Tuberculosis: The Essentials
Kendra L. Fisher, MD, PhD

THORACIC TUBERCULOSIS: THE BARE ESSENTIALS
Kendra Fisher MD, FRCP (C)
Department of Radiology
Loma Linda University Medical Center

INTRODUCTION

• ~ 3 million per year
(WHO)
• > 10 million per year

New cases of active TB
Mortality from TB
Prevalence in the USA
Location of TB

Objectives

Review transmission and pathogenesis of Mycobacterium tuberculosis (MTb)
Present typical distributions and patterns of MTb
Review common imaging manifestations of MTb
Briefly present pulmonary complications of MTb

TRANSMISSION of Mycobacterium tuberculosis

- Carried on airborne droplet nuclei
- Small size (1-5 um) allows air currents to keep them airborne for long periods
- Larger particles usually not infectious
- Techniques reducing droplet nuclei air effective in preventing airborne transmission

www.pathfwsm54.ucsf.edu

TUBERCULOSIS (TB)

- One of the most dreaded diseases known to mankind
- L. Robert Koch discovered TB bacteria in 1882
- Dr. E.L. Trudeau promoted isolation in 1880’s
- National Association for Study and Prevention of TB formed in 1904

TB Cases in foreign born persons: Top 10 countries by case rate/100,000

www.cdc.gov/nchstp/tb
**Pathogenesis of MTb**

Exposure to Infectious Particles

- No Infection (70-90%)
  - Non-immunologic defences
    - Inadequate
  - Infection (10-30%)
    - Early Progression (9%)
      - Inadequate Immunologic defences
    - Late Progression (5%)
      - Inadequate Immunologic defences
  - Adequate Containment (95%)
    - Immunologic defences
      - Adequate Containment (90%)

Modified from Murray & Nadel’s textbook of Respiratory Medicine

**Pathogenesis**

- Inflammatory response and necrosis are results of cell-mediated immune response
- Hypersensitivity develops 2-10 weeks after initial infection
- Development of +ve skin reaction
- Tubercle bacilli in the body may replicate and produce disease at any time

**RISK FACTORS for ACTIVE TB**

- End-stage renal disease, malnutrition, diabetes, drug and alcohol abuse
- Extremes of age (< 2 and > 70)
- Large inoculum of mycobacteria
- HIV, Aids, organ transplantation (immunosuppressive therapy)
- End-stage renal disease, malnutrition, diabetes, drug and alcohol abuse
- Cancers

**CLINICAL PRESENTATION**

- May mimic or occur concurrently with other diseases
- Symptomatic patients may have signs and symptoms that are
  - Generalized or systemic
  - Pulmonary
  - Related to other organs
  - Combination of these features
CLINICAL PRESENTATION
- Asymptomatic persons identified only through History of exposure
- Abnormal chest radiograph
- Positive skin reaction
- Cultures positive for tubercle bacilli

MANIFESTATIONS OF TB
- PRIMARY TB
  - Occurs in population not previously exposed
  - Most common in infants and children
  - Develops within 1 year of initial exposure
  - Radiologic manifestations depend on several host factors including age and immune status

Role of Radiographic Screening
- TB+ • No disease
- TB+ • Clinically inactive
- TB+ • Clinically active

MANIFESTATIONS OF TB
- POST PRIMARY TB
  - Lymphadenopathy
  - Parenchymal disease
  - Miliary Disease

Disease Manifestations
- Lymphadenopathy
- PRIMARY TB
- Parenchymal disease
- Pleural effusion
**Lymphadenopathy**

- 83 - 96% of children, 10 - 45% of adults
- Typically unilateral and right sided, bilateral in 1/3 of cases
- Nodes > 2 cm often have necrotic centers on CT
- Can be sole CXR feature, esp. infants

**Parenchymal Disease**

- Dense, homogeneous consolidation typically in segmental or lobar distribution
- Seen in 70% of children and 80% of adults
- May also see patchy, linear, nodular and mass-like parenchymal involvement
- Obstructive lobar or segmental atelectasis typically seen in children under 2
- Parenchymal focus resolves without sequelae in ~ 2/3

**Pleural Effusion**

- Very uncommon in children < 2 years
- 6% - 11% in children, 29% - 38% in adults
- Typically unilateral, often large, complications rare
- Usually observed with parenchymal and or nodal disease
- May be sole manifestation, seen in ~ 5% of adult cases
- Often complex, septated on US
- May see related complications
- Residual calcified fibrothorax can result

**Miliary Disease**

- May occur with primary or postprimary disease
- Tubercle bacilli discharges into blood or lymph vessel with embolization of viable bacilli to capillary beds of other organs
- Lung most commonly involved organ
- May be seeded from lung lesions or other organ disease focus
- Transbronchial biopsy necessary for diagnosis
- XR may be normal in early stages (25% - 40%), resolves within 2 - 6 months
- Diffuse alveolar pattern rare
**Miliary Disease - CT**
- Can demonstrate presence of nodules before CXR
- Innumerable well and poorly defined 1-4 mm nodules in random distribution
- May see associated intralobular interstitial and interlobular septal thickening

**PROGRESSIVE PRIMARY TB**
- Local progression of parenchymal disease with development of cavitation within 1 year of infection
- May also see miliary disease
- Occurs in 5% of patients with primary disease
- Risk factors include HIV infection, extremes of age, large inoculum of mycobacteria
- Similar in appearance and course to postprimary disease

**POSTPRIMARY TB**
- Previous infection with retained acquired immunity
- Endogenous reactivation (common) or exogenous reinfection (rare)
- Lung foci reactivation most common, can occur at any seeded site
- Predilection for upper lung zones
- Local control accompanied by involved tissue destruction

**Disease Manifestations**
- Lymphadenopathy (rare)
- Bronchogenic spread
- Endobronchial disease
- Miliary disease
- Pleural disease
- Parenchymal disease

**Parenchymal Disease**
- Apical and posterior segments upper and superior segments lower lobes characteristic
- Ill defined area of opacity associated with nodular and linear components radiating outward from hilum or in periphery
- Opacities may coalesce
- Often associated with cavitation (20%-45%)
- May see air-fluid levels (10%-20%)
- Tuberculoma predominant manifestation in 3%-6%
Bronchogenic Spread

- Area of caseous necrosis liquefies and communicates with bronchial tree
- Seen in 20% of postprimary TB cases
- CXR
  - Multiple, ill-defined, 5-10 mm nodules in segmental or lobar distribution
- CT
  - 2-4 mm centrilobular nodules, sharply marginated linear branching opacities (tree-in-bud opacities)
  - 5-8 mm poorly defined nodules, lobular consolidation, interlobular septal thickening all less common

Endobronchial Involvement

- 2%-4% of persons with pulmonary TB
- Characterized by bronchial stenosis
- Main, upper and lower lobe bronchi account for 75% of involved sites
- CXR
  - Associated paracoronal opacities (17%) and suprarenal or lobar atelectasis (17%)
- CT
  - Irregular or smooth circumferential bronchial narrowing associated with mural thickening

Pleural Disease

- Effusion less common manifestation of postprimary disease (19% of cases)
- Rupture of cavity or subpleural parenchymal focus into pleural space
- May be radiographically occult
- May become tuberculous empyema
- Can erode into chest wall
- Residual calcified fibrothorax can result

Pleural Effusion

- Typically unilateral and loculated
- May see air-fluid level indicating bronchopleural fistula
- “Split-pleura” sign on CT
- Detection of persistent fluid within calcified fibrothorax should raise concern for active disease and chronic tuberculous empyema

Miliary Disease

(Same as primary TB)
Lymphadenopathy

- Uncommon manifestation of postprimary TB (5% - 10%)
- Combination of calcified hilar nodes and Ghon focus (aka Ranke complex) suggestive of previous TB
- Ranke complex and/or upper lobe fibrosis seen in ~20% - 40% of active postprimary disease
- Also seen in healed disease

HEALING OF TB

- Resorption of caseous material
- Deposition of collagen (fibrosis)
- Dystrophic calcification at sites of caseous necrosis
- Not reliable marker for lesion activity
- Complete resolution of parenchymal disease in 2/3
- Remaining 1/3 have scar that may calcify (15%)
- Calcified granulomas common, tuberculomas seen in 9%

ACTIVE vs INACTIVE

- Calcified lymph nodes and nodules and/or upper lobe fibrotic changes seen in 20%-40% of active postprimary disease
- Also seen in healed disease
- Radiographic determination of disease activity based on their presence unreliable

CT FINDINGS

<table>
<thead>
<tr>
<th></th>
<th>ACTIVE</th>
<th>INACTIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrilobular</td>
<td>92%</td>
<td>95%</td>
</tr>
<tr>
<td>branching opacities</td>
<td>71%</td>
<td>0%</td>
</tr>
<tr>
<td>Lobular consolidation</td>
<td>62%</td>
<td>35%</td>
</tr>
<tr>
<td>Acinar nodules</td>
<td>61%</td>
<td>47%</td>
</tr>
<tr>
<td>Cavity</td>
<td>36%</td>
<td>22%</td>
</tr>
<tr>
<td>Ground glass</td>
<td>35%</td>
<td>22%</td>
</tr>
</tbody>
</table>

**Although CT may be helpful in determination of disease activity, definitive diagnosis requires isolation and identification of MTb in clinical specimens**

RESPONSE TO TREATMENT

- Best assessed by repeated sputum examinations
- Baseline radiograph at completion of treatment useful
- Regression of radiographic abnormalities slow process
- May see worsening in 1st 3 months of treatment
- Parenchymal and nodal abnormalities regress in parallel
- Failure of improvement after 3 months suggests drug-resistant organisms or superimposed process (adults)
- Resolution requires from 6 months to 2 years
COMPLICATIONS

Bronchiectasis and residual cavities
Mycetoma formation +/- hemoptysis
Broncholithiasis (uncommon)
Pott's Disease
Pleural empyema +/- bronchopleural fistula
Scar carcinoma
Rasmussen aneurysm

MYCETOMA

TB OSTEOMYELITIS

SCAR CARCINOMA

RASMUSSEN ANEURYSM

Patankar et al. AJR 2000; 174: 262-263
BRONCHOLITHIASIS

Seo et al. Radiographics 2002;22:S199-S213

PREVENTATIVE THERAPY and TREATMENT

- Bacille Calmette-Guerin (BCG) vaccination
- Those at high risk of acquiring infection
- Chemoprophylaxis
- Prevent latent infection from progressing to active TB
- Highly effective, reduce risk up to 90%
- Patient groups include HIV infected, close contacts of active TB, recently diagnosed TB, patients with underlying medical conditions reported to increase risk of TB

KEY POINTS

<table>
<thead>
<tr>
<th>PRIMARY TB</th>
<th>POSTPRIMARY TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymph node enlargement</td>
<td>90% - 95%</td>
</tr>
<tr>
<td>Consolidation</td>
<td>70%</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>5% - 10%</td>
</tr>
<tr>
<td>Necrosis</td>
<td>10%</td>
</tr>
</tbody>
</table>

SUMMARY

- Understand transmission and pathogenesis of Mycobacterium tuberculosis (MTB)
- Know typical distributions and patterns of MTB
- Recognize imaging manifestations of MTB
- Appreciate complications of pulmonary MTB