Radiology Techniques Department

Special Radiological Procedure

Ascending Aortography & Lower Limb Arteriography

Lecture 4

د. حيدر سعيد شندل
M.B.CH.B MSC. RAD. (ASU)

Ascending Aortography

Ascending aortography is a contrast-enhanced fluoroscopic study of the **ascending aorta** used to evaluate its anatomy and pathology.

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Indications

- Suspected **aortic aneurysm**
- **Aortic dissection**
- **Aortic valve disease** (e.g., regurgitation)
- Congenital anomalies (e.g., coarctation, though better seen in arch (
- Preoperative assessment (cardiac or aortic surgery)

Technique

- **Access**: (Femoral artery)
- **Catheter**: Pigtail catheter (preferred to reduce jet effect)
- **Position :**ascending aorta
- **Contrast injection**:
- High flow (20-30 mL/sec)
- Total volume –30-50 mL
- **Imagin ::** Fluoroscopy with cine acquisition

Normal Findings

- Smooth contour of ascending aorta
- Normal diameter
- Symmetric contrast opacification

Pathological Findings

- **Aneurysm**: localized or diffuse dilation
- **Dissection**: intimal flap, double lumen
- **Aortic regurgitation**: reflux of contrast into LV

Complications

- Arrhythmias (catheter irritation near aortic valve)
- Contrast reaction
- Embolization
- Vascular access complications

Lower Limb Arteriography

- Imaging of arterial supply of the lower extremities using contrast injection.

Indications

- **Peripheral arterial disease (PAD)**
- Claudication or critical limb ischemia
- Trauma
- Preoperative planning (bypass, angioplasty)
- Diabetic vascular assessment

Technique

Access:

Common femoral artery (ipsilateral or contralateral crossover)

Catheter placement:

Aorta → Iliac → Femoral → Popliteal → Tibial arteries

Contrast injection: Stepwise or bolus with runoff study

Imaging: Digital subtraction angiography (DSA)

Phases of Study

- Aortoiliac phase
- Femoropopliteal phase
- Infrapopliteal (tibial) phase

Normal Findings

- Smooth arterial walls
- Gradual tapering distally
- Good distal runoff (3-vessel supply to foot)

Pathological Findings

- **Stenosis**: focal narrowing
- **Occlusion**: complete blockage
- **Collateral circulation**: indicates chronic disease
- **Atherosclerosis**: irregular lumen
- **Diabetic changes**: distal vessel disease

Complications

- Hematoma at puncture site
- Arterial dissection
- Thrombosis or embolism
- Contrast nephropathy

Feature	Ascending Aortography	Lower Limb Arteriography
Target	Ascending aorta	Peripheral arteries
Main Use	Aortic pathology	PAD & limb ischemia
Injection	High-flow central	Stepwise peripheral
Catheter	Pigtail	Multi levels

Introduction

- Imaging plays a key role in evaluating respiratory diseases.
  The two advanced modalities are:
- **Computed Tomography (CT)** → primary tool
- **Magnetic Resonance Imaging (MRI)** → complementary role

CT of the Respiratory System

Principle

- Uses **X-rays** to generate cross-sectional images
- High spatial resolution → excellent for lung parenchyma

Types of Chest CT

- **HRCT (High-Resolution CT)**
  - Thin slices (1–1.5 mm)
  - Best for interstitial lung disease
- **CT Pulmonary Angiography (CTPA)**
  - With IV contrast
  - Gold standard for pulmonary embolism
- **Contrast-enhanced CT**
  - For tumors, mediastinum, vascular structures

CT Anatomy

- Lung parenchyma (air = black)
- Bronchi (branching pattern)
- Vessels (enhanced with contrast)
- Mediastinum (soft tissue window)

Advantages of CT

- Fast and widely available
- Excellent lung detail
- Best modality for:
  - Interstitial lung disease
  - Pulmonary embolism
  - Lung nodules

Limitations

- Radiation exposure
- Limited functional information

Key CT Findings

- **Ground-glass opacity (GGO)** → partial alveolar filling
- **Consolidation** → complete alveolar filling
- **Nodules/masses** → benign vs malignant
- **Honeycombing** → fibrosis
- **Tree-in-bud pattern** → small airway disease
- **Pulmonary embolism** → filling defect in arteries

MRI of the Respiratory System

Principle

- Uses **magnetic field + radiofrequency pulses**
- No ionizing radiation

Role in Respiratory Imaging

- MRI is **not first-line for lungs** due to:
- Low proton density (air-filled lungs)
- Motion artifacts

Main Indications

- Mediastinal masses
- Chest wall tumors
- Pleural disease
- Cardiopulmonary interactions
- Pediatric imaging (avoid radiation)

MRI Sequences

- **T1-weighted** → anatomy, fat
- **T2-weighted** → fluid, edema
- **STIR** → edema/inflammation
- **DWI (Diffusion)** → tumor characterization
- **MR Angiography** → vessels

MRI Findings

- Tumor invasion (chest wall, diaphragm)
- Pleural thickening/effusion
- Vascular abnormalities

Advantages of MRI

- No radiation
- Superior soft tissue contrast
- Multiplanar imaging

Limitations

- Poor lung parenchyma visualization
- Longer scan time
- Motion sensitivity
- Less available than CT

Feature	CT	MRI
Lung parenchyma	Excellent	Limited
Mediastinum	Good	Excellent
Speed	Fast	Slow
Radiation	Yes	No
Best use	ILD, PE, nodules	Tumors, soft tissue

Clinical Approach

- Suspected PE → CT Pulmonary Angiography
- Pediatric or soft tissue evaluation → MRI
- Interstitial lung disease → HRCT
- Mass staging → CT ± MRI

Introduction

- **Heart angiography** refers to imaging of the heart and its vessels using contrast.
- **Coronary arteriography** (coronary angiography) specifically visualizes the **coronary arteries**.
- 👉 It is the **gold standard** for diagnosing **coronary artery disease (CAD)**.

Basic Principle

- Injection of **iodinated contrast** into blood vessels
- Visualization using **fluoroscopy (X-ray in real time(**
- Produces dynamic images of blood flow

Indications

Diagnostic

- Suspected **coronary artery disease**
- Acute coronary syndromes (STEMI, NSTEMI)
- Evaluation of chest pain
- Pre-operative assessment (e.g., before valve surgery)

Therapeutic

- Percutaneous coronary intervention (**PCI**)
- Balloon angioplasty
- Stent placement

Procedure Steps

Vascular access

- Radial artery (preferred)
- Femoral artery

Catheter insertion

- Advanced to coronary ostia

Contrast injection

- Into right and left coronary arteries

Image acquisition

- Multiple projections (LAO, RAO views)

Coronary Artery Anatomy

Left Coronary Artery (LCA)

- LAD (Left Anterior Descending)
- LCX (Left Circumflex)

Right Coronary Artery (RCA)

- Supplies right heart and often inferior wall

Angiographic Findings

Normal

- Smooth lumen
- No narrowing

Abnormal

- **Stenosis** → narrowing (mild, moderate, severe)
- **Occlusion** → complete blockage
- **Atherosclerotic plaques**
- **Collateral circulation**
- **Coronary anomalies**

Quantification of Stenosis

- Mild <50%
- Significant: > 70% (>50% in the LT main artery)

Alternatives (Non-invasive)

CT Coronary Angiography (CTCA)

- Non-invasive
- Good for ruling out CAD

Stress Testing

- Functional assessment

Cardiac MRI

- Viability and perfusion

Advantages

- Gold standard for heart and coronary imaging
- Allows **simultaneous diagnosis and treatment**
- High spatial and temporal resolution

Complications

- Bleeding or hematoma (access site)
- Arrhythmias
- Contrast-induced nephropathy
- Allergic reaction
- Rare: stroke, myocardial infarction

Clinical Approach

- Stable patient → CT coronary angiography first
- High-risk or acute MI → invasive coronary angiography
- Intervention needed → proceed to PCI

Overview of the Venous System

Peripheral Venous System

- Superficial veins (e.g., great and small saphenous veins)
- Deep veins (accompany arteries; e.g., femoral, popliteal)
- Perforator veins (connect superficial to deep system)

Central Venous System

- Includes **vena cava (SVC & IVC)**, brachiocephalic veins, iliac veins
- Drains blood into the right atrium

Peripheral Venography

- Contrast imaging of peripheral veins using fluoroscopy.

Technique

- Contrast injected into a distal vein (e.g., foot vein for lower limb study)
- Sequential imaging as contrast travels proximally

Indications

- Suspected **DVT** (historically gold standard)
- Venous malformations
- Preoperative vein mapping

Findings

- Filling defects → thrombus
- Collateral circulation → chronic obstruction

Limitations

- Invasive
- Contrast-related risks
- Now largely replaced by **ultrasound Doppler**

Central Venography

- Contrast imaging of central veins using fluoroscopy.

Technique

- Contrast injected via central or peripheral vein
- Imaging of **SVC, IVC, and major central veins**

Indications

- Central venous stenosis/occlusion
- Dialysis access evaluation
- SVC syndrome

Advantages

- Real-time visualization
- Allows **intervention** (angioplasty, stenting)

Limitations

- Invasive
- Contrast-related risks
- Now largely replaced by **ultrasound Doppler**

CT Imaging of Arterial & Venous Systems

CT Angiography (CTA)

- Uses iodinated contrast
- High-resolution arterial imaging

CT Venography (CTV)

- Performed in delayed phase
- Evaluates venous structures

Indications

- Arterial: aneurysm, stenosis, embolism
- Venous: DVT (especially pelvic veins), IVC thrombosis

Advantages

- Fast
- Widely available
- Excellent spatial resolution

Limitations

- Radiation exposure
- Contrast nephrotoxicity

MRI of Arterial & Venous Systems

MR Angiography (MRA)

- Can be **contrast-enhanced** or **non-contrast (TOF, phase contrast)**

MR Venography (MRV)

- Visualizes venous flow and thrombosis

Indications

- Intracranial venous thrombosis
- Peripheral vascular disease (when CT contraindicated)
- Congenital vascular anomalies

Advantages

- No ionizing radiation
- Excellent soft tissue contrast
- Functional flow assessment

Limitations

- Longer scan time
- Motion sensitivity
- Contraindicated with some implants

Modality	Best Use	Advantages	Limitations
Ultrasound	Peripheral veins	Non-invasive, cheap	Operator dependent
Venography	Detailed vein anatomy	Gold standard (historical)	Invasive
CT	Arteries & deep veins	Fast, high resolution	Radiation
MRI	Complex/central veins	No radiation	Expensive, slower

Key Clinical Applications

- **DVT diagnosis** → Ultrasound ± CTV/MRV
- **Pulmonary embolism source** → CT
- **Central venous obstruction** → Venography / MRV
- **Pre-surgical planning** → CTA/MRA

Introduction

- Neuroimaging plays a central role in diagnosing brain pathology. The two main modalities are:
- **Computed Tomography (CT)**
- **Magnetic Resonance Imaging (MRI)**
- They are **complementary**, not competitive.

CT Scan of the Brain

Principle

- Uses **X-rays** to generate cross-sectional images
- Based on tissue density differences (Hounsfield units)

CT Appearance

- Bone → very bright (hyperdense)
- Blood (acute) → hyperdense
- CSF → hypodense
- Brain parenchyma → intermediate

Indications

- **Acute head trauma**
- **Intracranial hemorrhage**
- Suspected stroke (initial imaging)
- Skull fractures
- Hydrocephalus

Advantages

- Fast (ideal in emergencies)
- Widely available
- Excellent for **acute bleeding and bone**

Limitations

- Radiation exposure
- Limited soft tissue contrast
- May miss early ischemic stroke

MRI of the Brain

Principle

- Uses **magnetic field and radiofrequency pulses**
- Based on proton behavior (hydrogen atoms)

Common MRI Sequences

- **T1-weighted** → anatomy (fat bright, CSF dark)
- **T2-weighted** → pathology (fluid bright)
- **FLAIR** → suppresses CSF (good for edema, lesions)
- **DWI (Diffusion)** → acute ischemic stroke
- **SWI/GRE** → hemorrhage, microbleeds

MRI Indications

- **Brain tumors**
- **Multiple sclerosis**
- **Early ischemic stroke**
- Infections (encephalitis, abscess)
- Posterior fossa lesions

CT vs MRI in Stroke

CT (First-line)

- Rule out hemorrhage quickly
- May be normal in early ischemia

MRI (DWI)

- Detects ischemia within minutes
- More sensitive for early infarction

CT & MRI CONTRAST

CT Contrast

- Iodinated contrast
- Used for tumors, infection, vascular studies

MRI Contrast

- Gadolinium-based
- Highlights tumors, inflammation

Feature	CT Brain	MRI Brain
Speed	Very fast	Slower
Radiation	Yes	No
Hemorrhage	Excellent (acute)	Good (SWI)
Ischemia	Less sensitive early	Highly sensitive (DWI)
Soft tissue detail	Moderate	Excellent

Key Clinical Applications

- Trauma → CT first
- Stroke → CT first, MRI for confirmation
- Tumor → MRI best modality
- Demyelinating disease → MRI
- Infection → MRI preferred

Introduction

- **Cerebral angiography** is an invasive imaging technique used to visualize the **intracranial arterial and venous systems** in real time using contrast injection and fluoroscopy.
- It remains the **gold standard** for detailed evaluation of cerebral vasculature.

Basic Principle

- Injection of **iodinated contrast** into cerebral arteries
- Continuous **X-ray fluoroscopy** captures blood flow dynamically
- Produces high-resolution images of:
- Arterial phase
- Capillary phase
- Venous phase

Technique (Digital Subtraction Angiography – DSA)

Steps :

Vascular access

- Usually via **common femoral artery** (or radial approach)

Catheter navigation

- Guided into major vessels:
  - Internal carotid artery (ICA)
  - External carotid artery (ECA)
  - Vertebral arteries

Contrast injection

- Rapid injection while imaging

Image acquisition

- Subtraction technique removes bone → clear vessel visualization

Indications

Diagnostic

- **Cerebral aneurysms**
- **Arteriovenous malformations (AVMs)**
- **Vascular stenosis or occlusion**
- **Vasculitis**
- **Tumor vascularity**

Interventional (Therapeutic)

- Aneurysm coiling
- AVM embolization
- Mechanical thrombectomy in stroke
- Stenting/angioplasty

Imaging Phases

A. Arterial Phase

- Visualization of arteries
- Detect stenosis, aneurysm

B. Capillary Phase

- Parenchymal blush
- Tumor vascularity

C. Venous Phase

- Venous drainage patterns
- Detect venous thrombosis

Advantages

- Highest spatial and temporal resolution
- Dynamic (real-time flow assessment)
- Allows **simultaneous diagnosis and treatment**

Limitations

- Invasive
- Requires expertise
- Time-consuming compared to CT/MRI

Risks

- Stroke (embolism)
- Hemorrhage at puncture site
- Contrast reaction
- Contrast-induced nephropathy

Modality	Invasiveness	Detail	Use
CTA	Non-invasive	High	Emergency screening
MRA	Non-invasive	Moderate–high	Follow-up, screening
DSA	Invasive	**Highest (gold standard)**	Diagnosis + intervention

Key Clinical Applications

- **Subarachnoid hemorrhage** → detect aneurysm
- **Acute stroke** → thrombectomy guidance
- **AVMs** → detailed angioarchitecture
- **Pre-surgical planning**

Cardiac CT (CT Coronary Angiography – CTCA)

Principle

- Uses **multidetector CT + IV contrast**
- ECG-gated acquisition to reduce motion artifacts

Indications

- Suspected **coronary artery disease (CAD)** in low–intermediate risk patients
- Evaluation of **coronary anomalies**
- Assessment of **bypass grafts & stents**
- Calcium scoring (risk stratification)

Techniques

- **Non-contrast CT** → Coronary calcium score
- **Contrast-enhanced CTCA** → Coronary lumen visualization
- **ECG-gating**:
  - Prospective (low radiation)
  - Retrospective (functional assessment)

Advantages

- Non-invasive
- High negative predictive value
- Fast

Limitations

- Radiation exposure
- Requires heart rate control (<65 bpm ideal)
- Limited in heavily calcified arteries

Key Findings

- Coronary stenosis **(percentage narrowing)**
- Atherosclerotic plaques **(calcified , non calcified ,mixed)**
- Coronary anomalies
- Cardiac morphology

Arterial System Overview

Major Arterial Circulation

- **Aorta** (ascending, arch, descending)
- **Coronary arteries** (LAD, LCX, RCA)
- **Pulmonary arteries** (separate circulation)

Peripheral Arterial System

- Carotid arteries → brain
- Subclavian → upper limbs
- Iliac & femoral → lower limbs

Common Pathologies

- **Atherosclerosis** → stenosis/occlusion
- **Aneurysm** → vessel dilation
- **Dissection** → intimal tear
- **Embolism/thrombosis**

Catheter Technique (Angiography Basics)

Access Sites

- **Radial artery** (preferred)
- **Femoral artery**

Seldinger Technique (Core Concept)

- Needle insertion into artery
- Guidewire placement
- Needle removal
- Catheter advanced over guidewire

Catheter Navigation

- Fluoroscopic guidance
- Selective cannulation of target vessels
- Contrast injection for visualization

Complications

Access Site Complications

- Hematoma
- Bleeding
- Pseudoaneurysm
- Arteriovenous fistula

Vascular Complications

- Arterial dissection
- Thrombosis or embolism

Cardiac Complications

- Arrhythmias
- Myocardial infarction (rare)

Contrast-Related

- Contrast-induced nephropathy
- Allergic reactions

Radiation Risks

- Cumulative exposure (CT & fluoroscopy)

Prevention of Complications

- Proper patient selection
- Hydration before/after contrast
- Use of low-osmolar contrast
- Sterile technique
- Skilled catheter handling

Scenario	Best Modality
Low-risk chest pain	Cardiac CT
Acute MI	Invasive angiography
Peripheral arterial disease	CT/MR angiography
Aortic pathology	CT angiography