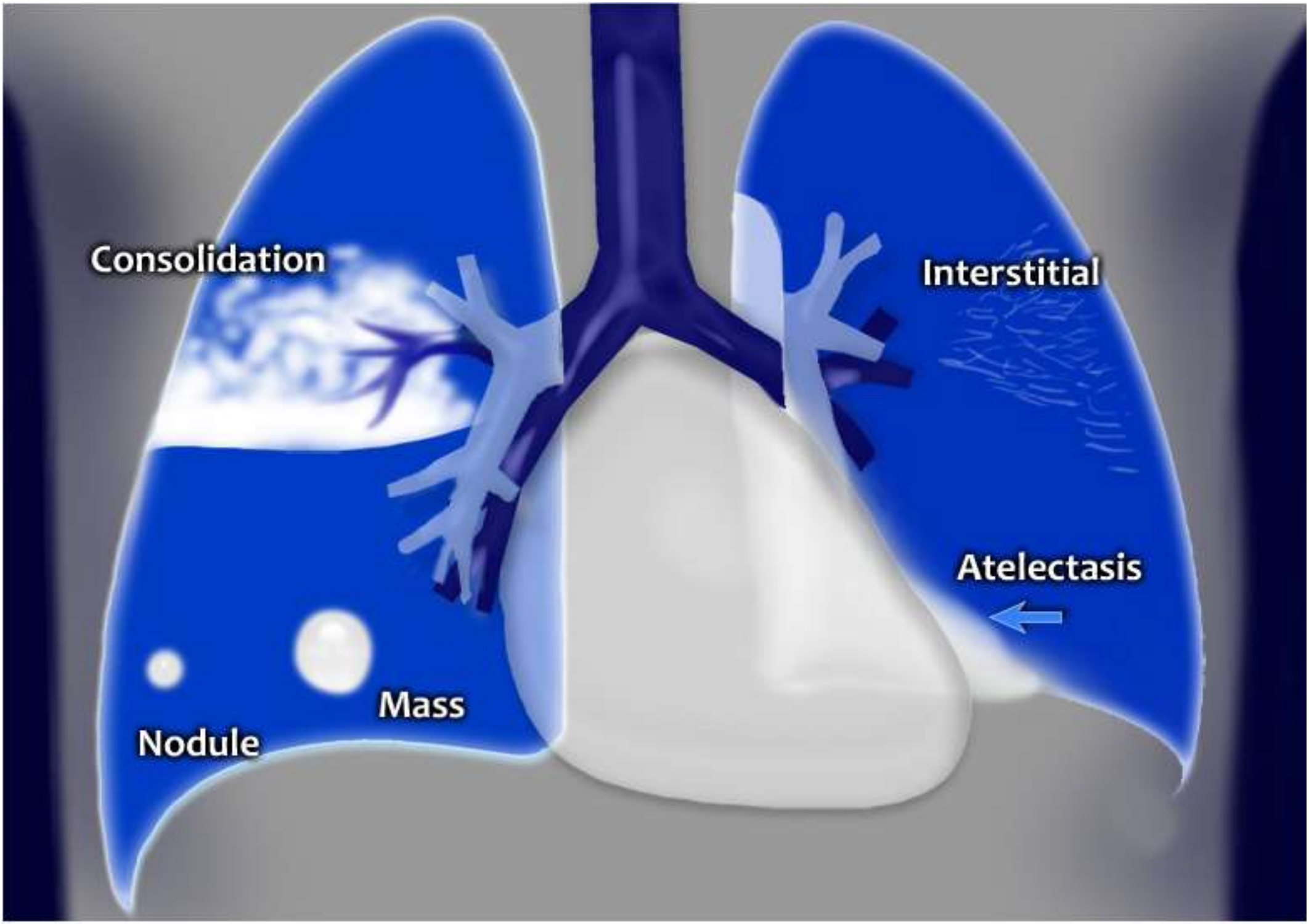
PNEUMONIA

Majid Keivamfar M.D
Pediatric Pulmonologist

ETIOLOGY

Pneumonia is an infection of the lower respiratory tract that involves the airways and parenchyma with consolidation of the alveolar spaces.


Consolidation
Interstitial
Atelectasis
Mass
Nodule

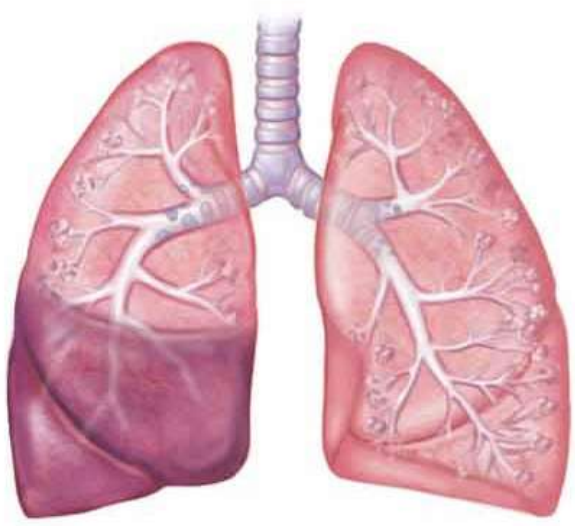
The term
lower respiratory tract infection
is often used to encompass
bronchitis,
bronchiolitis,
pneumonia,
or any combination of the three.

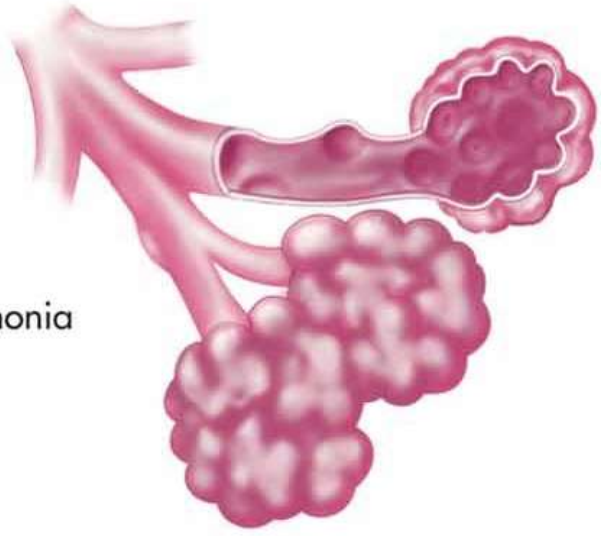
Pneumonitis

is a general term for lung inflammation that may or may not be associated with consolidation.

Lobar pneumonia

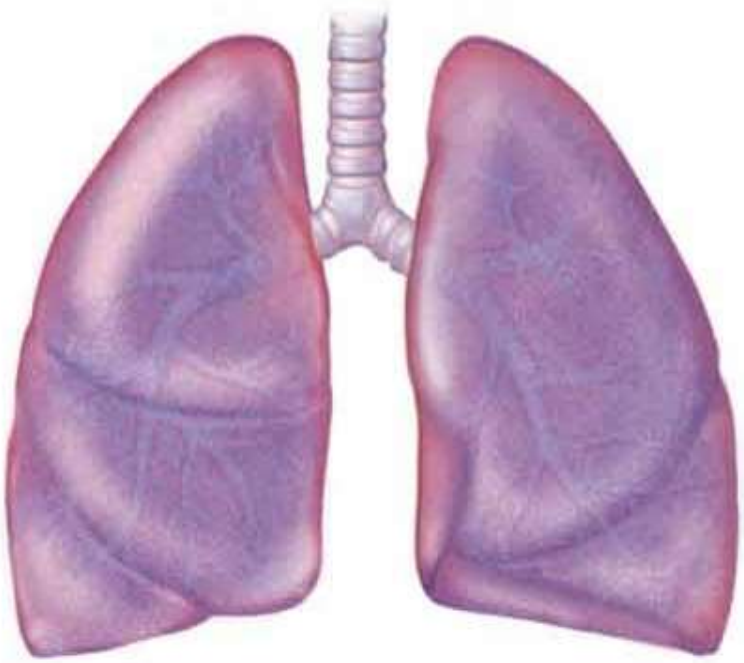
describes pneumonia localized to one or more lobes of the lung.

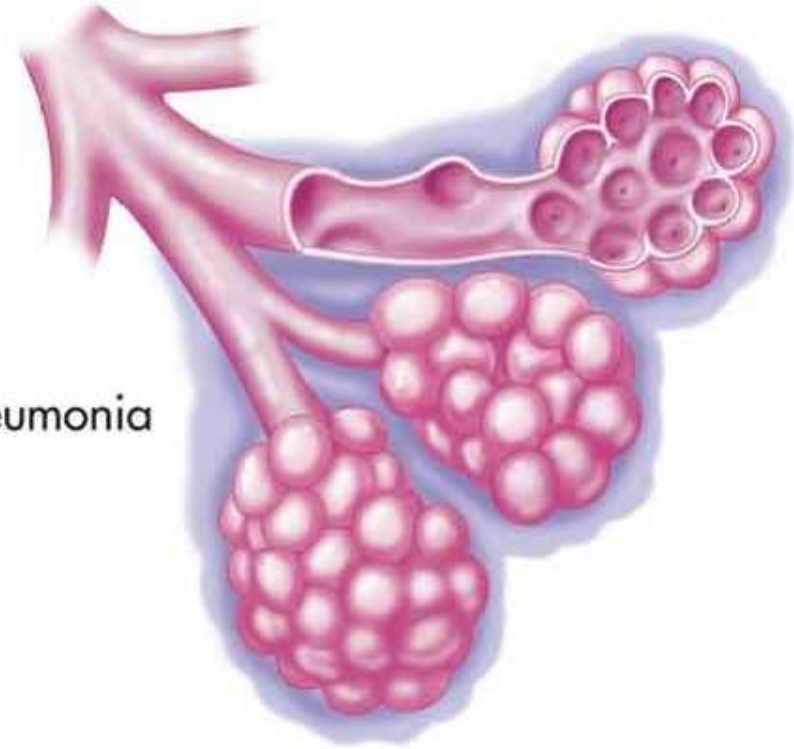




B. Lobar pneumonia

Atypical pneumonia
describes patterns typically
more diffuse or interstitial
Than lobar pneumonia.

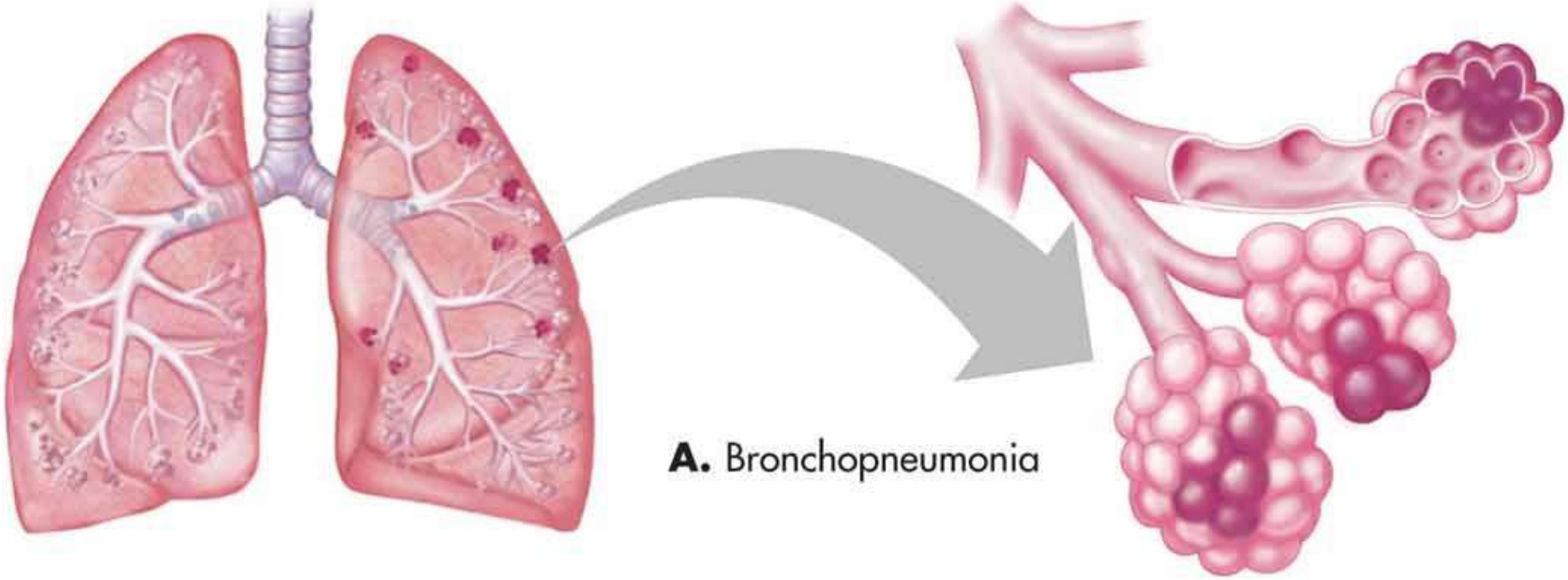


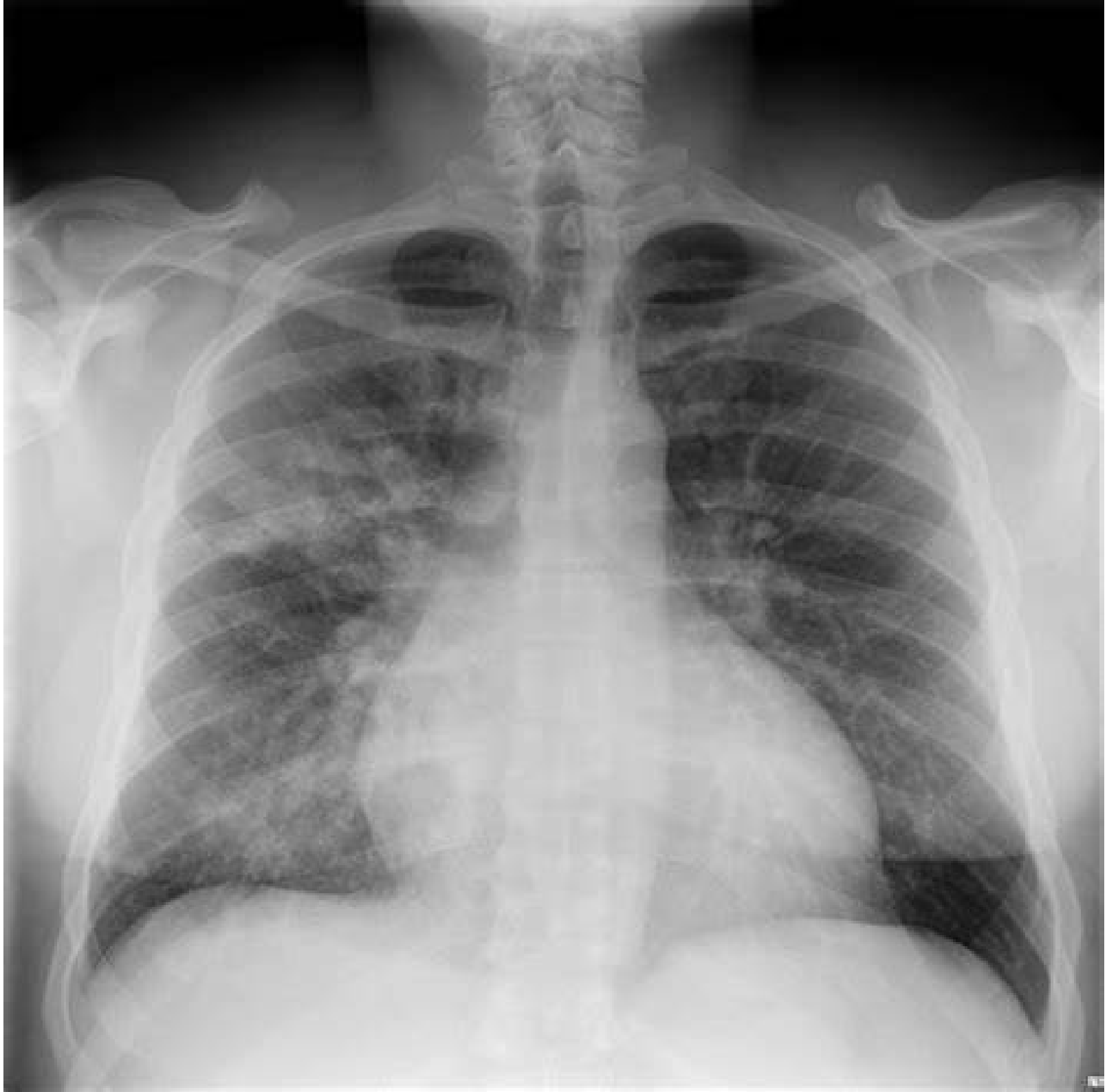


C. Interstitial pneumonia

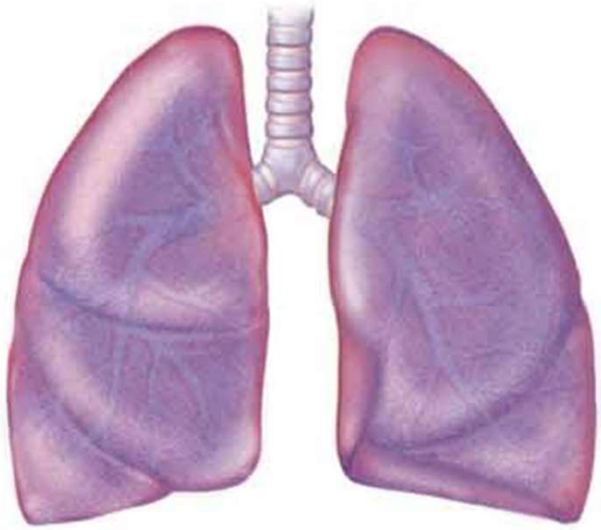
Bronchopneumonia

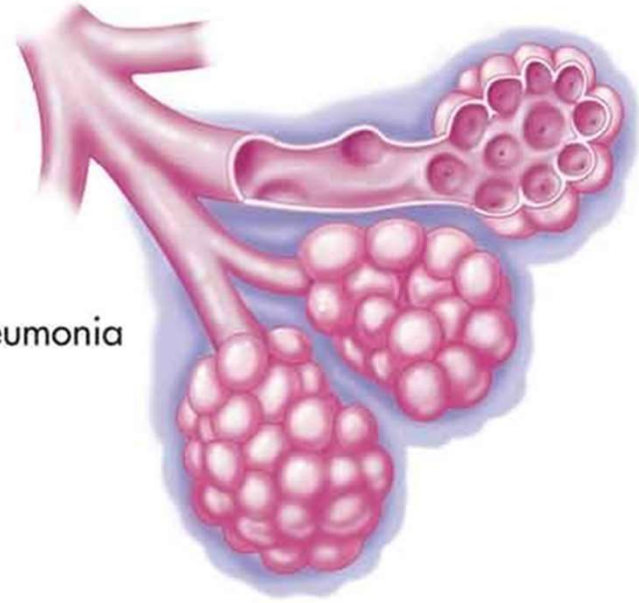
refers to inflammation of the lung that is centered in the bronchioles and leads to the production of a mucopurulent exudate that obstructs some of these small airways and causes patchy consolidation of the adjacent lobules.



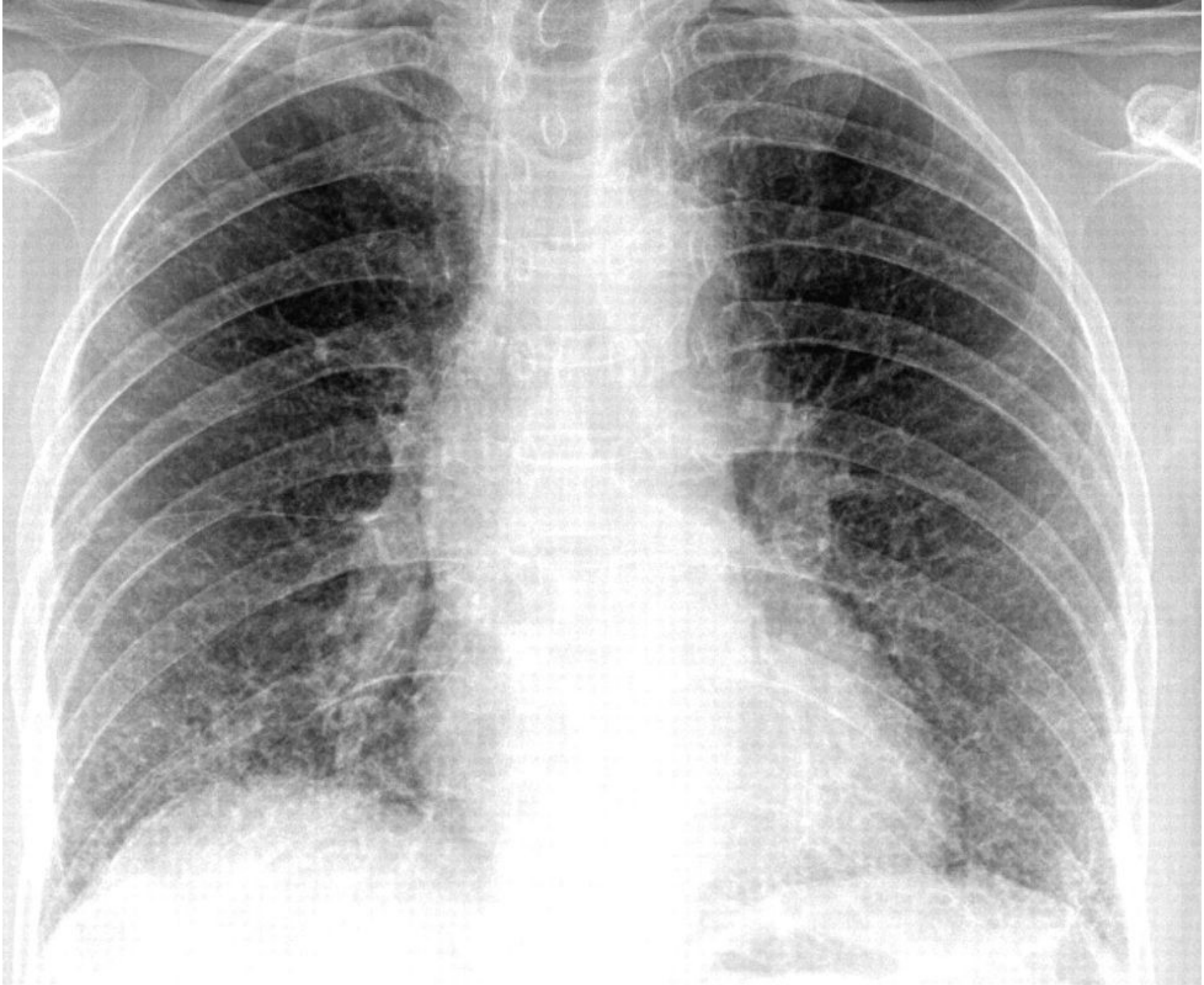


Interstitial pneumonitis refers to inflammation of the interstitium, which is composed of the walls of the alveoli, the alveolar sacs and ducts, and the bronchioles. Interstitial pneumonitis is characteristic of acute viral infections but also may be a chronic inflammatory or fibrosing process.





C. Interstitial pneumonia



AGE GROUP	COMMON PATHOGENS* (IN APPROXIMATE ORDER OF FREQUENCY)	LESS COMMON PATHOGENS
Neonates (up to 1 month of age)	Group B streptococcus, *Escherichia coli*, other gram-negative bacilli, *Streptococcus pneumoniae*	Cytomegalovirus, Herpes simplex virus, *Listeria monocytogenes*, *Treponema pallidum*, *Haemophilus influenzae* (type b,§ nontypable)

OUTPATIENTS† (7–10 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING HOSPITALIZATION‡ (10–14 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING INTENSIVE CARE*,‡ (10–14 DAYS TOTAL DURATION OF TREATMENT)
Outpatient management not recommended	Ampicillin *plus* cefotaxime or an aminoglycoside *plus* an antistaphylococcal agent if *Staphylococcus aureus* is suspected	Ampicillin *plus* cefotaxime or an aminoglycoside *plus* an antistaphylococcal agent if *S. aureus* is suspected

1 to 3 months			
Febrile pneumonia	Respiratory syncytial virus, other respiratory viruses (parainfluenza viruses, influenza viruses, adenoviruses), *S. pneumoniae*, *H. influenzae* (type b,[§] nontypable)		
Afebrile pneumonia	*Chlamydia trachomatis*, *Mycoplasma hominis*, *Ureaplasma urealyticum*, cytomegalovirus *Bordetella pertussis*		
	OUTPATIENTS[†] (7–10 DAYS TOTAL DURATION OF TREATMENT)	**PATIENTS REQUIRING HOSPITALIZATION[‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)**	**PATIENTS REQUIRING INTENSIVE CARE[*,‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)**
	Initial outpatient management not recommended	Amoxicillin or ampicillin if fully immunized for age for *S. pneumoniae* and *H. influenzae* type b. Alternatives: cefotaxime or ceftriaxone if not fully immunized or local *S. pneumoniae* penicillin resistance is significant, with clindamycin if MRSA suspected	Cefotaxime or ceftriaxone *plus* nafcillin, oxacillin, clindamycin, or vancomycin

3 months to 5 years	Respiratory syncytial virus, other respiratory viruses (parainfluenza viruses, influenza viruses, human metapneumovirus adenoviruses), *S. pneumoniae*, *H. influenzae* (type b,[§] nontypable)	*C. trachomatis*, *Mycoplasma pneumoniae*, *Chlamydophila pneumoniae*, group A streptococcus, *Staphylococcus aureus*, *Mycobacterium tuberculosis*

OUTPATIENTS[†] (7–10 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING HOSPITALIZATION[‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING INTENSIVE CARE[*,‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)
Amoxicillin *plus* erythromycin, azithromycin, or clarithromycin if atypical pneumonia suspected	Ampicillin Alternatives: cefotaxime or ceftriaxone if not fully immunized or local *S. pneumoniae* penicillin resistance is significant, with clindamycin if MRSA suspected; Add erythromycin, azithromycin, or clarithromycin if atypical pneumonia suspected	Cefuroxime or ceftriaxone *plus* azithromycin, erythromycin or clarithromycin *with or without* clindamycin or vancomycin

5 to 18 years	*M. pneumoniae, S. pneumoniae, C. pneumoniae,*	*H. influenzae* (type b,[§] nontypable), influenza viruses, adenoviruses, other respiratory viruses

OUTPATIENTS[†] (7–10 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING HOSPITALIZATION[‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING INTENSIVE CARE[*,‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)
Amoxicillin *or* erythromycin, azithromycin, or clarithromycin if atypical pneumonia suspected	Ampicillin *plus* erythromycin, azithromycin, or clarithromycin if atypical pneumonia suspected	Cefuroxime or ceftriaxone *plus* azithromycin, erythromycin or clarithromycin *with or without* clindamycin or vancomycin

≥18 years[§]	*M. pneumoniae, S. pneumoniae, C. pneumoniae, H. influenzae* (type b,[§] nontypable), influenza viruses, adenoviruses,	*Legionella pneumophila, M. tuberculosis*

OUTPATIENTS[†] (7–10 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING HOSPITALIZATION[‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)	PATIENTS REQUIRING INTENSIVE CARE[*,‡] (10–14 DAYS TOTAL DURATION OF TREATMENT)
Amoxicillin, *or* erythromycin, azithromycin, clarithromycin, doxycycline, moxifloxacin, gatifloxacin, levofloxacin, or gemifloxacin[‖] if atypical pneumonia suspected	Ampicillin *plus* erythromycin, azithromycin, or clarithromycin if atypical pneumonia suspected *or* moxifloxacin, gatifloxacin, levofloxacin, or gemifloxacin	Cefotaxime or ceftriaxone, *plus either* azithromycin or clarithromycin *with or without* clindamycin or vancomycin *or* moxifloxacin, gatifloxacin, levofloxacin, or gemifloxacin *with or without* clindamycin or vancomycin

Causes of pneumonia in immunocompromised persons include :

- ✓ gram-negative enteric bacteria
- ✓ mycobacteria (*M.avium complex*)
- ✓ *fungi (aspergillosis)*
- ✓ *viruses (CMV)*
- ✓ *Pneumocystis jiroveci (carinii)*

Pneumonia in patients with cystic fibrosis usually is caused by

- *Staphylococcus aureus*
- *Pseudomonas aeruginosa*
- *Burkholderia cepacia*

Risk factors for lower respiratory tract infections include:

- ✓ gastroesophageal reflux
- ✓ neurologic impairment (aspiration)
- ✓ immunocompromised states
- ✓ anatomic abnormalities of the respiratory tract
- ✓ residence in residential care facilities
- ✓ hospitalization, especially in ICU

CLINICAL MANIFESTATIONS

Age is a determinant in the clinical manifestations of pneumonia.

Neonates may have fever or hypoxia only, with subtle or absent physical examination findings .

With a young infant, apnea may be the first sign of pneumonia.

Fever, chills, tachypnea, cough, malaise, pleuritic chest pain, retractions, and apprehension, because of difficulty breathing or shortness of breath, are common in older infants and children.

Physical examination findings cannot reliably distinguish viral and bacterial pneumonias, but complete physical examination may help identify other foci of disease or associated findings to suggest an etiology.

In general viral pneumonias are associated more often with cough, wheezing, or stridor; fever is less prominent than with bacterial pneumonia.

Mucosal congestion and upper airway inflammation suggest a viral infection.

Bacterial pneumonias
typically are associated with
higher fever,
chills,
cough,
dyspnea,
and auscultatory findings
of lung consolidation.

Atypical pneumonia in young infants is characterized by tachypnea, cough, crackles on auscultation, and concomitant (chlamydial) conjunctivitis (infants) may be present.

Other signs of respiratory distress include nasal flaring, intercostal and subcostal retractions, and grunting.

LABORATORY AND IMAGING STUDIES

Bacterial flora of the upper respiratory tract do not accurately reflect flora present in lower respiratory tract infections, and high-quality sputum is rarely obtainable from children.

In otherwise healthy children without life-threatening disease, invasive procedures to obtain lower respiratory tissue or secretions usually are not indicated.

Serologic tests are not useful for the most common causes of bacterial pneumonia.

The white blood cell (WBC) count with viral pneumonias is often normal or mildly elevated, with a predominance of lymphocytes,

whereas with bacterial pneumonias the WBC count is elevated (>٢٠٠٠٠/mm^3) with a predominance of neutrophils.

Mild eosinophilia is characteristic of infant *C. Trachomatis* pneumonia.

Blood cultures are positive in ١٠% to ٢٠% of bacterial pneumonia and are considered to be confirmatory of the cause of pneumonia.

Urinary antigen tests are especially useful for *L.pneumophila* (*legionnaires' disease*).

Viral respiratory pathogens can be diagnosed using (PCR) or rapid viral antigen detection, but neither rules out concomitant bacterial pneumonia.

M.pneumoniae should be suspected if *cold agglutinins* are present in peripheral blood samples and can be confirmed by *Mycoplasma PCR*.

The diagnosis of *M. tuberculosis* *is established by :*

- *Tuberculin skin* test,
- Serum interferon-gamma release assay,
- Analysis of sputum
- Gastric aspirates by culture,
- Antigen detection,
- PCR.

The need to establish an etiologic diagnosis of pneumonia is greater for patients who are:

- ✓Ill enough to require hospitalization
- ✓Immunocompromised patients
- ✓Recurrent pneumonia
- ✓Pneumonia unresponsive to empirical therapy.

When there is a pleural effusion or empyema, a thoracentesis to obtain pleural fluid can be diagnostic and therapeutic.

Evaluation differentiates between empyema and a sterile parapneumonic effusion caused by irritation of the pleura contiguous with the pneumonia.

If the fluid is grossly purulent, removal reduces the patient's toxicity and associated discomfort and may facilitate more rapid recovery.

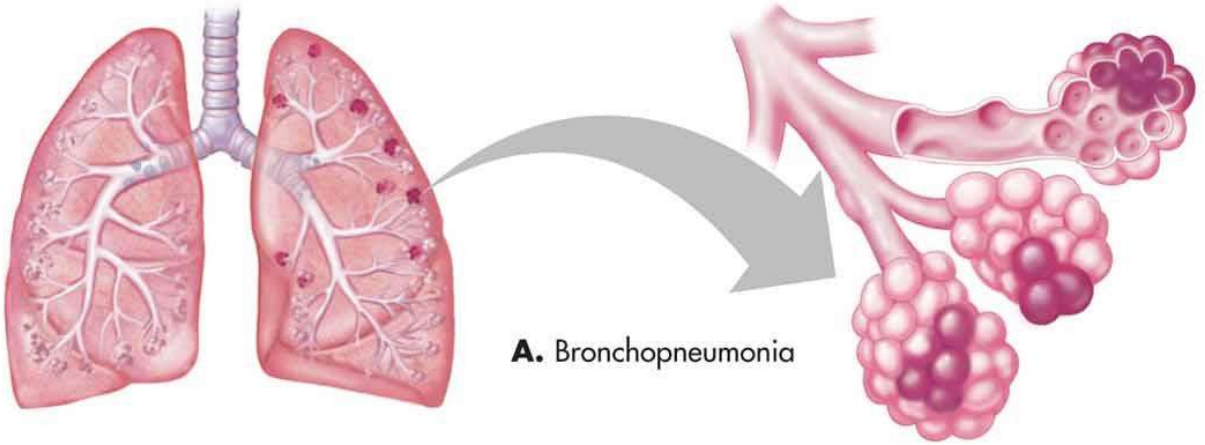
If the accumulation is large and impairs the ability of the lung to expand, removal of the fluid improves pulmonary mechanics and gas exchange.

Frontal and lateral radiographs are required to localize disease and adequately visualize retrocardiac infiltrates and are recommended for diagnosis among hospitalized children, but they are not necessary to confirm the diagnosis in well-appearing outpatients.

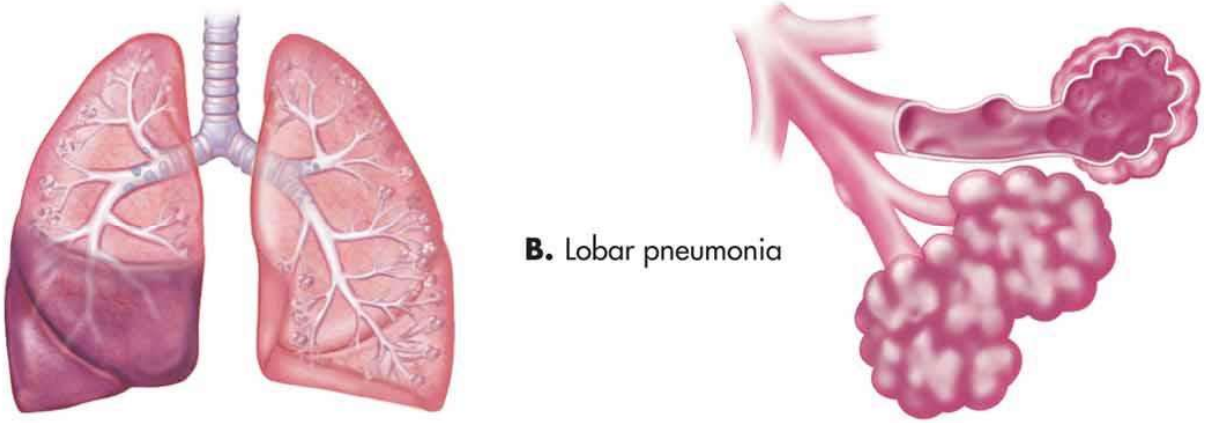
Bacterial pneumonia characteristically shows lobar consolidation, or a round pneumonia, with pleural effusion in ١٠% to ٣٠% of cases

Viral pneumonia characteristically shows diffuse, streaky infiltrates of bronchopneumonia and hyperinflation.

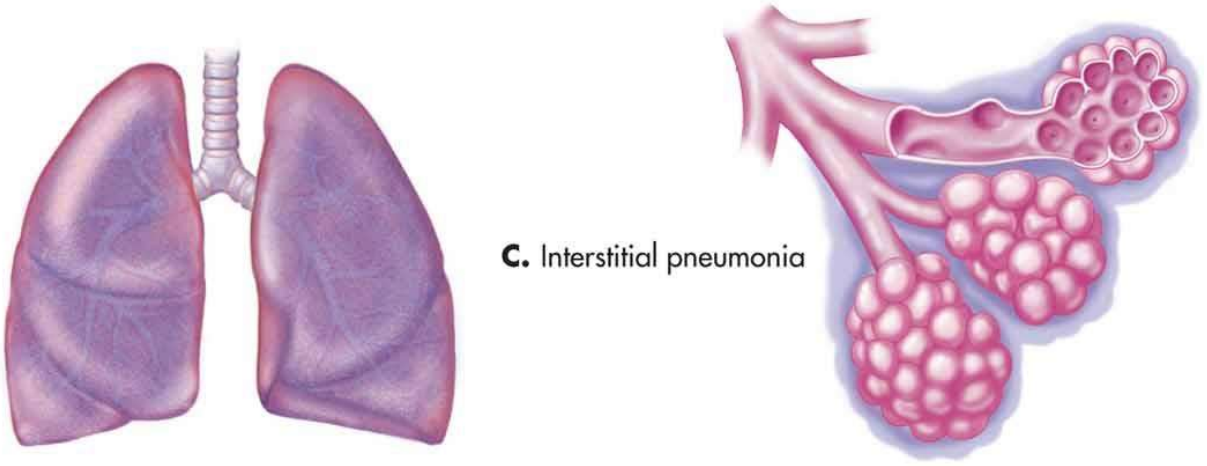
Atypical pneumonia, such as with M. pneumoniae and C. pneumoniae, shows increased interstitial markings or bronchopneumonia.



A. Bronchopneumonia



B. Lobar pneumonia



C. Interstitial pneumonia

Chest radiographs may be normal in early pneumonia, with infiltrates appearing during treatment as hydration is restored.

Hilar lymphadenopathy is
uncommon with bacterial pneumonia but may be
a sign of
tuberculosis,
histoplasmosis,
an underlying malignant neoplasm.

Decubitus views or ultrasound should be used to assess size of pleural effusions and whether they are freely mobile.

DIFFERENTIAL DIAGNOSIS

Pneumonia must be differentiated from other acute pulmonary diseases, including:

allergic pneumonitis,

asthma,

cystic fibrosis;

cardiac diseases,

autoimmune diseases,

Radiographically
pneumonia must be differentiated from
lung trauma,
hemorrhage,
foreign body,
sympathetic effusion due to
subdiaphragmatic inflammation.

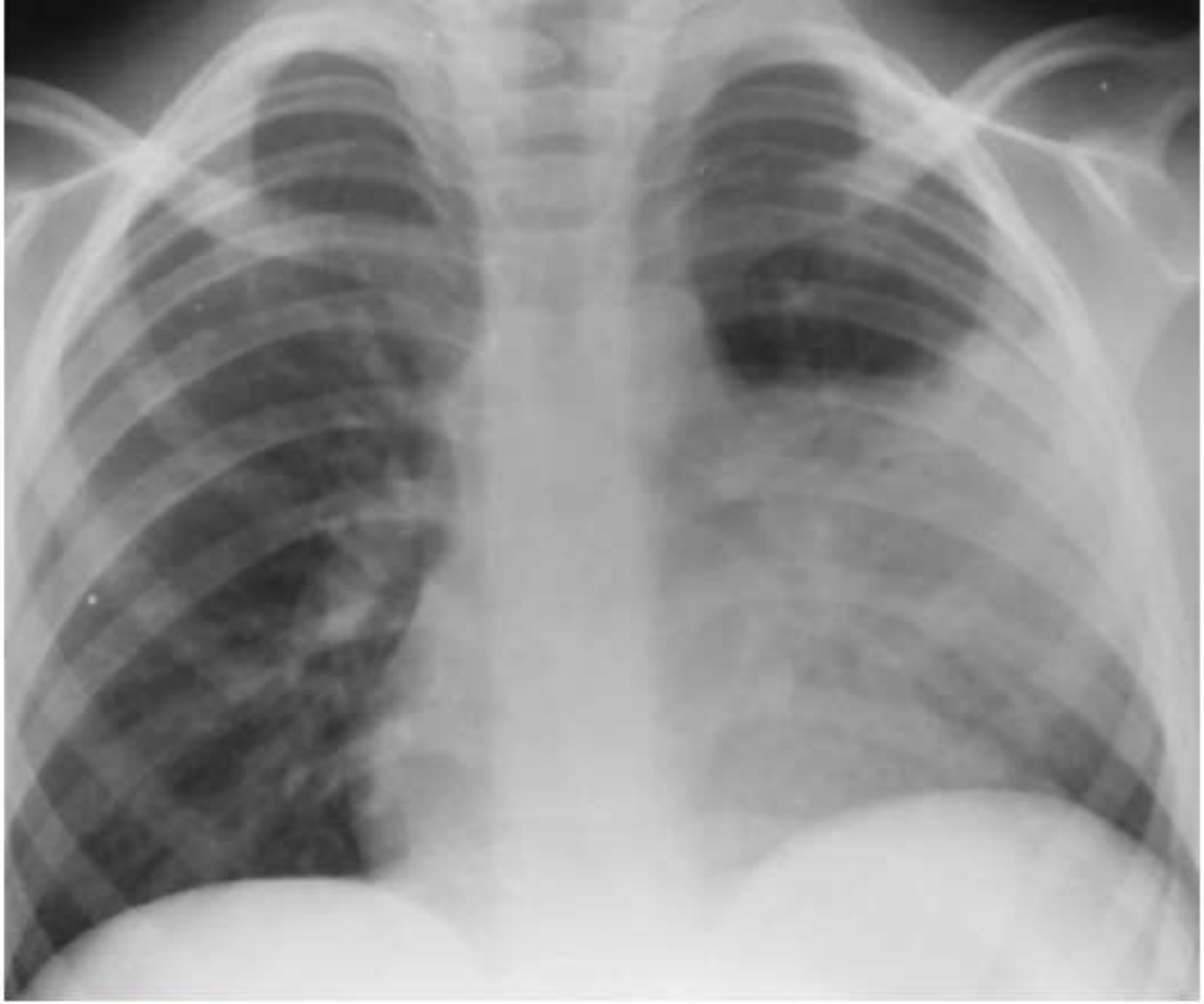


Figure 110-1 Acute lobar pneumonia of the lingula in a 6-year-old child with high fever, cough, and chest pain. Frontal chest radiograph shows airspace consolidation, which obliterates the silhouette of the heart border on the left. The left hemidiaphragm is mildly elevated as a result of splinting. *(From Markowitz RI: Diagnostic imaging. In Jenson HB, Baltimore RS, editors:* Pediatric Infectious Diseases: Principles and Practice, *ed 2, Philadelphia, Saunders, 2002, p 133.)*

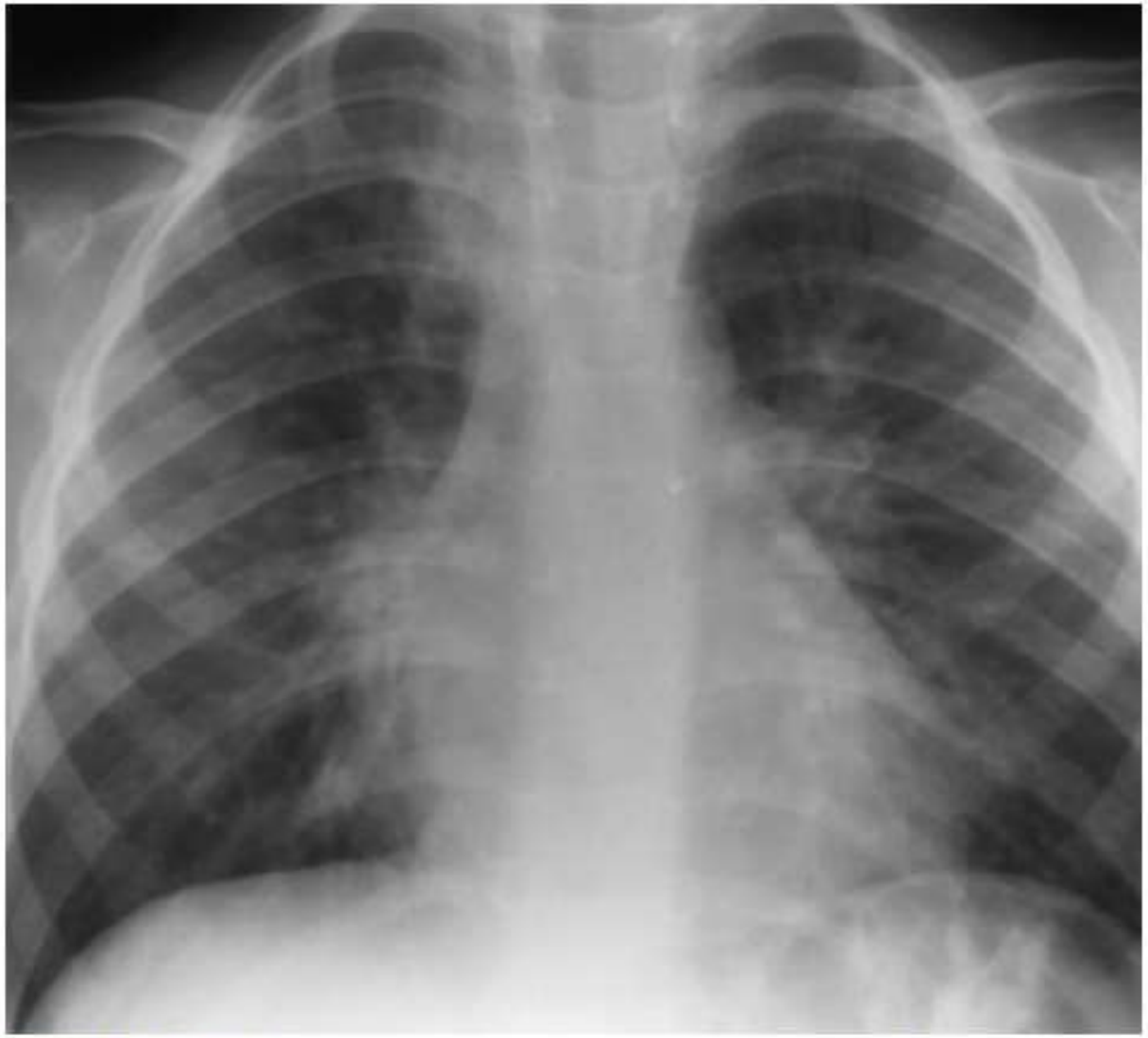


Figure 110-2 Diffuse viral bronchopneumonia in a 12-year-old boy with cough, fever, and wheezing. Frontal chest radiograph shows bilateral, perihilar, peribronchial thickening, and shaggy infiltrate. Focal airspace disease representing consolidation or atelectasis is present in the medial portion of the right upper lobe. The findings are typical of bronchopneumonia. *(From Markowitz RI: Diagnostic imaging. In Jenson HB, Baltimore RS, editors:* Pediatric Infectious Diseases: Principles and Practice, *ed 2, Philadelphia, Saunders, 2002, p 132.)*

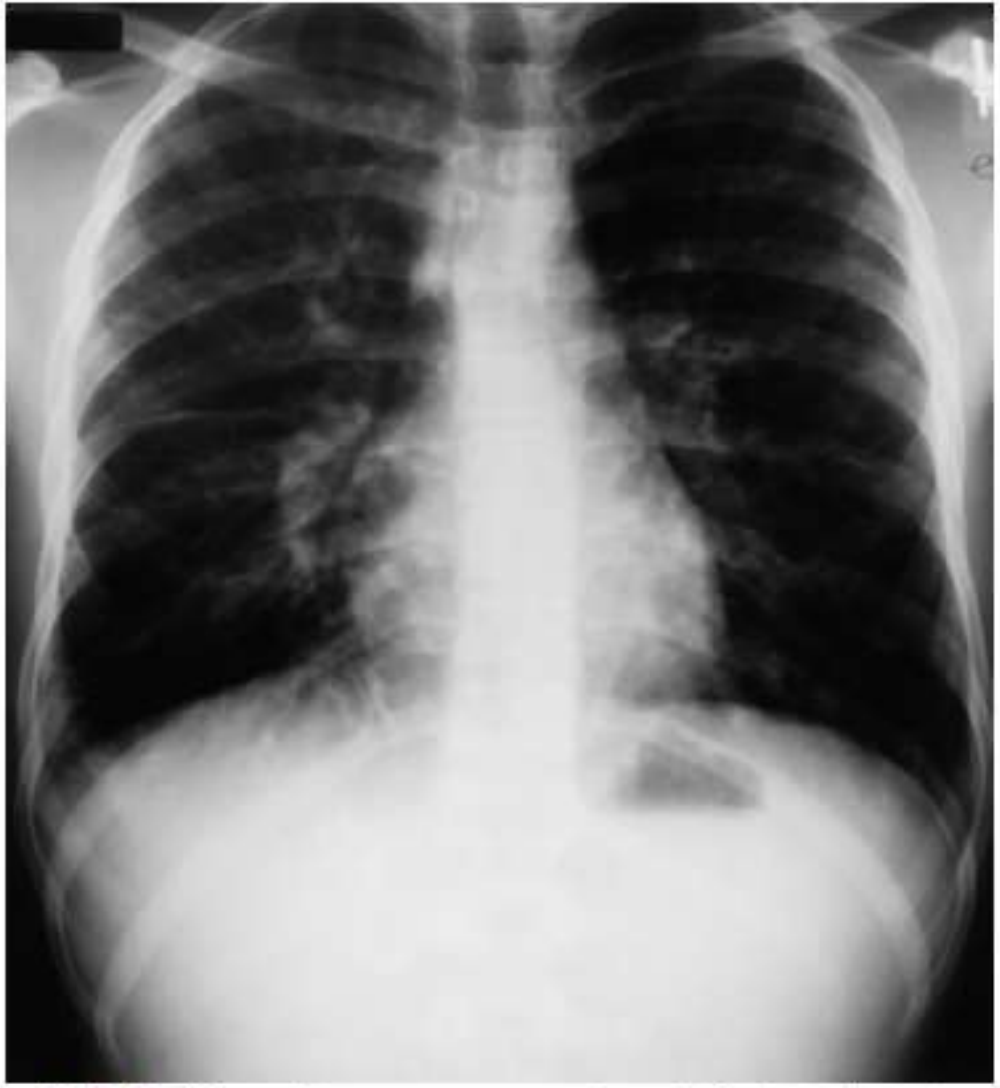


Figure 110-3 *Mycoplasma pneumoniae* infection (atypical pneumonia) in a 14-year-old boy with malaise, dry cough, and mild shortness of breath for 1 week. Frontal chest radiograph shows a diffuse pattern of increased interstitial markings, including Kerley lines. The heart is normal, and there are no focal infiltrates. Cold agglutinins were markedly elevated, and the patient responded to erythromycin. This radiographic pattern of reticulonodular interstitial disease is observed in 25% to 30% of patients with pneumonia caused by *Mycoplasma pneumoniae*. *(From Baltimore RS: Pneumonia. In Jenson HB, Baltimore RS, editors:* Pediatric Infectious Diseases: Principles and Practice, *ed 2, Philadelphia, Saunders, 2002, p 808.)*

Table 110-2	Differential Diagnosis of Recurrent Pneumonia
HEREDITARY DISORDERS	
Cystic fibrosis	
Sickle cell disease	
DISORDERS OF IMMUNITY	
AIDS	
Bruton agammaglobulinemia	
Selective IgG subclass deficiencies	
Common variable immunodeficiency syndrome	
Severe combined immunodeficiency syndrome	
DISORDERS OF LEUKOCYTES	
Chronic granulomatous disease	
Hyperimmunoglobulin E syndrome (Job syndrome)	
Leukocyte adhesion defect	
DISORDERS OF CILIA	
Immotile cilia syndrome	
Kartagener syndrome	

Table 110-2	Differential Diagnosis of Recurrent Pneumonia
ANATOMIC DISORDERS	
Sequestration	
Lobar emphysema	
Esophageal reflux	
Foreign body	
Tracheoesophageal fistula (H type)	
Cystic adenomatoid malformation	
Gastroesophageal reflux	
Bronchiectasis	
Aspiration (oropharyngeal incoordination)	

TREATMENT

children with :

- ✓Hypoxemia,
- ✓Inability to maintain adequate hydration,
- ✓Moderate to severe respiratory distress
- ✓Infants under ۶ months with bacterial pneumonia,
- ✓A pathogen with increased virulence

(e.g., methicillin-resistant *Staphylococcus aureus*),

- ✓*When* concern exists about a family's ability to care

should be hospitalaized.

Because viruses cause most community-acquired pneumonias in young children, not all children require empirical antibiotic treatment for pneumonia.

In contrast to pneumococcal meningitis, presumed pneumococcal pneumonia can be treated with high-dose cephalosporin therapy even with high-level penicillin resistance.

Vancomycin can be used if the isolate shows high-level resistance and the patient is severely ill.

For infants ۴ to ۱۸ weeks old with afebrile pneumonia most likely caused by *C. trachomatis*, a macrolide is the recommended treatment.

Oseltamivir or zanamivir should be used if influenza is identified or suspected, ideally within ۴۸ hours of symptom onset.

Table 110-3 Antimicrobial Therapy for Pneumonia Caused by Specific Pathogen

PATHOGEN	RECOMMENDED TREATMENT
Streptococcus pneumoniae with MIC for penicillin ≤2.0 μg/mL	Ampicillin or penicillin IV; amoxicillin PO
Streptococcus pneumoniae with MIC for penicillin ≥4.0 μg/mL	Ceftriaxone IV; levofloxacin† or linezolid PO
Group A streptococcus	Penicillin or ampicillin IV; amoxicillin or penicillin PO
Group B streptococcus	Penicillin or ampicillin IV; amoxicillin or penicillin PO
Haemophilus influenzae	Ampicillin IV or amoxicillin PO if β-lactamase negative; ceftriaxone or cefotaxime IV or amoxicillin-clavulanate PO if β-lactamase positive
Mycoplasma pneumoniae, Chlamydophila pneumoniae, or *Chlamydia trachomatis*	Azithromycin IV or PO

Table 110-3 Antimicrobial Therapy for Pneumonia Caused by Specific Pathogen

PATHOGEN	RECOMMENDED TREATMENT
Staphylococcus aureus, methicillin susceptible (MSSA)	Cefazolin, oxacillin, or nafcillin IV; cephalexin PO
Staphylococcus aureus, methicillin resistant (MRSA)	Clindamycin or vancomycin IV; clindamycin PO
Gram-negative aerobic bacilli (except *P. aeruginosa*)	Cefotaxime or ceftriaxone with or without an aminoglycoside IV; amoxicillin-clavulanate, cefdinir, or cefixime PO
P. aeruginosa	Ceftazidime IV with or without an aminoglycoside‡; ciprofloxacin† if susceptible PO
Herpes simplex virus	Acyclovir IV

COMPLICATIONS AND PROGNOSIS

Bacterial pneumonias frequently cause inflammatory fluid to collect in the adjacent pleural space, causing a parapneumonic effusion or, if grossly purulent, an empyema.

Small effusions may not require any special therapy. Large effusions may restrict breathing and require drainage.

Air dissection within lung tissue results in a pneumatocele.
Scarring of the airways and lung tissue may leave dilated bronchi, resulting in bronchiectasis and increased risk for recurrent infection.

Pneumonia that causes necrosis of lung tissue may evolve into a lung abscess.

Lung abscess is an uncommon problem in children and usually is caused by:
aspiration,
an obstructed bronchus,
Or virulent organisms.

Anaerobic bacteria usually predominate, along with various

Streptococci,

Escherichia coli,

Klebsiella pneumoniae,

Pseudomonas aeruginosa,

Staphylococcus aureus.

Chest radiograph or
CT scan reveals a cavitary lesion, often with an air-fluid level, surrounded by parenchymal inflammation. If the cavity communicates with the bronchi, organisms may be isolated from sputum.

Diagnostic bronchoscopy may be indicated to exclude a foreign body and obtain microbiologic specimens.

Lung abscesses usually respond to appropriate antimicrobial therapy with clindamycin, penicillin G, or ampicillin-sulbactam.

Most children recover from pneumonia rapidly and completely, although radiographic abnormalities may take ٤ to ٨ weeks to return to normal.

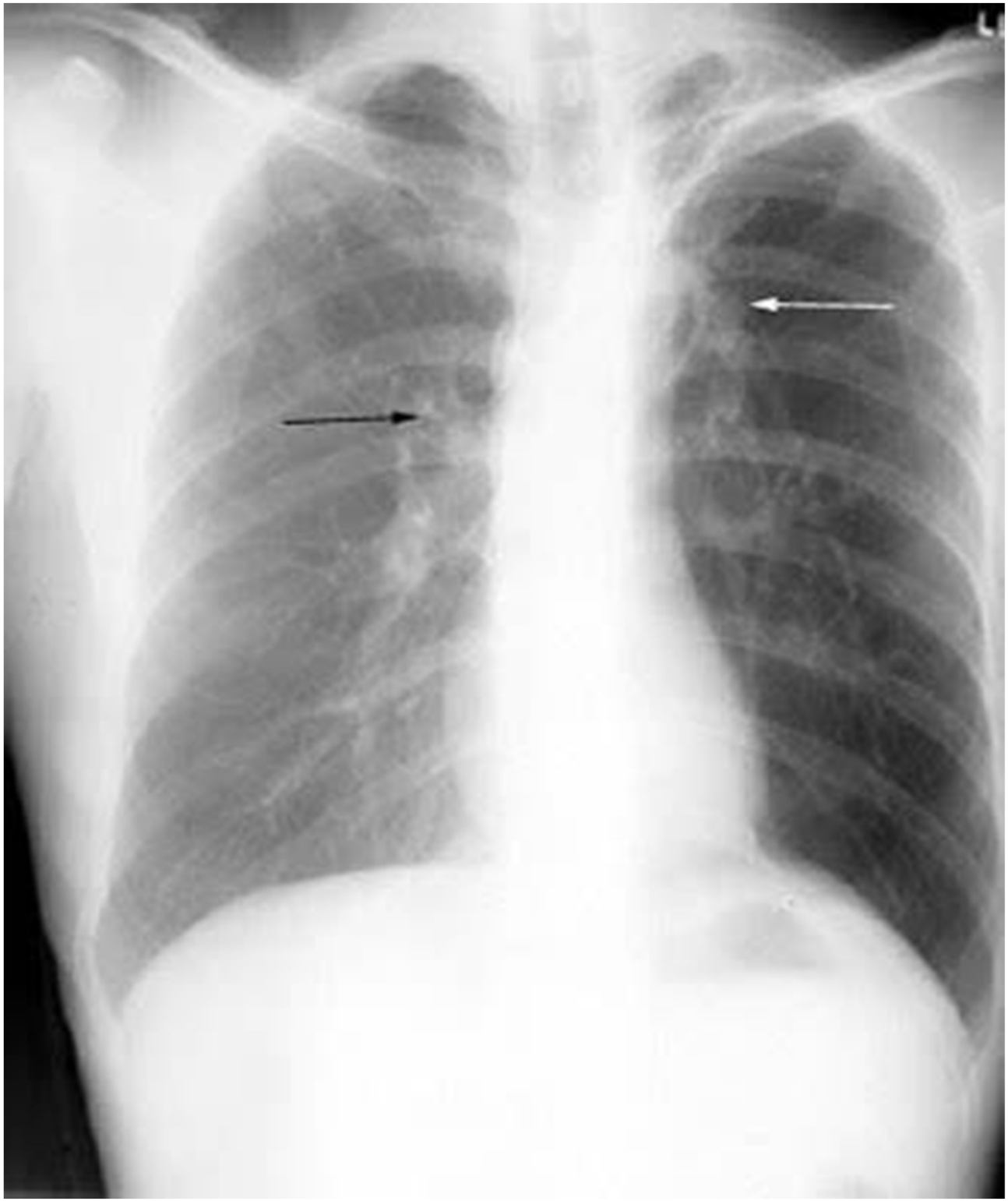
In a few children, pneumonia may persist longer than 1 month or may be recurrent. In such cases, the possibility of underlying disease must be investigated further, such as with

- Tuberculin skin test,
- Sweat chloride test,
- Serum immunoglobulin and IgG subclass determinations,
- Bronchoscopy to identify anatomic abnormalities or foreign body, and
- Barium swallow for gastroesophageal reflux.

Severe adenovirus pneumonia may result in **bronchiolitis obliterans**,

a subacute inflammatory process in which the small airways are replaced by scar tissue, resulting in a reduction in lung volume and lung compliance.

Unilateral hyperlucent lung, or Swyer-James syndrome, is a focal sequela of severe necrotizing pneumonia in which all or part of a lung has increased translucency radiographically; it has been linked to adenovirus type ٢١.



PREVENTION

Annual influenza vaccine is recommended for all children over ٦ months of age. Trivalent, inactivated influenza vaccine is licensed for use beginning at ٦ months of age; live, attenuated vaccine can be used for persons ٢ to ٤٩ years of age.

Universal childhood vaccination with conjugate vaccines for H. influenzae type b and S. pneumoniae has greatly diminished the incidence of these pneumonias.

The severity of
RSV infections can be reduced by use of
palivizumab in highrisk
patients

Reducing the duration of mechanical ventilation and administering antibiotics judiciously reduces the incidence of ventilator-associated pneumonias. The head of the bed should be raised to ٣٠ to ٤٥ degrees for intubated patients to minimize risk of aspiration, and all suctioning equipment and saline should be sterile.

Hand washing before and after every patient contact and use of gloves for invasive procedures are important measures to prevent nosocomial transmission of infections. Hospital staff with respiratory illnesses or who are carriers of certain organisms, such as methicillin-resistant *S. aureus, should comply with infection control policies to prevent* transfer of organisms to patients. Treating sources of aerosols, such as air coolers, can prevent *Legionella pneumonia.*


Thank you for your attention