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KEY FACTS

TERMINOLOGY

- Viral infection may involve airways &/or lung parenchyma (alveoli, interstitium)
- Bronchiolitis: Acute inflammation & necrosis of epithelial cells lining small airways with ↑ mucus production
 - Classically < 2 years of age
- Other terms: Viral pneumonia, lower respiratory tract infection, peribronchial pneumonia




IMAGING

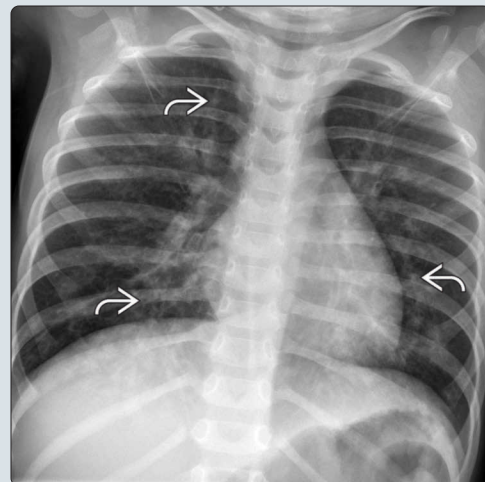
- Primary goal of chest radiography: Differentiate viral airway infection from bacterial pneumonia (which requires antibiotics)
 - 92% negative predictive value for bacterial pneumonia
- Best imaging clues for viral airway infection
 - ↑ peribronchial markings
 - Radiating linear rope-like or "dirty" perihilar opacities
 - "Doughnuts" of circumferentially thickened bronchial walls (viewed in cross section)


- Hyperinflation: Depression of hemidiaphragms with downward sloping on lateral view; ↑ AP chest diameter on lateral view; ± convex bulging of lungs between ribs
- Subsegmental atelectasis, possibly multifocal
- Lack of focal/lobar consolidation or pleural effusion
- Best imaging clues for viral parenchymal involvement
 - Interstitial, nodular, or patchy ground-glass opacities

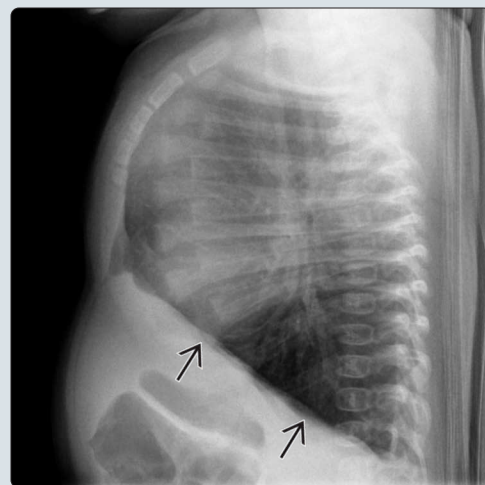
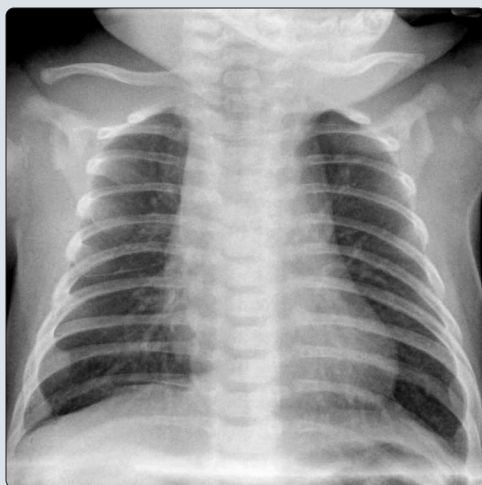
CLINICAL ISSUES

- Pathogens detected in hospitalized pediatric pneumonia patients: Viral 73%, bacterial 15%
- Most common viral etiologies differ by age
 - RSV < 2 years, rhinovirus > 2 years
- Treatment
 - Antibiotics for concomitant bacterial infection
 - Nebulized hypertonic saline in hospitalized infants may shorten length of stay
 - Antiviral therapy for influenza cases

(Left) AP radiograph in a wheezing child shows typical findings of viral airways disease. There are mildly increased perihilar markings with an increased number of "doughnuts" (thickened bronchial walls viewed in cross section) . The lungs show convex bulging between ribs , typical of hyperinflation. **(Right)** AP radiograph shows viral airways disease with increased perihilar markings of bronchial wall edema . There is no focal lung consolidation or pleural effusion.



(Left) AP radiograph in a wheezing child shows hyperinflated lungs with increased rope-like perihilar markings, consistent with viral airways disease. There is no focal lung consolidation. **(Right)** Lateral radiograph in the same patient shows marked hyperinflation with flattening of the hemidiaphragms  (much more evident than on the corresponding frontal view) & widening of the AP diameter of the chest. Also note the increased markings radiating from the hila.



TERMINOLOGY

Definitions

- Terminology varies, can be confusing
- Bronchiolitis (as defined by American Academy of Pediatrics): Viral lower respiratory tract infection in infants with "acute inflammation, edema, & necrosis of epithelial cells lining small airways," & ↑ mucus production
- Lower respiratory tract infection may describe findings identical to bronchiolitis in patients ≥ 2 years old but may also refer to any infection of lower airways & parenchyma
- Viral pneumonia may refer to viral infection of lung parenchyma ± airways infection
- Peribronchial pneumonia sometimes used to differentiate airways infection from parenchymal involvement
- Lower airways disease includes viral airways infection as well as asthma

IMAGING

General Features

- Best diagnostic clue
 - ↑ Peribronchial markings with symmetric hyperinflation

Radiographic Findings

- Primary goal: Differentiate viral airways infection from bacterial pneumonia
- Small airways viral infection
 - Lack of focal dense geographic, round, or "fluffy" lung consolidation (hallmark of bacterial infection)
 - ↑ peribronchial markings/↑ number of visible bronchi
 - Symmetric, coarse linear markings radiating from hila
 - ↑ thickness of bronchial walls appearing as doughnuts in cross section
 - Central lungs may appear dirty or busy
 - Hila may appear prominent on lateral view
 - Somewhat subjective finding
 - Hyperinflation
 - Hyperlucency
 - Depression of diaphragm > 10 posterior ribs or > 6 anterior ribs
 - Flattening/downward sloping hemidiaphragms (best seen on lateral view)
 - ↑ AP chest diameter (in infants, chest wider than tall on lateral view)
 - ± convex bulging of lungs between ribs
 - May not be seen > 2 years old: Bronchi larger, less prone to narrowing or obstruction with inflammatory change
 - Subsegmental atelectasis
 - Wedge-shaped or triangular opacity, often narrow
 - Most common in mid or lower lung
 - Often multifocal
 - Commonly misinterpreted as suspicious for bacterial pneumonia
- Parenchymal involvement
 - Interstitial nodular or patchy opacities
 - Lobar consolidation rarely occurs
 - Associated findings of airways infection
- Mild hilar lymphadenopathy
 - Not alarming in this setting (unlike adults)

- Gas-distended bowel loops in upper abdomen, typically due to air swallowing

CT Findings

- Not used primarily to make diagnosis of viral disease but may be obtained in patient with unclear clinical/imaging presentation
- Small airways viral infection
 - Prominent, ill-defined hila & peribronchial markings radiating into lung
 - Bronchial & bronchiolar wall thickening
 - Mosaic attenuation: Patchy heterogeneity of attenuation due to hypoventilation & air-trapping from obstruction/narrowing
 - Ground-glass opacities
 - Tree-in-bud nodules
- Parenchymal involvement
 - Interlobular septal thickening
 - Patchy, ill-defined consolidation
 - Nodules, micronodules
 - ± findings of small airways infection
- Mild hilar lymphadenopathy

Imaging Recommendations

- Best imaging tool
 - Chest radiographs (frontal & lateral)
 - Performance in identifying/excluding bacterial pneumonia
 - Positive predictive value: 30%
 - Negative predictive value (NPV): 92%
 - Goal: Antibiotic therapy for all children with bacterial pneumonia while minimizing unnecessary antibiotic administration (for isolated viral infection)
 - High NPV of chest radiograph helpful
 - Difficult to differentiate viral from bacterial pneumonia (i.e., lung parenchymal infection) on imaging
 - One study showed lobar infiltrate in 15% of exclusively viral pneumonia & exclusively interstitial infiltrate in 28% with bacterial pneumonia

DIFFERENTIAL DIAGNOSIS

Bacterial Pneumonia

- Focal/lobar lung consolidation > interstitial infiltrate
 - Confluent geographic, round, or fluffy opacities
- Lack of ↑ peribronchial markings, hyperinflation
- Pleural effusions more common with bacterial infection

Asthma

- ↑ peribronchial markings & hyperinflation
 - Inflammation of small airways common to asthma & viral disease
- Primary asthma diagnosis difficult to establish in young children

Bronchial Foreign Body

- May present with wheezing very similar to viral disease
- Asymmetric hyperinflation characteristic
 - Affected lung volume static throughout respiratory cycle
- Foreign body often radiographically occult

Left-to-Right Cardiovascular Shunts

- In infants, left-to-right shunts may have similar appearance
 - ↑ pulmonary arterial flow may mimic ↑ peribronchial markings
 - ± hyperinflation
- Shunts have associated cardiomegaly

Miliary Tuberculosis

- Diffuse small nodules, thickened interlobular septa
- Lymphadenopathy, may be low in attenuation
- History of sick contact with TB
- Very uncommon in young children

PATHOLOGY**General Features**

- Etiology
 - Acute inflammation & necrosis of epithelial cells lining small airways with ↑ mucus production
 - ↓ caliber of small, relatively compliant airway lumina significantly ↑ resistance to airflow in infants
 - Occlusion of airways results in hyperinflation & foci of subsegmental atelectasis
 - Parenchymal findings vary: Interstitial pneumonitis with lymphocytic infiltration, infection of alveolar epithelium, diffuse alveolar damage, desquamation of pneumocytes, hyaline-membrane formation, alveolar hemorrhage
 - Typical pathogens
 - Bronchiolitis: RSV > rhinovirus, adenovirus, influenza > coronavirus, human metapneumovirus (hMPV), parainfluenza
 - ◻ Multiple viruses in up to 25%
 - Hospitalization-inducing community acquired pneumonia: RSV, rhinovirus > hMPV, adenovirus, *Mycoplasma pneumoniae*, parainfluenza, influenza, coronavirus, *Streptococcus pneumoniae*, *Staphylococcus aureus*, *Streptococcus pyogenes*

CLINICAL ISSUES**Presentation**

- Signs & symptoms
 - Bronchiolitis: Rhinorrhea, cough, tachypnea, wheezing, rales, ↑ respiratory effort (grunting, nasal flaring, intercostal/subcostal retractions)
 - Community-acquired pneumonia: Cough, fever, anorexia, dyspnea, wheezing (up to 62%)
- Difficult to differentiate bacterial from viral parenchymal infection based on physical exam or laboratory tests
 - Procalcitonin level may have diagnostic role: NPV of 95% for bacterial infection if < 2 ng/ml

Demographics

- Age
 - Typical, striking radiographic findings of viral disease more often in young children (< 5 years of age)
- Epidemiology
 - Bronchiolitis: Most common cause of hospitalization in 1st year of life
 - Viruses cause majority of chest infections in preschool children (4 months-5 years of age)
 - < 2 years old: RSV most common

- Typical in late autumn, winter
 - > 2 years old: Rhinovirus most common
 - ◻ Typical in autumn, spring
- Pneumonia-related hospitalization from multicenter prospective study
 - Greatest in children < 5 years old
 - Viral in 73%, bacterial in 15%
- Predisposing conditions for more severe viral chest infections: Age < 6 months, prematurity, congenital heart disease, immunosuppression/immunodeficiency, asthma

Natural History & Prognosis

- Resolution of symptoms over time, typically days to weeks

Treatment

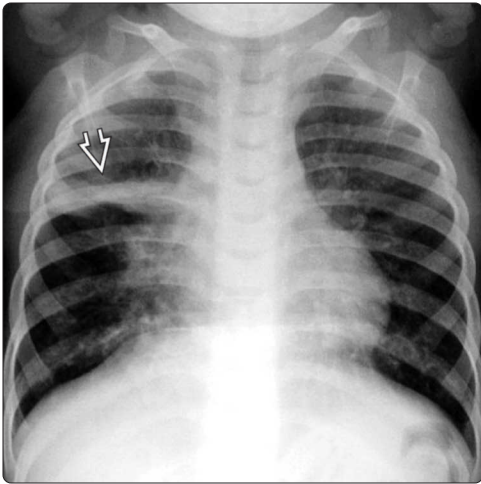
- Antibiotics for concomitant bacterial infection only (not isolated viral infection)
- Bronchiolitis
 - Nebulized hypertonic saline in infants may shorten hospitalization by increasing mucociliary clearance
 - Oxygen supplementation if saturations < 90%
 - Palivizumab (RSV prophylaxis, not vaccine): Given in 1st year of life to infants born before 29 weeks gestation or infants with hemodynamically significant heart disease or chronic lung disease of prematurity
 - Routine use of albuterol & nebulized epinephrine not recommended
 - Corticosteroid use not supported
- Clinical pneumonia with viral pathogen
 - Hospitalization if hypoxemia or respiratory distress
 - Antiviral therapy for influenza cases

DIAGNOSTIC CHECKLIST**Consider**

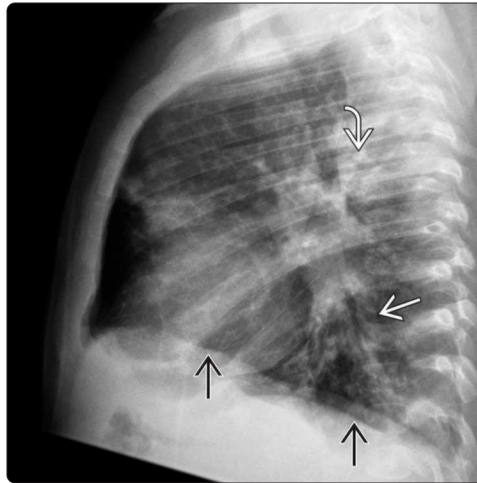
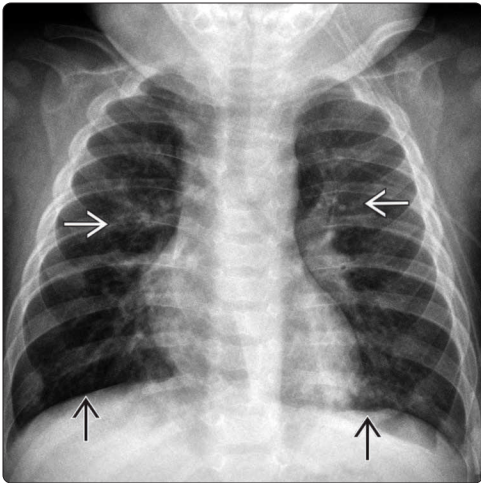
- Consider aspirated foreign body if lung volumes asymmetric

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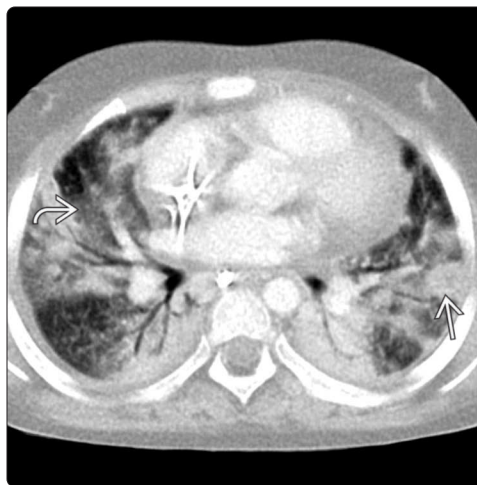
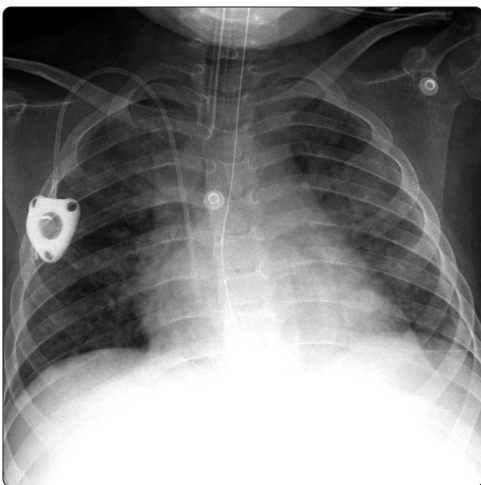
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(Left) AP radiograph in a child with viral illness shows symmetric hyperinflation, increased peribronchial markings, & a linear band of atelectasis in the right upper lobe. **(Right)** Axial CECT from a 25-year-old man with known influenza A infection shows tree-in-bud opacities in the right lower lobe, consistent with impaction of inflamed airways (bronchioles) by mucus or cells.



(Left) Frontal chest radiograph of a 5-month-old patient with cough & difficulty breathing shows bilateral "dirty" perihilar peribronchial opacities & lung hyperinflation with diaphragm depression, consistent with bronchiolitis. **(Right)** Lateral radiograph from the same patient shows linear opacities extending from the hila, thickened bronchial walls, & downward sloping of the flattened hemidiaphragms. Note the widened AP dimension of the chest.



(Left) AP chest radiograph of a 7-year-old girl with influenza A infection shows bilateral pulmonary opacities superimposed on bronchial wall thickening, consistent with viral parenchymal & airways disease. **(Right)** Axial CECT from the same patient shows bilateral patchy, consolidative & ground-glass opacities, which can be seen with influenza A chest infection.