Basic Radiology for the TB Clinician

Overview:
- Technical aspects of chest radiography
- Systematic approach to reading CXR
- Basic CXR anatomy
- Patterns of disease
- Radiographic manifestations of tuberculosis (TB)
Chest Radiography: Basic Principles

- X-ray photon: Absorbed / scattered / transmitted
- X-ray absorption depends on:
  - Beam energy (constant)
  - Tissue density

Maximum X-Ray Transmission (least dense tissue)

Maximum X-Ray Absorption (densest tissue)

Blackest
- air
- fat
- soft tissue
- calcium
- bone
- X-ray contrast
- metal

Whitest

Why we see what we see:

- Structures are visible on a radiograph because of the juxtaposition of two different densities
  ➔ Creating an interface

- Silhouette Sign
  **Loss of an expected interface**
  ➔ No boundary can be seen between two structures because they now are similar in density

*Image credit: Curry International Tuberculosis Center, UCSF*
Assess CXR Technical Quality

- Inspiratory effort
  - 9-10 posterior ribs
- Penetration
  - Thoracic intervertebral disc space just visible
- Positioning / rotation
  - Medial clavicle heads equidistant from spinous process
Inspiratory Effort

Low Lung Volumes  Full Inspiration
<table>
<thead>
<tr>
<th>Exposure</th>
<th>Overexposure</th>
<th>Proper Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Overexposure Image" /></td>
<td><img src="image2" alt="Proper Exposure Image" /></td>
<td><img src="image3" alt="Overexposure Image" /></td>
</tr>
</tbody>
</table>

*Image credit: Curry International Tuberculosis Center, UCSF*
Rotated (Oblique)

Image credit: Curry International Tuberculosis Center, UCSF

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A Systematic Approach to Reading a CXR

Image Credit: Lung Health Image Library/Gary Hampton
Approach to Reading a CXR

- Be Systematic
  - Lungs
  - Pleural surfaces
  - Cardiomedial contours
  - Bones and soft tissues
  - Abdomen

Image credit: Curry International Tuberculosis Center, UCSF

Interpretation: A-B-C-D-E

A=Air
B=Bones
C=Cardiovascular
D=Diaphragm
E=Everything else
Worth a Second Look

- Apices
- Retrocardiac areas (left and right)
- Hilar regions
- Below diaphragm

Apical TB

Image credit: Curry International Tuberculosis Center, UCSF
Apical TB (2)

Image credit: Curry International Tuberculosis Center, UCSF

Left Retrocardiac Opacity

Image credit: Curry International Tuberculosis Center, UCSF
Nodule Behind Diaphragm

Image credit: Curry International Tuberculosis Center, UCSF

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Basic CXR Anatomy

Image credit: Curry International Tuberculosis Center, UCSF
Basic CXR Anatomy

Frontal and Lateral Views

- Heart
- Aorta
- Pulmonary arteries
- Airways

*Image Credit: Lung Health Image Library/Pierre Virot*
- Aortic arch
- Right pulmonary artery
- Left pulmonary artery
- Trachea & bronchi

Image credit: Curry International Tuberculosis Center, UCSF
• Aortic arch
• Right pulmonary artery

Image credit: Curry International Tuberculosis Center, UCSF
- Aortic arch
- Right pulmonary artery
- Left pulmonary artery
- Trachea & bronchi

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Patterns of Disease

Image Credit: Lung Health Image Library/Gary Hampton
Chest Radiographic Patterns of Disease

- Consolidation / air-space opacity
- Interstitial opacity
- Nodules and masses
- Lymphadenopathy
- Cysts and cavities
- Pleural abnormalities

Consolidation / Air-Space Opacity

- Caused by filling of alveoli with fluid, pus, blood, cells (tumor), etc.
- May be diffuse, or isolated to segments or lobes of the lung
- May be associated with air bronchograms (air-filled bronchus surrounded by opacified lung)
Interstitial Opacity

- Disease localized to pulmonary interstitium, i.e., the alveolar septae and connective tissues that support the alveoli
- Hallmarks:
  - Lines and/or reticulation
  - Small, well-defined nodules
    - Miliary pattern
- DDX: Pulmonary edema, interstitial lung diseases (e.g., idiopathic pulmonary fibrosis), sarcoidosis, infection, tumor (lymphangitic spread), etc.
Interstitial Opacity: Lines

Image credit: Curry International Tuberculosis Center, UCSF
**Nodules and Masses**

- **Nodule**: Discrete pulmonary lesion, sharply defined, nearly circular opacity 0.2 - 3 cm
- **Mass**: Larger than 3 cm
- **Describe with qualifiers:**
  - Single or multiple
  - Size
  - Border characteristics
  - Presence or absence of calcification
  - Location
Lymphadenopathy (LAN)

- Non-specific terms:
  - Mediastinal widening
  - Hilar prominence

- Specific patterns:
  - Particular station enlargement (location)

Important to know what “normal” should look like in order to recognize “abnormal”
**Lymphadenopathy**

- Infrahilar window (right hilar and/or subcarinal)
- Left hilar
- Subcarinal
Lymphadenopathy

- Infrahilar window (right hilar and/or subcarinal)

Image credit: Curry International Tuberculosis Center, UCSF

Lymphadenopathy

- Left hilar

Image credit: Curry International Tuberculosis Center, UCSF
Lymphadenopathy

- Subcarinal

Right Paratracheal & Bilateral LAN

Image credit: Curry International Tuberculosis Center, UCSF
Right Hilar LAN

Image credit: Curry International Tuberculosis Center, UCSF
Subcarinal LAN

Image credit: Curry International Tuberculosis Center, UCSF

AP Window LAN

Image credit: Curry International Tuberculosis Center, UCSF
Cysts & Cavities

- Abnormal pulmonary parenchymal spaces ("holes"), filled with air and/or fluid, with a definable wall (>1 mm)
  - Cyst: Congenital or acquired
  - Cavity: Caused by tissue necrosis, (inflammatory and/or neoplastic)

- Characterize:
  - Wall thickness at thickest portion
  - Inner lining
  - Presence / absence of air / fluid level
  - Number and location

TB or Not TB? Cysts and Cavities

Are there radiographic features that suggest benign vs. malignant diagnoses?

“45 year old man from China with cough, weight loss”

Image credit: Curry International Tuberculosis Center, UCSF
TB or Not TB?  Cysts and Cavities (2)
Are there radiographic features that suggest benign vs. malignant diagnoses?

- **Benign cysts:** Uniform wall thickness, 1mm, smooth inner lining (e.g., PCP)
- **Benign cavities:** Max. wall thickness ≤ 4 mm, minimally irregular inner lining (e.g., TB)
- **Malignant cavities:** Max. wall thickness ≥ 16 mm, irregular inner lining

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**Pleural Disease: Basic Patterns**

- **Effusion**
  - Angle blunting to massive
- **Thickening**
- **Mass**
- **Air**
- **Calcification**
Pleural Effusion

Post-TB Pleural Calcification
Plombage with Lucite balls

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Radiographic Manifestations of TB
Can this be TB?

“Typical Pattern”: Post-Primary TB

- **Distribution**
  - Apical / posterior segments of upper lobes
  - Superior segments of lower lobes
  - Isolated anterior segment involvement unusual for *M. tb* (think *M. avium* complex)

“Typical Pattern”: Post-Primary TB

**Patterns of disease**
- Air-space consolidation
- Cavitation, cavitary nodule
- Endobronchial spread
- Miliary
- Bronchostenosis
- Tuberculoma
- Pleural effusions
  (empyema most likely in post-primary disease)
Can this be TB?

“Atypical Pattern”: Primary TB
- Distribution: Any lobe involved (slight lower lobe predominance)
- Air-space consolidation
- Cavitation is uncommon (<10%)
- Adenopathy is common (esp. children and HIV), predilection for right side
- Miliary pattern
- Pleural effusions

Can this be TB? Miliary TB
### Radiographic Patterns: Pulmonary TB

<table>
<thead>
<tr>
<th>TB Pattern</th>
<th>“Typical” (Post-Primary)</th>
<th>“Atypical” (Primary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infiltrate</td>
<td>85% upper</td>
<td>Upper: Lower 60: 40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually upper in children</td>
</tr>
<tr>
<td>Cavitation</td>
<td>Common</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Adenopathy</td>
<td>Uncommon</td>
<td>Children common</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adults ~30% Unilateral &gt; bilateral</td>
</tr>
<tr>
<td>Effusion</td>
<td>May be present</td>
<td>May be present</td>
</tr>
</tbody>
</table>

### CXR Pattern: Early vs. Advanced HIV

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Early HIV (CD4&gt;200)</th>
<th>Advanced HIV (CD4&lt;200)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>“Typical” (Post-Primary)</td>
<td>“Atypical” (Primary)</td>
</tr>
<tr>
<td>Infiltrate</td>
<td>Upper lobes</td>
<td>Lower lobes, multiple sites, or miliary</td>
</tr>
<tr>
<td>Cavitation</td>
<td>Common</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Adenopathy</td>
<td>Uncommon</td>
<td>Common</td>
</tr>
<tr>
<td>Effusion</td>
<td>Uncommon</td>
<td>More common</td>
</tr>
</tbody>
</table>
Can this be TB?  “Old / Healed” TB

- Ca++ granuloma–Ghon lesion
- Ca++ granuloma and hilar node calcification–Ranke complex
- Apical pleural thickening
- Fibrosis and volume loss

Image credit: Curry International Tuberculosis Center, UCSF

Basic Radiology for the TB Clinician

Summary:

- Remember: Technical quality can significantly impact your CXR interpretation
- Develop a systematic approach (and use it every time!)
- Practice identifying normal CXR anatomy
- Important to characterize and describe lesions—this can help with your differential diagnosis
- Whether typical or atypical
  - TB can always fool you!