Without Contrast: Hypodense or isodense mass.
  - With Contrast: Enhancing mass with possible necrotic or cystic areas.

- MRI:

  - T1-Weighted Images: Hypointense.
  - T2-Weighted Images: Hyperintense.
  - Post-Contrast: Strong enhancement.

- Ultrasound: Hypoechoic or mixed echogenicity masses.

- Renal Cysts:

- CT Scan: Well-defined, non-enhancing, water-density lesions.

- MRI: Hyperintense on T2-weighted images and hypointense on T1-weighted images, with no enhancement post-contrast.

Pancreas

- Pancreatic Cysts:

- CT Scan: Well-defined, low-attenuation lesions without enhancement.

- MRI: Hyperintense on T2-weighted images, hypointense on T1-weighted images.

- Pancreatic Neuroendocrine Tumors:

- CT Scan:

  - Without Contrast: Hypodense or isodense.
  - With Contrast: Hyperenhancing during the arterial phase.

- MRI:

  - T1-Weighted Images: Hypointense.
  - T2-Weighted Images: Hyperintense.
  - Post-Contrast: Early arterial phase enhancement.

Adrenal Glands

1. Pheochromocytomas:

- CT Scan:

  - Without Contrast: Well-circumscribed, homogeneous or heterogeneous lesions, often hypodense.
  - With Contrast: Intense enhancement.

- MRI:

  - T1-Weighted Images: Hypointense or isointense.
  - T2-Weighted Images: Hyperintense ("light bulb sign").
  - Post-Contrast: Intense enhancement.

- MIBG Scan: Increased uptake in pheochromocytomas.

Liver

1. Liver Hemangiomas:

- CT Scan:
    - Without Contrast: Hypodense.
    - With Contrast: Peripheral nodular enhancement with centripetal fill-in.
- MRI:
    - T1-Weighted Images: Hypointense.
    - T2-Weighted Images: Hyperintense.
    - Post-Contrast: Peripheral nodular enhancement with gradual fill-in.

Ear

1. Endolymphatic Sac Tumors:

- CT Scan: Bone erosion around the endolymphatic sac.
- MRI:
    - T1-Weighted Images: Isointense or slightly hyperintense.
    - T2-Weighted Images: Hyperintense.
    - Post-Contrast: Intense enhancement.

Q8. Discuss the role of HRCT and MRI in the evaluation of congenital sensorineural hearing loss.

Answer

Imaging plays a critical role in the **preoperative, intraoperative**, and **postoperative** stages of cochlear implantation. It guides **surgical planning**, helps avoid **complications**, and ensures **proper electrode placement**.

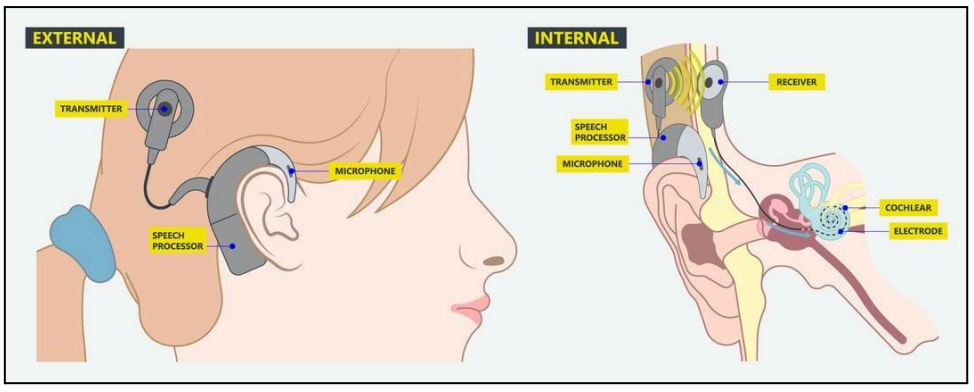
Preoperative Imaging

Preoperative imaging serves four key goals:

- Assess anatomical feasibility
- Detect contraindications
- Guide surgical approach
- Predict prognosis

Components of cochlear implant

Component	**Part**	**Location**	**Modality for Imaging**
External (worn externally)	**Microphone** + Speech Processor + Transmitting Coil	Behind ear, skin surface	Not seen on CT/MRI
Internal (implanted)	Receiver-Stimulator (electronics + magnet)	**Embedded in temporal bone**, subperiosteally on skull (usually above mastoid)	CT/MRI: **Visible**
	Electrode Array	**Inserted via round window** or cochleostomy → spirals through **scala tympani** of **cochlea**	CT: high-res axial/coronal MRI: limited due to artifacts (unless MRI-safe implant)



1. External Ear
To assess for congenital atresia, microtia, etc.

2. Middle Ear
Middle Ear Aeration

- **Opacification on CT** does **not contraindicate** cochlear implantation.
- If signs of **active otitis media** are present → **pre-op medical optimization** is recommended.

Mastoid Pneumatization

- HRCT helps assess **extent and pattern**:
    - **Cellular**: Well-aerated; favorable for cortical mastoidectomy.
    - **Sclerotic**: May be inflammatory or developmental; technically challenging.
    - **Hypocellular**: May limit facial recess access; alternate approach may be needed.
- Poor pneumatization → limits facial recess approach and may increase surgery time.

Round Window Niche

- **Preferred electrode insertion site**.
- HRCT evaluates **patency and ossification**:
    - **Stenosis/Ossification**: Seen in otosclerosis, Paget's, post-meningitic cases.
    - May need **cochleostomy** or **modified electrode** design.

3. Facial Nerve Canal
Facial Nerve Canal Anatomy

- Assessed on **axial and coronal HRCT**.
- Look for:
    - **Dehiscence** of tympanic or mastoid segments.
    - **Aberrant course**: e.g., anteriorly displaced facial nerve.
- Importance: Prevent injury during **facial recess approach** or **cochleostomy**.

4. Inner Ear
Inner Ear Malformations

Malformation	**HRCT/MRI Findings**	**Implant Feasibility**
Michel Aplasia	Absence of cochlea, vestibule, SCC	Contraindicated
Common Cavity	Cystic cavity; narrow IAC	Contraindicated
Incomplete Partition I	"Figure of 8" cochlea without modiolus	Contraindicated

Incomplete Partition II (Mondini)	1.5 turns, dilated apex, enlarged vestibule	Acceptable; ↑ CSF gusher risk
Incomplete Partition III	No modiolus; wide IAC; FN proximity	Allowed with precautions
Cochlear Hypoplasia	Small cochlea, possibly reduced nerve	Possible; variable outcome
Labyrinthitis Ossificans	Cochlear ossification post-meningitis	Depends on stage
Absent Cochlear Nerve	IAC < 2 mm, no nerve on MRI; modiolus < 3 mm	Contraindicated

5. Cochlear Parameters

Parameter	**Clinical Implication**
Number of Turns	Fewer turns → fewer electrodes → poorer outcome
Modiolus Thickness	<3 mm suggests **cochlear nerve deficiency**
Scala Symmetry	Helps predict **electrode alignment**
Early Ossification	MRI better than CT; may need **double-array electrodes**

Vascular Variants (Important in Surgical Access)

Anomaly	**Imaging Finding**	**Surgical Risk**
High-riding Jugular Bulb	Above hypotympanum floor, may be dehiscent	Risk of brisk bleeding
Dehiscent Carotid Canal	Thin/absent bone between cochlea and carotid	Avoid drilling near promontory
Low-lying Dura	Close to aditus/antrum roof	May restrict mastoidectomy

Intraoperative Imaging

Purpose: Confirm electrode insertion depth and configuration, particularly in:

- **Malformed cochleae**
- **Unusual surgical approaches**

Modality	**Utility**
Plain X-ray	Quick intra-op check (limited resolution)
Intra-op CT/CBCT	Real-time 3D confirmation

Ensures electrode enters **scala tympani** and avoids **tip fold-over**.

Postoperative Imaging

Goals:

- Verify **electrode trajectory** and cochlear coverage
- Evaluate **implant complications**
- Confirm integrity of **extracochlear components**

Preferred Modality: HRCT

What to Assess	Normal Finding	Abnormalities
Electrode position	Curvilinear track along cochlear turns	Tip fold-over, extracochlear placement, misdirection
Cochleostomy site	Electrode at round window or cochleostomy	Dislocation
Reference electrode	Seen adjacent to cochlea	Malposition or migration
Internal magnet	Normal location in skull behind auricle	Displacement (MRI-related or traumatic)

When MRI Is Used

- **With magnet-safe models only**
- For evaluating **infection, nerve irritation, or fibrosis**
- Caution: **Magnet heating or displacement** if device not MRI-compatible

Imaging-Based Contraindications to Cochlear Implantation

Category	Finding	Imaging Modality	Implication
Cochlear Aplasia / Michel Aplasia	Complete absence of cochlea, vestibule, SCCs	HRCT	**Absolute** contraindication – no electrode insertion possible
Common Cavity	Single undifferentiated cystic cavity; no modiolus or turns	HRCT	**Absolute** or high-risk; no true scala; high CSF leak risk
Absent Cochlear Nerve	Absent nerve in IAC; IAC < 2 mm, Modiolus < 3 mm	**MRI (CISS/FIESTA)** HRCT (indirect)	**Absolute** – No neural target to stimulate
Incomplete Partition Type I	Cystic cochlea with no modiolus; dilated vestibule	HRCT	High risk of **CSF gusher**; technically possible but guarded outcome

Labyrinthitis Ossificans	Ossification/fibrosis of cochlea (esp. basal turn)	HRCT / MRI	May preclude electrode insertion; early stage may allow partial
Cochlear Hypoplasia	Small cochlea with <2 turns; narrow modiolus	HRCT	Feasible with special electrode, but outcomes vary
Incomplete Partition Type III	Modiolus absent, wide IAC; facial nerve proximity	HRCT	Implantable with caution; high CSF gusher & FN stimulation risk
Internal Auditory Canal Aplasia	Absent IAC	HRCT + MRI	Suggests absent CN VIII – **Absolute contraindication**

Q9. Discuss basic principles of MR Spectroscopy. Discuss in brief, role of MR Spectroscopy in the evaluation of various brain pathologies.

Answer

MRS is a *noninvasive* molecular imaging technique that detects and quantifies tissue metabolites based on **chemical shift** properties of atomic nuclei.

- **Key Points**:
    - Complements MRI by providing **biochemical** rather than just **anatomical** information.
    - Detects **early metabolic changes** before structural changes appear.
    - Particularly useful in **brain**, **muscle**, and **prostate** imaging.

Principle of MRS

MRI	**MRS**
Uses differences in **proton density, T1, T2** for image formation.	Uses **chemical shift differences** between nuclei to generate a **spectrum**.

- **Chemical Shift**:
  Variation in resonant frequency of nuclei based on their molecular environment, measured in **parts per million (ppm)**.
- **Key Nuclei** (must have odd number of protons/neutrons):

Nucleus	**Resonance at 1.5T (MHz)**	**Clinical Use**
^{1}H	63.9	Most common (brain, muscle)
^{31}P	25.9	Energy metabolism
^{19}F	60.1	Research (CSF flow, tumors)
^{23}Na	16.9	Research (stroke, cartilage imaging)

MR Spectrum Interpretation

- **Horizontal axis**: Resonance frequency shift (ppm)
- **Vertical axis**: Relative signal intensity (concentration of metabolite)

Important Features to Analyze:

- Center of peak (chemical identity)
- Peak height (relative concentration)
- Line width (field homogeneity, T2 relaxation)
- Peak shape (singlet, doublet, triplet due to J-coupling)

Upfield (right) = **Lower frequency** (shielded protons)
Downfield (left) = **Higher frequency** (deshielded protons)

Common Metabolites Detected (^{1}H MRS)

Metabolite	Chemical Shift (ppm)	Key Clinical Relevance
N-acetylaspartate (NAA)	2.0	Neuronal marker (↓ in tumors, MS, infarcts)
Choline (Cho)	3.2	Cell membrane turnover (↑ in tumors, demyelination)
Creatine (Cr)	3.0	Energy metabolism (stable reference)
Lactate (Lac)	1.3	Anaerobic metabolism (↑ in ischemia, tumors, abscess)
Myoinositol (mI)	3.5	Glial marker (↑ in gliosis, Alzheimer's)
Glutamate-Glutamine (Glx)	2.1–2.6	Excitatory neurotransmitters

Sequences and Localization

Technique	Features
SVS (Single Voxel Spectroscopy)	One voxel; better SNR; simple; faster
MRSI/CSI (Chemical Shift Imaging)	Multivoxel; spatial metabolite maps; longer time
PRESS (Point RESolved Spectroscopy)	Common SVS method; high SNR
STEAM (STimulated Echo Acquisition Mode)	Short TE possible; 50% signal loss
ISIS (Image-Selected In Vivo Spectroscopy)	Used in short T2 nuclei (^{31}P, ^{23}Na)

- **Water suppression** critical (CHESS pulses, inversion recovery).
- **Outer volume suppression** for avoiding lipid contamination.

Clinical Applications of MRS

Area	Application
Brain tumors	Differentiate tumor vs abscess vs radiation necrosis
Epilepsy	Lateralization of mesial temporal lobe epilepsy
Demyelination	MS plaques (↑Cho, ↓NAA), NAWM changes
Pediatric brain	Canavan's (↑NAA), mitochondrial disorders (↑Lactate)
Trauma	Diffuse axonal injury (↓NAA/Cr ratio)
Stroke	Acute infarcts (↑Lactate, ↓NAA)
Psychiatry	Metabolic changes in schizophrenia, bipolar disorder
HIV/AIDS	Differentiate lymphoma from toxoplasmosis

Examples: Specific Findings

Pathology	Key Spectroscopy Pattern
Glioblastoma	↑ Cho, ↓ NAA, lipid-lactate peaks
Pyogenic abscess	Amino acids, lactate, acetate, succinate
Tubercular abscess	Predominantly lipid, lactate
Meningioma	Alanine peak at 1.48 ppm
IDH-mutant glioma	2-hydroxyglutarate peak at 2.25 ppm
Alzheimer's disease	↓ NAA, ↑ Myoinositol

Artifacts in MRS

Artifact	Cause	Remedy
Field inhomogeneity	Shimming issues, metal implants	Re-shimming, voxel reposition
Inadequate water/lipid suppression	Poor pulse calibration	CHESS, better positioning
Motion	Patient movement	Head fixation
Voxel bleeding	Imperfect voxel selection	Outer volume suppression

Fast MRS Techniques

Method	Principle
SENSE, GRAPPA	Parallel imaging, faster acquisition
EPSI	Echo planar spectroscopic imaging
Spiral MRSI	Spiral k-space trajectory, fast, good SNR
Turbo MRSI	Multiple spin echoes to accelerate acquisition

Future Directions

- 3T and higher field MRS (better SNR, resolution).
- Whole brain fast MRSI (for neurodegenerative diseases).
- Spectroscopic contrast agents (e.g., gadofluoride).
- Standardized, automated protocols for clinical use.

Q 10. A 14-year-old male presented with fever, pain and swelling of right proximal arm.

a) What are the various differential diagnosis?

b) Discuss in brief, role of imaging in the evaluation of such a case.

Answer

1. Osteomyelitis

- Description: An infection and inflammation of the bone.

- Clinical Features: Fever, localized pain, swelling, warmth, and sometimes redness over the affected area.

- Diagnosis: Elevated white blood cell count, ESR, CRP, blood cultures, and imaging (X-ray, MRI, or bone scan).

2. Septic Arthritis

- Description: Infection within a joint, commonly bacterial.

- Clinical Features: Severe pain, fever, swelling, and limited range of motion in the affected joint.

- Diagnosis: Joint aspiration and analysis, blood cultures, elevated inflammatory markers, and imaging.

3. Cellulitis

- Description: A bacterial skin infection that can extend to deeper tissues.

- Clinical Features: Red, swollen, warm, and tender skin. Fever and lymphangitis (red streaks) may also be present.

- Diagnosis: Clinical examination, blood cultures, and possibly ultrasound to check for abscess formation.

4. Pyomyositis

- Description: A bacterial infection of the skeletal muscles, often caused by Staphylococcus aureus.

- Clinical Features: Localized muscle pain, swelling, tenderness, and fever.

- Diagnosis: MRI, ultrasound, blood cultures, and elevated inflammatory markers.

5. Ewing's Sarcoma

- Description: A malignant bone tumor commonly affecting adolescents.

- Clinical Features: Pain and swelling at the site of the tumor, fever, and sometimes a palpable mass.

- Diagnosis: Imaging (X-ray showing a characteristic "onion-skin" appearance, MRI, CT), biopsy, and bone scan.

6. Osteosarcoma

- Description: A primary malignant bone tumor typically occurring in children and adolescents.

- Clinical Features: Progressive pain, swelling, and sometimes a palpable mass. Fever is less common but may occur.

- Diagnosis: X-ray (showing a "sunburst" pattern), MRI, CT, biopsy, and bone scan.

7. Rhabdomyosarcoma

- Description: A malignant tumor of skeletal muscle origin, more common in children.

- Clinical Features: Pain, swelling, and sometimes fever, depending on the location.

- Diagnosis: Imaging (MRI or CT), biopsy, and possibly PET scan.

8. Leukemia

- Description: A malignancy of the blood and bone marrow.

- Clinical Features: Bone pain, fever, fatigue, pallor, and other signs of bone marrow suppression (anemia, thrombocytopenia).

- Diagnosis: Complete blood count (CBC), bone marrow biopsy, and imaging if localized pain is present.

9. Trauma / Fracture

- Description: Injury to the bone or surrounding tissues.

- Clinical Features: History of trauma, localized pain, swelling, and sometimes deformity.

- Diagnosis: X-ray, CT scan for complex fractures.

10. Juvenile Idiopathic Arthritis (JIA)

- Description: An autoimmune disorder causing inflammation of the joints.

- Clinical Features: Joint pain, swelling, stiffness, fever, and fatigue.

- Diagnosis: Clinical examination, blood tests (RF, ANA), and imaging (ultrasound, MRI)

11. Bursitis

- Description: Inflammation of a bursa (a small fluid-filled sac near joints).

- Clinical Features: Localized swelling, pain, and reduced movement in the affected area.

- Diagnosis: Clinical examination, ultrasound, and MRI if needed.

12. Reactive Arthritis

- Description: Arthritis that develops in response to an infection elsewhere in the body.

- Clinical Features: Joint pain and swelling, often accompanied by other systemic symptoms such as fever.

- Diagnosis: Clinical examination, blood tests, and imaging if necessary.

ROLE OF IMAGING

1. X-ray

- Purpose: The first-line imaging tool used to assess bone structure and integrity. X-rays can quickly identify fractures, bone lesions, or abnormal growths.

- Utility: Helps rule out or confirm fractures, detect bone tumors (like osteosarcoma and Ewing's sarcoma), or show signs of osteomyelitis (such as periosteal reactions and bone destruction).

2. Ultrasound

- Purpose: Utilized to evaluate soft tissues, muscles, and smaller structures not well visualized on X-rays.

- Utility: Useful for detecting soft tissue abnormalities such as cellulitis, abscesses, pyomyositis, or muscle tears. It can also guide diagnostic procedures like aspiration or biopsy.

3. Magnetic Resonance Imaging (MRI)

- Purpose: Provides detailed images of bone and soft tissue, including marrow.

- Utility: Excellent for diagnosing osteomyelitis, which might show bone marrow oedema before changes are visible on X-rays. MRI is invaluable for evaluating bone tumors, soft tissue tumors (like rhabdomyosarcoma), and differentiating between benign and malignant lesions. It also helps in assessing joint diseases such as septic arthritis or juvenile idiopathic arthritis.

4. Computed Tomography (CT) Scan

- Purpose: Offers detailed images of bone and can provide finer details than an X-ray.

- Utility: Particularly useful when complex bone structures are involved or when precise details about bone destruction or tumor extension are needed. CT can be superior for evaluating complex fractures or in surgical planning.

5. Bone Scan

- Purpose: A nuclear imaging method that helps detect bone metabolism and blood flow.

- Utility: Useful in detecting osteomyelitis, metastatic bone disease, or primary bone tumors over the whole body, indicating active bone processes that might not yet be visible on X-rays.

6. Positron Emission Tomography (PET) Scan

- Purpose: Combined with CT (PET/CT), this provides metabolic and anatomical details.

- Utility: Useful for identifying malignant tumors and their metastases, differentiating between benign and malignant lesions, and sometimes for infection.
