Radiological Aspects of Pulmonary Tuberculosis in Immunocompetent Hosts

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Tuberculosis: “the captain of all (wo)men of death”

- Overall, one third of the world’s population is currently infected with TB
- 95% of TB cases occur in developing countries
- Over 8 million people become newly infected with TB each year
- 2 million deaths/year due to TB
- World-wide, someone is newly infected every second
- WHO estimates between 2002-2020, 1000 million people will be newly infected, 150 million people will get sick, and 36 million people will die of TB
Estimated TB incidence rates, 2000

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Mycobacterium Tuberculosis

- Aerobic, acid-fast bacilli
- Transmission through air-born particles containing 1-3 bacilli
- Infection when 1-5 bacteria deposited in terminal alveolus
- Develops in 10-15% of those exposed
- Lung primary site of disease in 80-84% cases in United States
Primary vs Post-Primary Disease

- **Primary tuberculosis**: Self-limited, mild pneumonic illness; often undiagnosed
  - Before development of cellular immunity, bacilli spread via lymphatics to hilar nodes and distant sites
  - With intact cell-mediated immunity, activated T-cells and macrophages form granulomas that limit spread of organism.
  - Following CMI, viable bacilli may remain dormant within granuloma

- **Post-primary (reactivation) TB**: In patients previously sensitized to TB bacilli. Most often from reactivation of latent infection. Much more aggressive disease.
Primary vs Post-Primary Disease

Transmission ➔ Primary Tuberculosis ➔ Latent Tuberculosis ➔ “Reactivation” Tuberculosis

Skin-test conversion in 6 to 8 weeks ➔ Spontaneous healing in 6 months ➔ Progression within 2 years, 5% ➔ Progression with concurrent HIV infection, 10% each year

Small, Fujiwara. NEJM 2001;345: 192.
Symptoms of Pulmonary TB

- Clinical manifestations variable depending on host and microbe
- Cough (most common symptom)
- Hemoptysis
- Fever (37-80% cases)
- Loss of appetite, weight loss, weakness, night sweats, malaise
Patient A

- 26 year old man with cough for 2 months and recent onset of flu-like symptoms presents to PCP
- Diagnosed with bronchitis and advised to take NyQuil and Sudafed
- Cough persisted with some rusty colored sputum
- Patient began to have cold sweats at night
- Returned to PCP for follow-up
- PCP obtained CXR
Patient A

- thick walled cavity in right upper lobe
- multiple coarse nodular densities in right upper lobe
Patient A: DDx for thick-walled cavitary lesion

- Tuberculosis
- Cavitating acute pneumonia (s. aureus or pseudomonas)
- Fungal disease
- Cavitating bronchogenic carcinoma
- Abscess (bacterial, septic, opportunistic)
- Metastasis
Patient A

- CT ordered but cancelled when PPD and sputum both came back positive
CXR: The mainstay of evaluation for pulmonary TB

**Primary TB:** 4 major ways seen on chest film

1) Parenchymal consolidation
2) Lymphadenopathy
3) Pleural effusion
4) Miliary disease
1) Parenchymal consolidation

- Pulmonary infiltrate seen in approximately 85% cases of primary disease
- Most often homogenous, ill-defined borders, and unifocal consolidation
- Often indistinguishable from typical bacterial pneumonia
- 25% cases have multi-lobar findings
- Over 50-60% occur in middle or lower lung zones
- In 2/3 cases, focus resolves without scar (6 mo-2yrs for clearing)
- Scar remains in 1/3 of cases: Ghon Focus (calcified primary nodule) or Simon focus (calcified secondary foci in lungs)
1) Parenchymal Consolidation

Primary TB in 14-yr old. Right upper lobe opacity, right hilar, and right paratracheal adenopathy

Primary TB in 40-yr old. Right lower lobe consolidation
2) Lymphadenopathy

• 90% cases of primary disease in children show hilar and/or mediastinal lymphadenopathy

• 10-43% cases in adults

• Enlarged nodes typically in hila and right paratracheal area

• Most often unilateral; bilateral in up to 31% cases

• Usually seen in association with lung consolidation

• Ranke Complex: calcified hilar node and calcified parenchymal lesion (Ghon focus)
2) Lymphadenopathy

Right paratracheal and right hilar adenopathy. Normal lungs.

Lymphadenopathy: Ranke Complex

Ghon focus: calcified nodule

Simon focus

Calcified hilar lymph nodes

McAdams HP, Erasmus J, Winter J. p659.
3) Pleural Effusion

- Usually late result of primary TB (3-7 months following exposure)
- Present in 10-40% cases in adults
- Nonspecific
- Most often unilateral
- Usually have resolution of effusion with therapy

Miller WT, Miller WT. p113.

34 year old. Primary TB. Main finding of left pleural effusion
4) Miliary TB

- Occurs in 1-7% of patients with all forms of TB-most likely a manifestation of primary disease
- Classic findings are diffuse small (2-3mm) nodular opacities
- 85% cases show even distribution of nodules with slight lower lobe predominance
- Associated with lymphadenopathy in 95% cases in children and 12% adult cases
- Associated with parenchymal consolidation in 42% cases in children and 12% adult cases
- Most commonly seen in HIV patients, elderly, children
Miliary TB

40 yr old man. Reticular opacities in both lungs. Film on right is taken 2 weeks later and shows more discrete nodules in left lung.

Post-Primary Tuberculosis: Distinguishing Features

1) Apical or posterior segment of upper lobe or superior segment of lower lobe
2) Cavitation: present in approximately 40% post-primary cases
3) Absence of lymphadenopathy
**Post-primary Disease**

- Heterogenous, poorly marginated opacity in apical or posterior segment of upper lobe or superior segment of lower lobe
- 88% cases have more than one pulmonary segment involved

Clumped nodular opacities in upper lobes. Right>left.

McAdams HP, Erasmus J, Winter J. p668.
Post-primary Disease: Cavitation

Miller WT, Miller WT.

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Post-primary TB: Cavitation

- No specific findings to indicate tuberculous cavity
- Thin walled or thick walled
- 9-21% cavities have air-fluid level
- 15-20% time associated with bronchogenic spread

McAdams HP, Erasmus J, Winter J. p669.
Active vs. Stable Disease

• Stable disease only determined by 6 months of unchanging x-rays and negative sputum cultures
• Radiographic findings cannot determine active vs. stable disease based on single CXR or CT
Stable or Active?

Multifocal calcifications suggest healing, stable lesions. However, state of disease cannot be determined from single image.

McAdams HP, Erasmus J, Winter J.
Limitation of CXR in TB

- CXR normal in up to 15% patients with sputum proven TB
- CXR not good in early stages of miliary TB
- CXR not good in HIV associated TB: normal in 14-40% cases of AIDS patients with culture positive sputum
Role of CT

• Many patients do not need CT in initial diagnosis
• CT more accurate in diagnosing primary TB
• Can detect subtle sites of parenchymal consolidation
• Can help identify and confirm lymphadenopathy
• Help diagnose miliary TB
• Can view bronchogenic spread as “tree in bud” lesions not seen on CXR
• Identify cavities not seen on CXR: CXR saw cavities in 22% patients vs. CT that found cavities in 58% patients
• Helpful in determining disease activity
Patient M

- 26 yr-old asymptomatic woman with history of TB
- Recently moved to Boston from Thailand
- Positive PPD
- CXR performed
Patient M

Ill-defined 2-cm diameter nodule in right upper lobe. Concerning for reactivation TB. Without access to any prior films, a CT is performed.
CT: cavitory right upper lobe nodule which communicates to bronchus
Patient M: Reactivation TB with bronchogenic spread in RUL

Tree in Bud Pattern: communication with bronchus

PACS, BIDMC


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