Imaging in the Hospital Setting

Definition and Epidemiology

Imaging in the hospital setting involves diagnostic modalities (e.g., CT, MRI, ultrasound, X-ray) to evaluate acute and complex conditions, guiding diagnosis and management. This document covers protocols for suspected stroke, pulmonary embolism (PE), bleeding, gallbladder/liver issues, pulmonary conditions (including ILD and parapneumonic effusions), necrotizing fasciitis, osteomyelitis, acute limb ischemia, peripheral artery disease (PAD), and other emergencies (e.g., aortic dissection, appendicitis, renal stones).

Prevalence Imaging is used in ~50-70% of hospital admissions, with CT comprising 60% of studies, MRI 20%, ultrasound 15%, and X-ray 5%. Stroke and trauma account for 30% of emergent imaging; PE, abdominal, and pulmonary issues each ~15%.

Risk Factors Acute symptoms (e.g., chest pain, neuro deficits), trauma, infection, comorbidities (e.g., diabetes, CKD). Contrast risks include AKI (CIN, 5-10% in CKD) and anaphylaxis (<0.1%).

Rare Demographics Pediatric imaging (e.g., congenital anomalies), pregnancy (radiation concerns), contrast allergies requiring alternative protocols.

Pathophysiology

Mechanisms Imaging modalities exploit tissue properties: X-ray/CT use radiation attenuation, MRI uses proton magnetic resonance, ultrasound uses sound wave reflection. Contrast (iodinated for CT, gadolinium for MRI) enhances vascular or tissue differences. Stroke imaging detects ischemia (CT/MRI perfusion), PE uses CT pulmonary angiography (CTPA) for emboli, and infections (e.g., SEA) show enhancement on MRI. Non-contrast CT chest visualizes ILD fibrosis or effusions; MRCP highlights biliary ductal pathology. Doppler ultrasound and CTA assess limb ischemia/PAD vascular occlusion.

Effects Imaging identifies structural (e.g., hematoma), vascular (e.g., PE, limb ischemia), or infectious (e.g., osteomyelitis) pathology, guiding intervention. Radiation risks DNA damage; contrast may cause AKI or allergic reactions.

Molecular Pathways CT contrast: Iodinated agents increase X-ray attenuation via electron density. MRI: Gadolinium shortens T1 relaxation. Ultrasound: Piezoelectric crystals generate sound waves. MRCP: T2-weighted imaging enhances bile fluid signal.

Key Pathway Imaging modality → Tissue interaction (radiation, magnetic, sound) → Visualization of pathology → Diagnostic and therapeutic guidance.

Indications and Imaging Modalities

Condition	Preferred Study	Contrast	Indications	Notes
Suspected Stroke	CT Head non-contrast (CTH NC)	No	Acute neuro deficits, suspected ischemic/ hemorrhagic stroke	Sensitivity 90% for hemorrhage, 60% for ischemia; rapid (<5 min)
Acute Stroke Protocol	CT Perfusion + CTA Head/ Neck	Yes (iodinated)	Ischemic stroke within 4.5-24h, thrombolysis/ endovascular candidate	Detects penumbra, large vessel occlusion; MRI alternative if time permits
Pulmonary Embolism	CT Pulmonary Angiography (CTPA)	Yes	Chest pain, dyspnea, high Wells score	Sensitivity 95%, D-dimer >500 ng/mL; V/Q scan if contrast allergy
Pulmonary Issues (Non-PE)	CXR, CT Chest non-contrast (NCCT)	No	Dyspnea, cough, suspected pneumonia, ILD, parapneumonic effusion	CXR first-line; NCCT for ILD (fibrosis), effusions; CTPA only if PE suspected
Intracranial Bleed	CTH NC	No	Trauma, headache, AMS, suspected ICH/ SAH	Detects ICH, SAH; CTA if aneurysm suspected
GI Bleed	CT Abdomen/ Pelvis with contrast	Yes	Hematemesis, melena, hemodynamic instability	Identifies active bleeding; tagged RBC scan if CT negative
Gallbladder Issues	Ultrasound RUQ, MRCP	No	RUQ pain, fever, Murphy's sign, suspected ductal pathology	US sensitivity 95% for cholelithiasis, 80% for cholecystitis; MRCP for choledocholithiasis, strictures
Liver Issues	CT Abdomen triphasic	Yes	Jaundice, elevated LFTs, suspected mass	Arterial/portal/venous phases for HCC, cirrhosis; MRI if indeterminate
Necrotizing Fasciitis	CT Soft Tissue with contrast	Yes	Severe pain, crepitus, fever, skin changes	Gas in tissues, fascial enhancement; MRI if equivocal
Osteomyelitis	MRI Spine/ Extremity with contrast	Yes (gadolinium)	Bone pain, fever, ESR/CRP elevation	Sensitivity 95% for marrow edema; CT if MRI contraindicated
Aortic Dissection	CTA Chest/ Abdomen	Yes	Tearing chest pain, pulse deficit	Sensitivity 98%; TEE if unstable

Condition	Preferred Study	Contrast	Indications	Notes
Appendicitis	CT Abdomen/ Pelvis with contrast	Yes	RLQ pain, fever, McBurney's tenderness	Sensitivity 95%; ultrasound in pregnancy/pediatrics
Renal Stones	CT Abdomen non-contrast	No	Flank pain, hematuria	Sensitivity 98%; ultrasound if radiation concern
Spinal Epidural Abscess	MRI Spine with contrast	Yes	Back pain, fever, neuro deficits	Sensitivity 95%; CT myelography if MRI unavailable
Acute Limb Ischemia	CTA Lower Extremity, Doppler US	Yes (CTA)	Sudden limb pain, pallor, pulselessness	CTA sensitivity 95% for occlusion; Doppler for initial assessment
Peripheral Artery Disease	Doppler US, CTA Lower Extremity	Yes (CTA)	Claudication, non-healing ulcers, ABI <0.9	Doppler for stenosis; CTA for surgical planning

Clinical Presentation

- Symptoms
  - **Stroke** Sudden weakness, aphasia, vision loss
  - **PE** Dyspnea, chest pain, syncope
  - **Pulmonary Issues** Cough, hypoxia, hemoptysis, pleuritic pain
  - **Bleeding** Headache (ICH), hematemesis (GI), hypotension
  - **Gallbladder/Liver** RUQ pain, jaundice, fever
  - **Nec Fash** Severe pain, skin necrosis, sepsis
  - **Osteomyelitis** Bone pain, swelling, fever
  - **Acute Limb Ischemia** Sudden pain, paresthesia, pulselessness
  - **PAD** Claudication, rest pain, ulcers
  - **Rare** Seizures (ICH), dysphagia (esophageal rupture), limb paralysis (ischemia)

Exam

- **Stroke** Hemiparesis, facial droop, dysarthria
- **PE** Tachycardia, hypoxia, JVD
- **Pulmonary** Crackles, wheezes, dullness (effusion)
- **Bleeding** Pallor, tachycardia, AMS
- **Gallbladder** Murphy's sign, scleral icterus
- **Nec Fash** Crepitus, bullae, erythema
- **Osteomyelitis** Tenderness, erythema, sinus tract
- **Limb Ischemia** Pallor, cold limb, absent pulses
- **PAD** Diminished pulses, skin atrophy, hair loss

- **Rare** Horner's (dissection), paraplegia (SEA), RLQ guarding (appendicitis)

Red Flags

SBP <90 mmHg, SpO2 <90%, neuro deficits, temp >40°C, pulseless limb

Labs and Studies

Labs

- CBC Anemia (GI bleed), leukocytosis (infection)
- CMP Cr >1.5 mg/dL (CIN risk), LFTs (liver), lipase (pancreatitis)
- Coagulation INR >1.5 (bleeding risk), D-dimer (PE)
- Advanced
    - Lactate (sepsis, nec fash), troponin (MI mimic), BUN/Cr (GI bleed)

Other Studies

- **Stroke** NIHSS score, CTP metrics (CBF, CBV)
- **PE** Wells score, V/Q scan (contrast allergy)
- **Pulmonary** Sputum culture, thoracentesis (effusion)
- **Bleeding** Endoscopy (GI), angiogram (active bleed)
- **Gallbladder** HIDA scan (acalculous cholecystitis), MRCP (ductal obstruction)
- **Nec Fash** LRINEC score, surgical exploration
- **Osteomyelitis** Bone biopsy, ESR/CRP
- **Limb Ischemia/PAD** Ankle-brachial index (ABI), arterial Doppler
- **Advanced**
    - **TOF-MRA (stroke, no contrast), elastography (liver fibrosis)**

Diagnosis

Criteria

Imaging-based diagnosis: CTH NC for stroke/bleed, CTPA for PE, NCCT chest for ILD/effusions, ultrasound/MRCP for gallbladder, MRI for osteomyelitis/SEA, CTA/Doppler for limb ischemia/PAD. Protocols vary by urgency, contrast tolerance, and radiation risk.

Differential

Stroke (seizure, hypoglycemia), PE (MI, pneumothorax), pulmonary (CHF, COPD), bleed (tumor, abscess), gallbladder (pancreatitis), nec fash (cellulitis), osteomyelitis (fracture), limb ischemia (DVT, neuropathy).

Flowsheet

Step 1 History/Exam Identify symptoms, vitals, risk factors (trauma, CKD)

Step 2 Labs CBC, CMP, D-dimer, INR; guide imaging choice

Step 3 Imaging Select modality (table above), contrast based on Cr, allergy

Step 4 Interpret Findings Correlate with clinical (e.g., CTPA emboli, MRCP stone)

Step 5 Confirm Differential Additional studies (e.g., biopsy, endoscopy)

Treatment

General Principles

Use imaging to guide intervention (surgery, anticoagulation, antibiotics), minimize radiation/contrast risks, and monitor complications.

Supportive Care

- IV Fluids NS 500 mL bolus (hypotension), pre-hydration for CIN
- Allergy Prophylaxis if iodine allergy: Prednisone 50 mg PO 13h/7h/1h pre-contrast, diphenhydramine 50 mg IV
- Monitoring Cr q24h post-contrast, vitals q4h

Specific Therapies

- **Stroke** tPA (CTH NC clear, <4.5h), thrombectomy (CTA occlusion)
- **PE** Heparin 80 units/kg IV bolus, CTPA-confirmed
- **Pulmonary** Antibiotics (CXR/NCCT pneumonia), drainage (effusion)
- **Bleeding** Embolization (CT active bleed), PCC (INR >1.5)
- **Gallbladder** Cholecystectomy (US cholecystitis), ERCP (MRCP stone)
- **Nec Fash** Debridement (CT gas), antibiotics (vancomycin)
- **Osteomyelitis** Surgery (MRI abscess), antibiotics (nafcillin)
- **Limb Ischemia** Embolectomy (CTA thrombus), heparin
- **PAD** Revascularization (CTA stenosis), cilostazol 100 mg PO BID

- **Advanced**
  - **Stenting (CTA dissection), lithotripsy (CT stones), ablation (CT liver HCC)**

Monitoring

- Repeat imaging (e.g., CTH 24h post-tPA, NCCT chest post-drainage)
- Daily Cr, CBC (post-contrast, infection)
- Consults (e.g., neurosurgery, vascular surgery, IR)

Complications

Acute

- Contrast-Induced Nephropathy Cr rise >0.5 mg/dL (5-10% in CKD)
- Anaphylaxis Hypotension, bronchospasm (<0.1%)
- Radiation Exposure Cancer risk (CT ~5-10 mSv, <0.1% lifetime risk)

Long-Term

- CKD CIN progression to dialysis (1-2% high-risk)
- False Positives/Negatives Unnecessary procedures (e.g., CT appendicitis)
- Rare
  - Contrast extravasation, MRI gadolinium retention, claustrophobia

Clinical Scenarios

Case 1 Acute Stroke

- **Presentation**: 65 y/o M with sudden left hemiparesis, dysarthria. Vitals BP 160/90, HR 80, SpO2 96%, RR 16. Exam NIHSS 12, facial droop.
- **Labs/Studies**: CTH NC No hemorrhage, CTA MCA occlusion, CTP Penumbra present.
- **Interpretation**: Ischemic stroke, large vessel occlusion.
- **Management** tPA 0.9 mg/kg IV, thrombectomy. Repeat CTH 24h. Neuro ICU. Recovery by week 2.

Case 2 Pulmonary Effusion

- **Presentation**: 55 y/o F with dyspnea, fever post-pneumonia. Vitals BP 120/80, HR 95, SpO2 92%, RR 20. Exam Dullness to percussion, reduced breath sounds.
- **Labs/Studies** WBC 14K, D-dimer 300 ng/mL. NCCT Chest Parapneumonic effusion, no PE.

- **Interpretation** Complicated effusion, non-PE pulmonary issue.
- **Management**: Thoracentesis, ceftriaxone 2 g IV q24h. Repeat NCCT day 3. Effusion resolves by week 1.

Case 3 Gallbladder Obstruction

- **Presentation**: 45 y/o M with RUQ pain, jaundice. Vitals BP 130/80, HR 90, SpO2 98%, RR 16. Exam Murphy's sign, scleral icterus.
- **Labs/Studies**: LFTs Bilirubin 4 mg/dL, ALP 200 U/L. US Cholelithiasis, MRCP Common bile duct stone.
- **Interpretation**: Choledocholithiasis, obstructive jaundice.
- **Management:** ERCP, cholecystectomy. Monitor LFTs. Discharge day 5, stable.

Case 4 Acute Limb Ischemia

- **Presentation:** 70 y/o M with sudden leg pain, pallor. Vitals BP 140/80, HR 100, SpO2 96%, RR 18. Exam Cold, pulseless right leg.
- **Labs/Studies**: Cr 1.0 mg/dL, lactate 3 mmol/L. CTA Femoral artery thrombus.
- **Interpretation** Acute limb ischemia, arterial occlusion.
- **Management**: Heparin 80 units/kg IV, embolectomy. Vascular consult. Limb salvaged by day 3.

Expert Tips

- Use CTH NC first for stroke; CTA/CTP only if thrombolysis candidate
- Order NCCT chest for ILD, effusions; CTPA only if PE likely (Wells >4)
- Use MRCP for biliary obstruction; US first for gallbladder stones
- Doppler US for initial limb ischemia/PAD; CTA for surgical planning
- Pre-hydrate (NS 1 L) for Cr >1.5 to prevent CIN; avoid contrast in GFR <30
- Pitfalls
    - Missing SAH on CTH NC; LP if high suspicion, CT negative
- Advanced
    - TOF-MRA for stroke (no contrast), MRCP with secretin (pancreatic ducts)

Key Pearls

- CTH NC for stroke, bleed; CTPA for PE; NCCT chest for ILD/effusions
- US/MRCP for gallbladder; CTA/Doppler for limb ischemia/PAD
- Contrast enhances CT/MRI; avoid in Cr >1.5, allergies without prophylaxis
- MRI with contrast for osteomyelitis/SEA; CT for nec fash (gas)
- Radiation, CIN, anaphylaxis are risks; tailor imaging to patient factors

References

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