Pulmonary Infection

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Pulmonary Infection

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Purpose

• Review imaging patterns of infection and findings that might help differentiate causative pathogens
• Gain a better understanding of possible causes of nonspecific "infectious/inflammatory" findings
Background

• Pneumonia is the most common cause of death due to infection in the United States
• Imaging studies are critical for diagnosis and management of pulmonary infections
• Imaging signs are frequently nonspecific and may also be manifestations of noninfectious disease
• Imaging signs may be useful in suggesting a specific diagnosis or narrowing the differential diagnosis
• Clinical data should be correlated with imaging to form an accurate diagnosis
Lobar pneumonia (focal nonsegmental pneumonia)

- Exudate begins in distal airspaces and spreads through interalveolar pores (pores of Kohn) in a centripetal pattern
- Relatively homogenous area of alveolar consolidation
- Characteristic relative sparing of bronchi (air bronchogram)
- Most common presentation of community acquired pneumonia due to Streptococcus pneumoniae
- Other causes include Klebsiella pneumoniae, Legionella pneumophila, Haemophilus influenzae, Mycobacterium tuberculosis
**Bronchopneumonia (lobular pneumonia)**

- Suppurative peribronchiolar inflammation manifests as ill-defined nodules, branching linear opacities, and multifocal lobular areas of consolidation.
- Most commonly due to *S. aureus*.
- Other causative pathogens include *Klebsiella pneumoniae*, *Hemophilus influenzae*, *Pseudomonas aeruginosa*, *Escherichia Coli*. 
Bronchopneumonia (lobular pneumonia)

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Interstitial pneumonia

• Interstitial pneumonia
  • Inflammation of cells in the interstitial tissue of the alveolar septa causing diffuse or patchy groundglass opacification
  • Can be caused by viral pneumonia, Mycoplasma, Chlamydia, or Pneumocystis
Streptococcus Pneumoniae

- Most common cause of community acquired pneumonia requiring hospitalization
- Risk factors include extremes of age, heart disease, lung disease, alcoholism, and splenectomy
- Abrupt onset with fever, chills, pleuritic chest pain
- Typical appearance is homogenous consolidation that crosses segmental boundaries but involves only one lobe (lobar pneumonia)
- Rarely manifests as spherical area of consolidation that mimics a mass (round pneumonia) most often in children
- Pleural effusion in up to ½ of cases
Staphylococcus

- Usually follows aspiration of organisms from upper respiratory tract
- Patchy or lobar dense consolidation
- Severe lung destruction with abscess formation
- Cavitation in 30%
- Frequently multifocal, bilateral in 40%
- Pleural effusion in 2/3
Haemophilus influenzae

• Normal upper respiratory tract flora
• 10-42% mortality rate
• Nonspecific pattern of consolidation with peripheral predilection
Actinomycosis

• Uncommon indolent infection resulting from aspiration of oropharyngeal or gastrointestinal secretions

• Nonspecific pattern of consolidation

• Focal or multifocal abscess formation

• Does not respect normal anatomic barriers
Nocardia

- Immunocompromised in 50%
- Can be acute, subacute, or chronic
- Hematogenous spread to other organs, most commonly CNS
- Variable imaging patterns, may be focal or multifocal
- May complicate alveolar proetinosis
Legionella

- One of most common causes of severe community acquired pneumonia in immunocompetent hosts
- Infection may occur when legionella contaminates water systems, such as air conditioners and condensers
- Peripheral airspace consolidation similar to that seen in S. Pneumoniae
- Imaging findings often lag behind clinical picture
- Pleural effusion common
Mycoplasma

- Most common **atypical** CAP of children and young adults
- Initially involves peribronchovascular interstitium, then extends to the adjacent alveoli
- Unilateral or bilateral patchy consolidation, nodular or reticular opacities
- Can cause bronchiolitis without pneumonia
Gram negative bacilli

- Pneumonias most commonly caused by Klebsiella, Enterobacter, Serratia, E. coli, Proteus, and Pseudomonas
- Patients are invariably affected by chronic medial or pulmonary disease
- Typically affects lower lobes
- Klebsiella is most common – cavitary (30-50%) with bulging fissure sign (nonspecific)
- Pseudomonas – most common cause of nosocomial pulmonary infection
Viral pneumonia

- Can be caused by a large number of viruses
- Radiograph – most common finding is peribronchial and interstitial thickening, particularly in children
- Sometimes consolidation or hemorrhage may develop
- CT findings may include mosaic attenuation, ground glass opacification and consolidation, centrilobular nodules, tree in bud, bronchial wall thickening
Mycobacterial pneumonia

- Indolent bacterial infection
- Often relapsing course
- Associated with fibrosis, calcification and adenopathy
- Increased susceptibility with impaired cellular immunity
- Primary: consolidation (any lobe) with adenopathy
- Miliary: diffuse nodules without adenopathy
- Reactivation: apical fibrosis, cavitaiton, calcification
Fungal Infections

• Pathogenic fungi – can infect any host
  • Coccidiomycosis, blastomycosis, histoplasmosis

• Saprophytic fungi – infect only immunocompromised hosts
  • Pneumocystis, candidiasis, mucormycosis, and aspergillosis
Aspergillus

- Saprophytic fungus
- Different forms depending on immune response
- Categorized into saprophytic, allergic, and invasive forms
  - Mycetoma- saprophytic growth which colonizes preexisting lung cavity
  - Allergic bronchopulmonary aspergillosis – hypersensitivity reaction which occurs in the major airways
  - Angioinvasive aspergillosis is seen in immunocompromised hosts with severe neutropenia – invasion of small to medium pulmonary arteries and development of hemorrhagic nodules or infarcts
Halo sign- angioinvasive aspergillosis

- Peripheral rim of ground glass surrounding a nodule or mass
- Highly suggestive of angioinvasive aspergillosis setting of fever and neutropenia
- Ground glass represents hemorrhage surrounding infarcted lung
- Other infectious etiologies include mucormycosis, Candida, Pseudomonas, HSV, and CMV, and septic emboli
- Noninfectious causes include Wegener granulomatosis, hemorrhagic metastasis, and Kaposi sarcoma
Air Crescent – angioinvasive aspergillosis

- Crescent of air separates a mass or nodule from the cavity wall
- Also seen in angioinvasive aspergillosis
- Good prognostic indicator
- Represents necrotic retracted lung tissue separated from peripheral viable lung tissue
Monad sign - mycetoma

• Seen in immunocompetent host
• Fungal ball develops in a preexisting lung cavity
• preexisting lung cavity, usually from TB or sarcoidosis
Finger in Glove – Allergic bronchopulmonary aspergillosis

- Represents dilated bronchi with impacted mucus
- Branching endobronchial oacities that course alongside neighboring pulmonary arteries
- Classically associated with ABPA which is seen in patients with asthma and cystic fibrosis
- May also be seen with endobronchial tumor, bronchial atresia, and postinflammatory bronchiectasis
Pneumocystis

- Saprophytic fungus, affects immunocompromised individuals
- Radiograph- diffuse bilateral perihilar consolidation
- CT – diffuse ground glass, can have a crazy paving appearance
- Lung cysts (10-34%) due to tissue invasion and secondary necrosis - upper lobe predominant
- Chronic PCP can cause architectural distortion and cronicchiectasis
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Tree in Bud

• Indicates infectious bronchiolitis
• Small airways or terminal bronchioles become indirectly visible when filled with mucus, pus, fluid, or cells
• Initially described in endobronchial tuberculosis but may be an imaging manifestation of various infections caused by bacteria, fungi, parasites, and viruses
• Rare cause of tree in bud appearance is infiltration of the small pulmonary arteries/arterioles
Cavitary nodules

• Suspicious for septic emboli due to infective endocarditis in the setting of illicit drug use, peripheral venous thrombophlebitis, or central venous catheter
• Can also be seen in mycobacterial or fungal infection
• Noninfectious etiologies include metastases, Wegener's granulomatosis or lymphoma
Pneumatoceles

- May be ventilator induced or post-infectious
- Air filled lucencies associated with a recent infection - increase over days to weeks and regress after weeks or months
- Due to obstruction of an airway due to the ball-valve mechanism
- Multiple possible pathogens
- S. aureus most common
Lymph node necrosis

- Tuberculosis, nocardiosis, and candidiasis should be considered
Inhomogeneous enhancement and cavitation

- Suggestive of necrotizing infection—upt to 7% of bacterial pneumonia
- Often seen before frank abscess formation
- Evident as geographic area of hypoenhancing lung parenchyma
- Cavitation may be the result of suppurative or caseous necrosis or lung infarction.
- Suppurative necrosis occurs with infections by S. aureus, anaerobes, and gram negative bacteria
- Drainage may be counterproductive, as opposed to abscess
Abscess

- Occurs from liquefactive necrosis
- Air fluid level – can also be seen in empyema with bronchopleural fistula
- Lung abscess associated with aspiration pneumonia, necrotizing pneumonia, or septic pulmonary emboli
- Organisms prone to abscess formation include S. aureus, Klebsiella, Pseudomonas, and Proteus
Abscess vs. empyema

Abscess
- Round in all projections
- Forms acute angle with chest wall
- Abruptly interrupt bronchovascular structures
- Thick irregular walls

Empyema
- Lentiform shape
- Obtuse angles
- Distorts and compresses adjacent lung
- Usually smooth wall
- Split pleura sign
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- Split pleura sign
Reverse Halo sign

- Peripheral rim of consolidation surrounding ground glass opacification
- Relatively specific for organizing pneumonia
- Can also be a sign of fungal pneumonia or paracoccidiomycosis
- Highly suggestive of angioinvasive Aspergillosis in setting of neutropenia
- When associated with nodular walls and a pattern of endobronchial spread, tuberculosis should be considered
- Several additional noninfectious causes
Crazy paving

- Combination of ground glass opacification and smooth interlobular septal thickening
- Characteristically in pulmonary alveolar proteinosis
- Infectious causes include PCP, bacterial, viral, TB
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