Clinical Chest Radiography Interpretation
Part I
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Disclosure
• No real or potential conflict of interest to disclose.
• No off-label, experimental or investigational use of drugs or devices will be presented.

Course Objectives
Part I
• At the end of this presentation, the participant will be able to:
  – Describe the basics of obtaining a clinical chest radiograph.
  – Identify a systematic approach to the interpretation of clinical chest radiography.
  – Analyze the normal presentation of a clinical chest radiograph.

References
Additional references at end of presentation

Historical Perspectives
Wilhelm Conrad Roentgen
Dutch Physicist
• Discovered form of radiation
  – Roentgen ray
• First diagnostic radiograph 1896
• Won Nobel Prize for Physics 1901

General Principles to Interpretation
• Develop a systematic approach to interpretation
• Link your interpretation to clinical findings
• Compare with a previous radiograph, if available
• Does your interpretation make sense?
Chest Radiograph Basics

Producing an Image
- Strahlung ray (x-ray) from cathode tube
- Attenuation of the ray
- Radiant energy
- Cassette
- Image

Radiolucency, Radiopaque, and Radiodensity
- Radiolucency
  - Allows the passage of rays
  - Causes blackening of the film by permitting – Low absorbency
- Radiopaque and radiodensity
  - Does not allow the passage of rays
  - Less blackening of the film – High absorbency

Relative Densities
- Results from the difference in density of materials
- Hierarchy of relative densities (least dense to most dense)

Relative Densities (continued)
- Gas
  - Black in color
  - Least dense material
  - Clinical example
    - Air in lungs

Relative Densities (continued)
- Fat
  - Gray-black in color
  - Clinical example
    - Fat layer in the soft tissues
Chest Radiograph Basics

Relative Densities (continued)

• Soft tissue and water
  – Gray in color
  – Clinical example
  • Soft tissues and fluid levels

Source: Property of Theresa Campo (used with permission)

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Chest Radiograph Basics

Relative Densities (continued)

• Bone and metal
  – White in color
  – Highest density
  – Clinical example
    • Bones
    • Foreign body (metal)

Source: Property of Theresa Campo (used with permission)

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Chest Radiograph Basics

Before Beginning the Interpretation

• Patient identification
• X-ray view
  – PA, AP, lateral, decubitus
• Breath
  – Inspiration or expiration
• X-ray penetration
  – Under or over penetration
• Rotation

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Chest Radiograph Basics

Views of a Chest Radiograph

• Posterior-anterior (PA view)
• Anterior-posterior (AP view)
• Lateral view
• Lateral decubitus view

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Chest Radiograph Basics

Views of a Chest Radiograph (continued)

• Posterior-anterior (PA view)
  – Standard position for a routine CXR
  – Pt positioned with their anterior chest wall placed against the cassette
  – Shoulders are rotated to touch the cassette
  – Full inspiration

Source: https://commons.wikimedia.org/wiki/File:Rx_de_t%C3%B3rax_PA_normal.JPG

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Chest Radiograph Basics

Views of a Chest Radiograph (continued)

Posterior-anterior (PA view)

Source: https://commons.wikimedia.org/wiki/File:Frontal_view_of_lung_inｄｉｃａｔｉｎｇＰＡａｎｄＡＰ_Pａｒｔｈｅｎｏｔｏｍｙ.jpg

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Chest Radiograph Basics

Views of a Chest Radiograph (continued)

- Anterior-posterior (AP view)
  - Used when the patient is unable to cooperate with a PA view (common with portable x-ray)
  - Cassette is placed behind the patient
  - Heart is a greater distance from the film → more magnification
  - Scapulae are visible in lung fields

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Comparison of PA vs. AP Views

<table>
<thead>
<tr>
<th></th>
<th>PA view</th>
<th>AP view</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lungs</td>
<td>More distinct lung markings</td>
<td>Lung volumes are shallow</td>
</tr>
<tr>
<td>Heart</td>
<td>Smaller</td>
<td>Appears larger than normal</td>
</tr>
<tr>
<td>Clavicles</td>
<td>Superimposed over the lungs</td>
<td>Above the apex of the lungs</td>
</tr>
<tr>
<td>Scapula</td>
<td>Seen in the periphery</td>
<td>Seen over the lung fields</td>
</tr>
<tr>
<td>Ribs</td>
<td>Posterior ribs are distant</td>
<td>Anterior ribs are distant</td>
</tr>
<tr>
<td>Other</td>
<td>Cervical and thoracic vertebrae are more clearly visible</td>
<td>---</td>
</tr>
<tr>
<td>Usage</td>
<td>Most common</td>
<td>Only in the critically ill / unable to stand for a PA view</td>
</tr>
</tbody>
</table>

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Lateral view

- Pt is upright with the left side of the chest against the cassette (arms over head)
- Allows for views behind the heart and diaphragmatic dome
- Used with PA views to produce a three dimensional position of the organs or abnormal densities

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Lateral decubitus view

- Pt is lying on right or left side
  - Left lateral decubitus position → left side
  - Right lateral decubitus position → right side
- Typically used to evaluation a pleural effusion not easily observed in the upright views
- Dependent lung has increased density
Chest Radiograph Basics

Views of a Chest Radiograph (continued)

Lateral decubitus view

Source: Property of Theresa Campo (used with permission)

Technical Quality of the Radiograph

Inspiration
Penetration
Rotation

Normal Inspiration

1 2 3 4 5 6 7 8

Source: https://commons.wikimedia.org/wiki/File:Chest_Xray_PA_3-8-2010.png

Poor Inspiration

1 2 3 4 5

Source: Property of Theresa Campo (used with permission)

Technical Quality of the Radiograph (continued)

• Normal inspiration
  – Views should be obtained with full inspiration to assess pulmonary abnormalities
  – Full inspiration
    • Diaphragm at the level of the 8–10th posterior rib
    • Diaphragm at the level of the 5–6th anterior rib

• Inspiration vs. expiration
  – Expiration can be useful in the following situations
    • Suspected pneumothorax
    • Suspected foreign body in the bronchus
Chest Radiograph Basics

**Evaluation of a Pneumothorax**

*Normal inspiration*
Left pneumothorax

*Expiration*
Left pneumothorax

Source: Daffner and Hartman 2014

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**Evaluation of a Bronchus Foreign Body**

*Normal inspiration*
No volume change on the left

*Expiration*
Shift to the right • obstruction of left main bronchus

Source: Daffner and Hartman 2014

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**Chest Radiograph Basics**

**Technical Quality of the Radiograph**

- **Penetration**
  - The lower thoracic vertebrae should be visible through the heart
  - The bronchovascular structures (behind the heart) should be seen
    - Trachea
    - Aortic arch
    - Pulmonary arteries

**Comparison of PA vs. AP Views**

<table>
<thead>
<tr>
<th>Normal PA View</th>
<th>Normal Lateral View</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Thoracic disc spaces should be barely visible through the heart</td>
<td>• Should see 2 sets of ribs</td>
</tr>
<tr>
<td>• Vertebral bodies not visible</td>
<td>• Sternal edge may be visible</td>
</tr>
</tbody>
</table>

**Over-penetration vs. Under-penetration**

<table>
<thead>
<tr>
<th>Over-penetration</th>
<th>Under-penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Dark</td>
<td>• Light</td>
</tr>
<tr>
<td>• Heart becomes radiolucent</td>
<td>• Cardiac shadow is opaque</td>
</tr>
<tr>
<td>• Less density in the lungs (appearance of lacking lung tissue)</td>
<td>• Little or no visibility of the thoracic vertebrae</td>
</tr>
<tr>
<td>• Vertebral discs are clearly seen</td>
<td>• Lungs are dense in presentation</td>
</tr>
</tbody>
</table>

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**Technical Quality of the Radiograph**

- **Rotation**
  - Normal rotation
    - Observe the clavicular heads • should be equal distance from the spinous processes of the thoracic vertebral bodies and symmetrical
  - Problems with poor rotation
    - May result in distortion of normal anatomic structures

Source: Property of Theresa Campo (used with permission)
Chest Radiograph Basics

Normal vs. Poor Rotation

Foundational Concepts

- Why choose a plain radiograph?
  - Visualize basic abnormalities
  - Air-fluid levels
  - Stones
  - Identify gross abnormalities
  - Identify a foreign body
- 2 dimensional view of a 3 dimensional structure

Common diagnosis associated with plain radiograph
- Infiltrates
- Radiopaque foreign body
- Gangrene
- Fracture
- Pneumothorax
- Hemothorax
- Pleural effusion

Standard rules of chest radiography
- Obtain a thorough history and physical examination
- Always evaluate the entire radiograph
- Before confirming a diagnosis re-examine the patient and the radiograph and be sure the diagnosis fits the clinical picture
- Always confirm the right patient
- Develop a systematic approach
- Do not get distracted
- Why is the plain radiograph appropriate?
- Why is a diagnostic study appropriate?

Radiation Dosage

- Three measures to describe radiation dose
  - Absorbed
    - Amount of energy absorbed/unit mass
  - Effective
    - All irradiated tissue and organ risk of exposure
  - Organ
    - Organ risk of exposure
Chest Radiograph Basics

X-ray Equivalent

- Chest x-ray = 3 days of background radiation
- C-spine = 1.5 days of background radiation
- Pelvis = 14 days of background radiation
- Abdomen = 16 days of background radiation
- Thoracic spine = 24 days of background radiation
- Lumbar spine = 60 days of background radiation

Chest Radiograph Basics

Effective Radiation Dose (millisievert – mSv)

- Plain radiographs
  - 0.02 mSv chest x-ray
- CT scan
  - 2.0 mSv head
  - 20–60 mSv chest, abdomen, and pelvis
- Nuclear medicine
  - 10–25 mSv (sestamibi scan – dual isotope scanning)

Chest Radiograph Basics

Anatomy and Physiology

Source: https://upload.wikimedia.org/wikipedia/commons/8/89/Mediastinal_structures_on_chest_X-ray%2C_annotated.jpg

Chest Radiograph Basics

Anatomy and Physiology (continued)

Source: https://commons.wikimedia.org/wiki/File:Chest_Xray_PA_3-8-2010.png

Chest Radiograph Basics

Foundational Concepts

- Pathophysiology
  - Does the pathophysiology match the findings on the radiograph?
  - Does the clinical picture match the pathophysiology?
  - Abnormal findings vs. a normal variant

Chest Radiograph Basics

Foundational Concepts – Looking at the Film

1. Identification
2. Date
3. View
4. Marker
5. Inspiration
6. Rotation
7. Penetration

Source: https://commons.wikimedia.org/wiki/File:Chest_Xray_PA_3-8-2010.png
Chest Radiograph Interpretation

*A Systematic (A-I) Approach*

- Adequacy
  - Inspiration
  - Penetration
  - Rotation

- Airway
  - Observe the main airways
  - Trachea midline and seen to the carina (Bifurcation T4–T5)
  - Slowly angles downward to the thoracic inlet (retrotracheal line 3 mm)

- Bones and soft tissue
- Cardiac
- Diaphragm
- Edges (pleura)
- Fields (lungs)
- Gastric bubble
- Hila and mediastinum
- Impression

**Adequacy and Airway**

**Adequacy**

Inspiration?

Penetration?

Rotation?

**Airway**

Tracheal position?

Level of bifurcation

Source: https://commons.wikimedia.org/wiki/File:Chest_Xray_PA_3-8-2010.png
Chest Radiograph Interpretation

**Bones and Soft Tissue**

- **Bones**
  - Ribs
  - Clavicles
  - Scapula
  - Humerus
  - Lower cervical and thoracic spine

- **Soft tissue**
  - Obesity may obscure underlying structures (i.e., lung markings)
  - Breast tissue may obscure the costophrenic angles
  - Lucencies within soft tissue may represent gas (subcutaneous air)

**Cardiac**

- **Heart**
  - 2/3 of the heart should lie on the left side of the chest
  - 1/3 of the heart should lie on the right side of the chest
  - Left atrium and ventricle → left heart border
  - Right atrium → right heart border

**Soft Tissue**

- Any obscuring of structures?
- Subcutaneous air?
Chest Radiograph Interpretation

Diaphragm

- Both should form a sharp margin with the lateral chest wall
- Both should have contours that are clearly visible medially to the spine
- The right contour should be higher than the left

Edges (Pleura)

- Pleura should only be visible when there is a pathologic abnormality
- Lung markings should extend to the edges
- Common abnormalities
  - Pneumothorax (air)
  - Hemothorax (blood)
  - Pleural effusion (fluid)

Fields (Lungs)

- Visible markings of the arteries and veins throughout to the chest wall
- Start at apices and work down
- Compare bilaterally
- Should not have any shadowing, lucency, or vascular enlargement
Chest Radiograph Interpretation

**Gastric Bubble**
- A round/ovoid shape under the left hemidiaphragm
- There is a thick line separating gas in the stomach from air in the lungs
- Free intra-abdominal gas forms a crescent under the diaphragm, and is separated from the lungs only by the thin membrane of the diaphragm.

Chest Radiograph Interpretation

**Hilum and Mediastinum**
- **Hila**
  - Consists of major bronchi and pulmonary veins/arteries
  - Not symmetrical, but contain same structures bilaterally
  - Left is usually higher than the right
  - Similar size and density
  - Can help to identify masses and lymphadenopathy

Chest Radiograph Interpretation

**Mediastinum** (continued)
- Trachea should be to the right
- Aortic arch is the first convexity on the left
- Pulmonary artery is the next convexity on the left

Chest Radiograph Interpretation (continued)

**Mediastinum (three regions)**
- **Anterior**
  - Area between sternum and front of heart and great vessels
- **Middle**
  - Area between anterior and posterior pericardium
  - Includes: Pericardium, heart, aortic arch, proximal brachial cephalic vessels, pulmonary veins/arteries, trachea, main bronchus, and lymph nodes
- **Posterior**
  - Area behind the heart and trachea including vertebral bodies
• Mediastinum (three regions)

Chest Radiograph Interpretation

Hilum and Mediastinum (continued)

Mediastinum

Aortic arch

Vessels

Aorta/width

Chest Radiograph Interpretation

Hilum and Mediastinum (continued)

What do you think so far?

Chest Radiograph Interpretation

Interpretation

When to Adjust the Approach

ICU Films

• Identify tubes first
• Look for pneumothorax
• Proceed with systematic interpretation

When to Adjust the Approach

Pediatric Films

• Can be challenging
• Look different in children
• Different diseases
• Change with age
• Limited patient cooperation
• Thymus can cause confusion

When to Adjust the Approach
When to Adjust the Approach
Pediatric Films (continued)

• Heart
  – Newborn hearts can be more than ½ the width of the chest
  – Good inspiration needed to judge heart size
  – Poor inspiration can significantly change the look and position of the heart

• Thymus
  – Increases in size from birth through puberty
  – But child grows so it appears smaller with age
  – Can be variable in size and appearance (i.e., shrink rapidly due to illness or grow due to chemotherapy)

Chest Radiograph Basics

REMINDER!
• Standard rules of chest radiography
  – Obtain a thorough history and physical examination
  – Always evaluate the entire radiograph
  – Before confirming a diagnosis re-examine the patient and the radiograph and be sure the diagnosis fits the clinical picture
  – Always confirm the right patient
  – Develop a systematic approach
  – Do not get distracted
  – Why is the plain radiograph appropriate?
  – Why is a diagnostic study appropriate?

End of Part 1
Thank you for your time and attention.

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