Most radiographic findings are not specific for a disease or even a pathologic process. CT is not a primary tool, but is increasingly used to detect and characterize infiltrates. Radiologists will benefit from increased understanding of the pathologic basis of radiographic findings. Correlation of imaging findings with pathologic findings is essential to improve the practice of radiology.

**Background and Aims**

- Begins peripherally and spreads centripetally
- **S. pneumoniae**, **K. pneumoniae**, & **H. influenzae**
- **CXR:**
  - Homogeneous air-space consolidation
  - Air-bronchogram
- **HRCT:** "ground-glass" attenuation (incomplete filling of alveoli)

**Lobar Pneumonia**

**Bronchopneumonia**

- Less rapid spread of infection & more virulent organisms
- **S. aureus**, **H. influenzae**, **P. aeruginosa**, and anaerobic bacteria
- **CXR:**
  - Multifocal and bilateral consolidation
  - Air-bronchogram usually absent
- **HRCT:** Centrilobular nodules and branching linear structures, air-space nodules, and multifocal lobular consolidation
Bronchopneumonia
Patchy and mainly peribronchiolar inflammation

Interstitial Pneumonia
- Alveolar disease absent or minimal (≠ Pneumocystis infection)
- *M. pneumoniae*, viruses and *Pneumocystis jirovecii*
- CXR:
  - Patchy or diffuse ground-glass opacity
  - Reticulation: alveolar interstitial thickening
- HRCT: Centrilobular nodules, bronchovascular thickening, “ground-glass” attenuation, lobular consolidation, and septal thickening

Miliary Infection
- Seeding of microorganisms present in the blood
- Organisms lodge within pulmonary capillaries
- *Mycobacterium tuberculosis*
- CXR:
  - Nodules 1 to 3 mm Ø, randomly distributed
- HRCT: Centrilobular nodules and branching linear opacities ("tree-in-bud"), air-space nodules, and septal thickening


From Reittner AJR 2000; 174:37-41
Forgie S et al. Semin Respir Crit Care Med 2009;30:67

From Franquet T. Eur Respir J 2001; 18:196-208
Lung Abscess
- Complication of a relatively localized focus of bronchopneumonia
- *Staphylococcus aureus, P. aeruginosa, and K. pneumoniae*
- **CXR:**
  - Rounded opacity w/wo air-fluid level
  - Irregular inner wall
- **HRCT:**
  - Spherical mass with a wall of irregular thickness.
  - Central low attenuation or a cavity
  - Air-fluid level (incomplete drainage)

Septic Embolism
- **Origin:** cardiac valves (endocarditis), peripheral veins (thrombophlebitis), and catheters or pacemaker wires
- Tricuspid valve endocarditis (IVDA)
- **CXR:**
  - Multiple bilateral nodules (0.5 to 3 cm)
  - Poorly defined margins and cavitation
- **HRCT:** wedge-shaped pleural-based areas of consolidation (infarction), “feeding vessel sign”, and hemorrhage

Pulmonary Infections
- **Immunocompetent**
- **Immunosuppressed**
  - Mildly Immunosuppressed

The spectrum of organisms and the clinicopathologic lesions differ between these two groups
Intracavitary Aspergilloma

6 months later

Intracavitary Aspergilloma (Ankylosing Spondylitis)

The “Tree-in-Bud”

Def: Centrilobular nodules and/or V-shaped or Y-shaped branching linear opacities that resemble a budding tree in spring time

Infectious Bronchiolitis

- Disorder of infants and children associated with viral (usually RSV) or mycoplasma infection
- Occasionally in adults

Diffuse Panbronchiolitis

- Progressive form of cellular bronchiolitis
- Japan and Eastern Asia
- Colonized with H. influenza & P. aeruginosa

Diffuse Panbronchiolitis

Histologically (typical triad):
- Peribronchiolar mixed inflammatory cell infiltrate
- Follicular bronchiolitis
- Foamy macrophages in interstitial and alveolar spaces

**Courtesy of M. Kawabata MD, Tokyo, Japan**
Viral Infection

- Bronchiolitis
- Alveolar Disease
- Nodules w/wo Hemorrhage

Bronchiolar exudate
Intrapulmonary eosinophilic exudate
Mucosal wall infiltration
Air-space hemorrhage & edema
Diffuse alveolar damage (DAD)
Nodule, exudate & hemorrhage

Vascular endothelium

- Bilateral interstitial infiltrates
- Moderate to rapid progression
- Bilateral alveolar infiltrates
- ARDS

Hantavirus Pulmonary Syndrome

Eosinophilic exudate
Mononuclear wall infiltration
Air-space hemorrhage & edema
Diffuse alveolar damage (DAD)
Hyaline membrane formation
Nodular areas of consolidation

Early HPS - Alveolar edema due to endothelial damage

Late HPS - DAD

Pulmonary Tuberculosis

- Primary
- Post-primary
  - Reactivation TB
  - Reinfection TB

The spectrum of organisms and the clinicopathologic lesions differ between these two groups.
A 67 year old woman

Mildly Immunocompromised

Semi-invasive Aspergillosis

Dx: rare form of pulmonary aspergillosis originating in mildly immunocompromised patients with underlying lung disease

- Clinical symptoms are nonspecific and often insidious
- The slow progression of clinical and radiographic findings (several months to years) may contribute to a delay in Dx
- HRCT findings:
  - Unilateral or bilateral parenchymal opacities
  - "Pseudopleural" thickening
  - Multiple nodular opacities with/without cavitation

Franquet T et al. AJR 2000

Immunocompromised
**Who is at risk?**

**Liver**

**Lung**

**Solid Organ Transplant**

**HIV**

**COPD**

**Burns**

**Renal**

**ICU**

**Neutropenia and HSCT**

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**Angioinvasive vs. Airway invasive**

**Angioinvasive:**
- "Nodule with halo": opaque nodule (≥ 1 cm) surrounded by a rim of "ground-glass" attenuation
- Wedge-shaped pleural based consolidation: pulmonary infarct

**Airway-invasive:**
- Peribronchiolar consolidation, small centrilobular nodules (< 1 cm), "ground-glass" opacities, and lobar consolidation

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**Angioinvasive Aspergillosis**

**"Wedge-shaped consolidation"**

- Segmental or subsegmental infarcts
- Similar to those due to bland pulmonary emboli

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**The “Air-Crescent Sign”**

**Def:** A collection of air in a crescentic shape that separates the wall of a cavity from an inner mass.

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**The “Halo Sign”**

**Def:** Ground glass opacity surrounding the circumference of a nodule or mass. Represents a focus of pulmonary infarction surrounded by alveolar hemorrhage
23 yo male with severe neutropenia & fever 12 days after HSCT

Airways-invasive Aspergillosis

Aspergillus bronchopneumonia

Non-Tuberculous Mycobacteria

Lady Windermere Syndrome

- *Mycobacterium avium* complex (MAC)
- Immunocompetent elderly women
- No significant smoking history or underlying pulmonary disease
- Right middle lobe or lingula

Non-Tuberculous Mycobacteria

Summary

Imaging techniques play an important role in the Dx of lung infections

Integration of clinical features, imaging (HRCT), and microbiology is mandatory

Correlation of imaging findings with pathologic findings is essential to improve the practice of radiology