

Chapter 14



Pharmacologic Treatment of Respiratory Infectious Diseases

Objectives

Upon completion of this chapter, you will be able to

- Discuss pathogens associated with and diagnosis of:
 - Community-acquired pneumonia
 - Hospital-acquired pneumonia
 - Ventilator-associated pneumonia
 - Health care–associated pneumonia
 - Otitis media
 - Sinusitis
 - Pharyngitis
 - Croup
 - Epiglottitis
 - Tuberculosis
 - Pneumocystis jiroveci* pneumonia
 - Bronchitis
 - Whooping cough
 - Bronchiolitis
 - Avian influenza
 - COVID-19
- Describe goals of pharmacotherapy and monitoring parameters for:
 - Community-acquired pneumonia
 - Hospital-acquired pneumonia
 - Ventilator-associated pneumonia
 - Health care–associated pneumonia
 - Otitis media
 - Sinusitis
 - Pharyngitis
 - Croup
 - Epiglottitis
 - Tuberculosis
 - Pneumocystis jiroveci* pneumonia
 - Bronchitis
 - Whooping cough
 - Bronchiolitis
 - Avian influenza
 - COVID-19
- Ask questions to develop a therapeutic plan for an individual with a respiratory infectious disease and find the answers.
- Discuss controversies in pharmacologic treatment of respiratory infectious diseases.
- Discuss chemical terrorism as it relates to the role of antibiotics.

Key Terms

antibiogram	cross-allergenicity	otitis media
bronchiolitis	croup	pharyngitis
bronchitis	culture	pneumonia
community-acquired pneumonia	empiric therapy	sinusitis
	epiglottitis	tuberculosis

Abbreviations

CAP	community-acquired pneumonia	Hib	<i>Haemophilus influenzae</i> type B
CMV	cytomegalovirus	HIV	human immunodeficiency virus
CT	computerized tomography	IDSA	Infectious Diseases Society of America
DOT	directly observed treatment	PJP	<i>Pneumocystis jiroveci</i> pneumonia
DVT	deep vein thrombosis	PPD	purified protein derivative
EUA	Emergency Use Authorization	RSV	respiratory syncytial virus
GAS	Group A β -hemolytic <i>Streptococcus</i>	TB	tuberculosis
HAP	hospital-acquired pneumonia	TMP-SMX	trimethoprim-sulfamethoxazole
HCAP	health care–associated pneumonia	VAP	ventilator-associated pneumonia
HCW	health-care worker		

Respiratory tract infections are among the most common infectious diseases seen in health care today. Any area of the respiratory tract can become infected, and because it is a continuous system, disease can easily spread to other areas of the respiratory tract. Respiratory infections are generally differentiated on the basis of anatomy. Acute otitis media, sinusitis, and pharyngitis are the primary infectious processes of the upper airways, whereas bronchitis and pneumonia occur in the lower respiratory tract.

In treating these infections, several questions need to be answered. First and foremost, we need to consider whether an antibiotic is really necessary. Viral infections do not respond to antibiotics, and the use of antibiotics in viral syndromes negatively influences bacterial resistance patterns and puts the patient at unnecessary risk for adverse effects that can be caused by antimicrobials. Second, if antimicrobial therapy is necessary, we need to consider what the likely infecting organisms are, how serious the infection is, and what the antibiotic susceptibility/resistance patterns in the locality are. We can try to get cultures, but these are not always conclusive. Finally, we need to consider the patient. Does the patient require a procedure to control the source of the infection (e.g., an empyema would require a chest tube to drain the pus from the pleural space)? Will the antibiotic reach the site of infection? What drug(s), dose(s), administration route(s), and schedule(s) are best suited to the patient? What symptomatic treatment is necessary, and when is prophylactic antibiotic therapy appropriate? This chapter offers insights into these questions and the treatment of respiratory infectious diseases.



This chapter presents what seems like a host of organisms that cause respiratory infections, along with a corresponding host of antimicrobial agents to treat them. The total may seem overwhelming, but reference tables simplify the material whenever possible. You received a basic foundation for learning about anti-infective agents in Chapter 8, and this chapter builds on that knowledge by integrating major respiratory infectious diseases with overall effective therapy. Keep in mind that most treatment depends ultimately on identifying the causative microorganism and then selecting an antimicrobial that is effective against that particular microorganism.

14.1 Developing a Therapeutic Plan for Respiratory Infectious Diseases

14.1a Empiric Treatment

To deliver effective therapy, you must develop a specific therapeutic plan. There are many steps to developing a therapeutic plan. You may be actively involved in several of these and not so involved in others. Here are some of the things to consider for any respiratory infectious disease.

Much of the treatment of respiratory tract infections is **empiric therapy**, meaning that antibiotic therapy is begun without identifying the pathogenic organism or without a positive **culture** from a specimen. However, we do have knowledge of specific pathogens that are common in respiratory infections. In addition, we can list empirically some antibiotics that have usually been effective against these suspected pathogens. We can then develop a table that lists the site of infection and suggested “best guess” antibiotics. See Table 14–1, which lists commonly suspected respiratory pathogens for the disease states covered in this chapter and matches them with their “best guess” effective antibiotics. Of course, if treatment of respiratory infectious diseases were this easy, we could end this chapter right here; therefore, it is important to note that, although Table 14–1 does establish the background for this chapter, there is more to the story.

Table 14–1 Respiratory Infectious Diseases, Suspected Pathogens, and Initial Antimicrobial Recommendations

Disease	Suspected pathogen(s)	Initial antimicrobial
Childhood otitis	<i>Streptococcus pneumoniae</i> , <i>Haemophilus influenzae</i> , <i>Moraxella catarrhalis</i>	amoxicillin, azithromycin, or trimethoprim-sulfamethoxazole cefuroxime or amoxicillin/clavulanate
Sinusitis	<i>Streptococcus pneumoniae</i>	amoxicillin or trimethoprim-sulfamethoxazole azithromycin, telithromycin
Pharyngitis	Group A <i>Streptococcus</i>	penicillin
Epiglottitis	<i>Haemophilus influenzae</i>	cefuroxime or cefotaxime or ceftriaxone
Croup*	Parainfluenza viruses, respiratory syncytial virus (RSV), coronavirus, <i>Mycoplasma pneumoniae</i>	Nebulized epinephrine and glucocorticoids, azithromycin for <i>Mycoplasma pneumoniae</i>
Acute bronchitis	Viruses (most common cause), <i>Mycoplasma pneumoniae</i> , <i>Chlamydia pneumoniae</i> , <i>Bordetella pertussis</i>	azithromycin, clarithromycin
Acute exacerbations of chronic bronchitis	Viruses, <i>Haemophilus influenzae</i> , <i>Moraxella catarrhalis</i> , <i>Streptococcus pneumoniae</i>	azithromycin, trimethoprim-sulfamethoxazole, doxycycline, fluoroquinolones, cefpodoxime
Bronchiolitis	RSV	ribavirin for severe cases
Community-acquired pneumonia	<i>Streptococcus pneumoniae</i> , <i>Haemophilus influenzae</i>	See Table 14–7
Pneumonia (ventilator-associated, hospital-acquired, health care–associated)	Gram-negative aerobic rods, <i>Staphylococcus aureus</i>	See Table 14–7

*Croup (laryngotracheitis) is usually caused by viruses. Bacterial infection may occur as a consequence of the croup. The most commonly found bacteria include *Staphylococcus aureus*, *Streptococcus pneumoniae*, and *Streptococcus pyogenes* (Group A *Streptococcus*).

14.1b Local Resistance Patterns (the Antibigram)

Once the pathogen of the suspected common respiratory infection has been identified and initial choice of antibiotics has been determined, the next step is to customize that information for the particular health-care setting and practice site. Some facilities may have different resistant strains, and the first- or second-choice drug may not be effective. Many factors must be considered in choosing empiric therapy, but a key element is understanding how effective antibiotics are against the likely infecting organisms in your local community or practice setting. Most health-care systems regularly provide something called an **antibiogram**. The antibiogram is a compilation of the culture results received by the local laboratory and is usually updated yearly. It gives the types of organisms and numbers of isolates, along with a comparison of the antibiotics that are both effective and noneffective in that particular institution. You can use this to make a “best guess” of which antibiotic to use for the suspected causative infecting organism.



14.1c Individualizing Therapy

With the infectious process and likely pathogen identified, you are one step closer to empiric treatment. An antibiogram from your practice setting can help narrow the antimicrobial choices. However, a few more steps are still necessary. You will need several more pieces of information before you'll know what, if any, antibiotic to use. Here are some further questions you should ask:

- (1) Is an antibiotic really necessary?
- (2) Does the patient have any allergies?
- (3) Are there any age restrictions for the antibiotic you wish to use?
- (4) How might the dosage form affect your choice of antibiotic?
- (5) Will the antibiotic reach the site of infection?

Is an Antibiotic Really Necessary?

Many patients present with respiratory symptoms and request treatment with antibiotics. A major question all clinicians must address is whether the patient really needs antibiotics to treat the condition. Many of the conditions discussed in this chapter are viral in origin and will not respond to antibiotics. Patients who have previously recovered well after receiving an antibiotic will request antibiotics for their next illness; in fact, their main reason for seeing a health-care provider may be to get an antibiotic.

Overuse of antibiotics has contributed to the rise in antibiotic resistance in the United States and throughout the world. Fortunately, this rise in resistance has been met with advances in antibiotic development. However, we have reached a point where new antibiotic discovery has slowed, and the antibiotics we have aren't always effective against the infectious agent, resulting in a "perfect storm" situation. It is also possible to cause a patient harm by overusing antibiotics. Some of our newer antibiotics have the potential for more significant side effects and morbidity.

Does the Patient Have Any Allergies?

Penicillin allergy is fairly common, and allergies to other antibiotics are becoming more common. We must also be aware of the incidence of **cross-allergenicity**. Cephalosporins and some other β -lactam antibiotics may cause an allergic reaction in patients who are allergic to penicillins, so they should be avoided if possible in penicillin-allergic patients—especially if the reaction was severe. You need to be certain of the description of the patient's allergic reaction, since that will give you an idea of the risk to the patient. The patient needs to be questioned about the time, course, and symptoms of the allergic reaction, and this information should be carefully documented in the patient's medical record. Patients who have a history of rash to penicillin are less likely to react to the other β -lactam antibiotics and often can be safely given even penicillin. Patients who have anaphylactic reactions, or even hives, with one medication are more likely to experience cross-allergenicity (a similar severe reaction) with chemically related compounds.



It is important to carefully determine how many isolates or samples from the infection site were tested, from what sources the isolates were obtained, and in what physical areas in the health-care system the infected patients were located. Intensive care units (ICUs) may have very different microbial flora and antibiotic sensitivities than more general medical/surgical areas. Also, specialty facilities, such as a pediatrics hospital, will not present the same picture as an adult inpatient facility.



It's important for both the patient and the health-care worker to understand that not all patients who have previously recovered after receiving an antibiotic did so solely because of the antibiotic. Infections sometime resolve regardless of what we do or do not do.

Are There Any Age Restrictions for the Antibiotic You Wish to Use?

Children cannot be given all the same antibiotics adults can. Tetracyclines cause tooth staining and affect bone growth in developing children younger than age 8; thus, they are contraindicated. Quinolones may cause bone joint disease (arthropathy) with erosions of cartilage in weight-bearing joints, so they are not recommended for children under 18 years old. Elderly patients often require special consideration with certain classes of antibiotics, such as aminoglycosides, due to their likely decreased renal function.



Controversy

Quinolones' effects on bone joints in children relate to cartilage and are based on animal data from beagle dogs. In certain situations, the benefit of using a quinolone in a child may outweigh the risk of cartilage damage.



There are always exceptions. Quinolone antibiotics, for example, are usually equally effective when given orally or intravenously.

How Might the Dosage Form Affect Your Choice of Antibiotic?

If the patient is clinically ill and requires hospitalization, you may wish to choose an intravenous dosage form. This is especially necessary if the patient is nauseated or otherwise unable to take a medication orally. In general, with the exception of quinolone and antibiotics that have oral and IV equipotent serum levels, intravenous forms give higher, faster blood levels of the antibiotic and may work more quickly.

If the patient is a child, you might want a chewable or suspension form of the antibiotic if an oral dosage form is to be used. You may also want to see how these forms are flavored, since the taste of many antibiotics is very unpleasant.



Time for Review

If a patient is acutely ill and in urgent need of an antibiotic, why is it still important to check the chart for medication allergies before administering one?



Daptomycin is an example of an antibiotic that should not be used for the treatment of pneumonia because distribution to the lung is poor and the drug is inactivated by pulmonary surfactant.

Will the Antibiotic Reach the Site of Infection?

Depending on the pharmacokinetic characteristics of the antibiotic, it might not reach the site of infection at an adequate concentration to eradicate the infecting organisms. This is especially problematic when treating pneumonia. Many antibiotics do not penetrate the pulmonary or pleural tissue very well, especially when the infectious process is affecting blood flow to the area. This doesn't necessarily preclude using the antibiotic, but it may mean that a higher than normal dose will be required. This may be important with sinus or otitis inner ear infections as well.



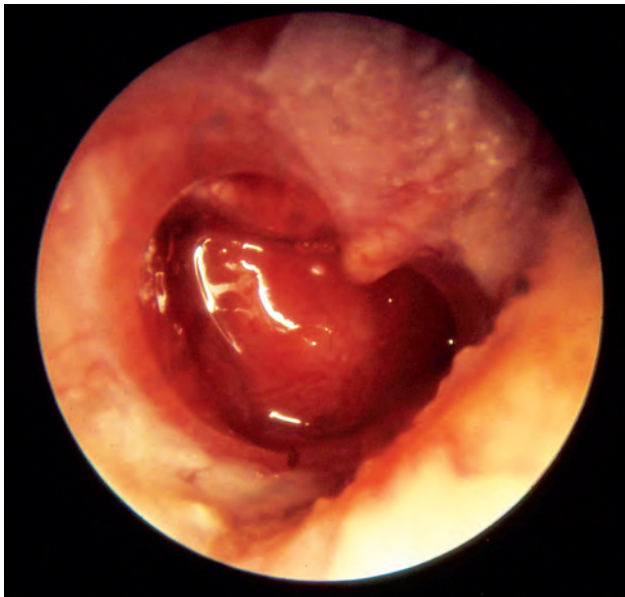
Now that you know the questions to ask and the basics for developing a therapeutic plan, it's time to get more specific about different respiratory infectious diseases pertinent to the pulmonary system. We will start from the top anatomically and progress down to the lower respiratory tract.

14.2 Upper Airway Infectious Diseases

14.2a Otitis Media

Although one may not consider ear infections pertinent to a discussion of respiratory infectious diseases, the ears' communication with the nasal passageways make them a common site for the spread of respiratory infections. **Otitis media** (see Figure 14–1), or inflammation of the middle ear, is one of the most common causes of morbidity in infants and children—even with all the antibiotic choices available. It is estimated that more than 60% of children will have at least one episode of acute otitis media by their first birthday, and about 75% will have had an episode by age 3.

Figure 14–1 Otoscopic View of Otitis Media

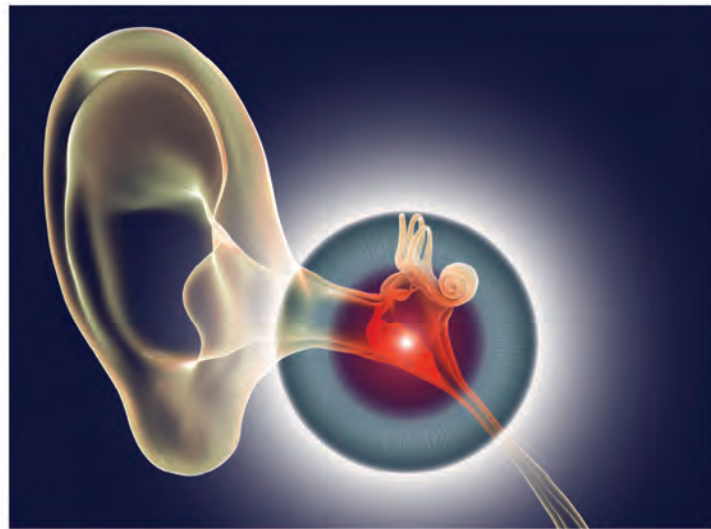


Source: "Otitis media" by B. Welleschik is available under a CC BY-SA 3.0 license via Wikimedia.

Acute otitis media is most common in infancy and early childhood, peaking in incidence between the ages of 6 and 18 months. It is more common in males and in certain ethnic groups, including Americans Indians, Alaska Natives, and among the Canadian Inuit. An estimated \$3 billion to \$4 billion is spent annually on medical and surgical treatment of otitis media in the United States. Figure 14–2 lists the factors that increase the risk of acute otitis media in children.

Diagnosis and Treatment

The clinical course of otitis media may include nonspecific symptoms, particularly in young children. Typical symptoms include irritability, ear tugging, lethargy, anorexia, fever, and/or vomiting. These usually occur in a child who has had cold symptoms of runny nose, nasal congestion, or cough.

Figure 14–2 Factors That Increase the Risk of Otitis Media in Children

- Male gender
- Sibling in the home
- Early age at onset of acute otitis media
- Bottle feeding
- Group daycare
- Exposure to tobacco smoke
- Nationality—American Indian, Alaskan Native, and Canadian Inuit
- Use of pacifier

Source: Shutterstock

The physician examines the child, looking for bulging of the tympanic membrane and/or other signs of acute inflammation and middle ear effusion. An accurate diagnosis is extremely important so antibiotics may be prescribed for children who need them and avoided when not necessary. Ibuprofen or acetaminophen may be used in all children to reduce the pain and fever. When the diagnosis is made, it is reasonable to treat children under 2 years of age with appropriate antibiotics. For children over 2, the decision to treat with antibiotics can be individualized.

The use of the conjugate polysaccharide *Haemophilus influenzae* type B vaccine has been very effective at decreasing the incidence of this organism as a pathogen for otitis media and gives us proof that prevention is important in this disease. Measures should be taken to avoid exposure to allergens, irritants, and other sick individuals.

Microbial Causes

Table 14–2 lists the typical bacterial causes and their prevalence. Protection of the middle ear from bacterial or viral invasion depends on the length of the eustachian tube, the pressure difference between the middle ear and the nasopharynx, and the angle of the eustachian tube opening. Infants are most likely to get otitis media because their eustachian tubes are shorter and wider and are at a flatter angle relative to the nasopharynx than in older children and adults. Acute otitis media generally occurs when an infant develops a viral respiratory tract infection that results in edema and congestion of the entire respiratory tract. Middle ear secretions cannot be drained into the nasopharynx because of inflammatory obstruction of the eustachian tube. These accumulated secretions become an excellent environment for the growth of bacteria.



● ● ● Time for Review

What are some risk factors for development of otitis media?



Table 14–2 Bacterial Pathogens That Cause Acute Otitis Media

Pathogen	Percent of cases (approximate)
<i>Streptococcus pneumoniae</i>	29%
<i>Streptococcus pyogenes</i>	19%
<i>Haemophilus influenzae</i>	14%
<i>Staphylococcus aureus</i>	14%
No bacteria found	19%

Rates of agents were for patients with no spontaneous perforation.

Source: Hana Dojčárová, "[Bacterial pathogens causing acute otitis media]," *Klinická Mikrobiologie a Infekční Lekarství* 22, no. 1 (March 2016): 13–8.

Pharmacologic Treatment

The first decision in the management of acute otitis media is whether to treat the patient with antibiotics. Children and adults with acute otitis media should receive therapy for associated symptoms; as mentioned previously, ibuprofen or acetaminophen may be used for relief of pain and fever, but these medications have not been shown to help hasten recovery from acute otitis media nor do they help resolve effusions. Effusions are important because they can result in hearing loss, which may also impair speech. Effusions are also relevant because the presence of fluid in the ear decreases antibiotic penetration.

Analgesics and antipyretics, such as acetaminophen or nonsteroidal anti-inflammatory agents (ibuprofen, naproxen, aspirin, etc.), are helpful in relieving the fever and ear pain that are often present with otitis media. Aspirin is not used in children because of its association with Reye's syndrome. A significant percentage of children recover from their acute episode of otitis media with symptomatic treatment only. Clinically, there is no way to know which patients need antibiotics and which will recover on their own; therefore, as mentioned previously, the decision can be based on age and how sick the individual appears.

Most cases of acute otitis media are treated empirically, and the causative organisms are not typically isolated. Therefore, as with many common infections, it is very important to know the likely pathogens and the local resistance patterns. If treatment fails, it is likely that the infection was caused by a virus—or else the bacterium is either resistant to the drug therapy or is one that does not typically cause otitis media. The development of resistance is rapidly becoming an all-too-common problem, and all health-care providers must carefully evaluate the antibiotics to be used. An additional challenge is to use an antibiotic that will achieve a "killing" level in the fluid in the middle ear.



Do you know someone who has had "tubes" put in his or her ears? A frequent nonpharmacologic treatment for recurrent otitis media is myringotomy and insertion of tympanostomy tubes. This procedure reduces the recurrence of otitis media by approximately 50%. The insertion of tympanostomy tubes interrupts the cycle of recurrent infections and helps prevent hearing loss.

The three most common bacterial pathogens in acute otitis media are *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. Resistant strains of these bacteria have emerged and complicated the therapy choices for otitis as well as other respiratory tract infections. There is no one preferred antimicrobial for all children or adults with acute otitis media. Amoxicillin is usually used as a first-line agent in young children. Amoxicillin achieves the highest concentrations in the middle ear effusions and should be the first choice in young children with no penicillin allergy or recurrent infection. Older children are more likely to harbor resistant organisms, owing to their prior treatment with antibiotics. First-line therapies in adults and children over 3 years of age include high-dose amoxicillin, cefuroxime axetil (Ceftin®), amoxicillin/clavulanate (Augmentin®), cefpodoxime proxetil (Vantin®), and cefdinir (Omnicef®). These agents have good coverage against resistant pneumococcal infections. Patients who have received a course of antibiotics within the previous 3 months are classified as high-risk for resistance. Higher doses may be recommended in these cases.

Table 14–3 details the dosage and regimens that should be used with each of these antibiotics.

Table 14–3 First- and Second-Line Antibiotic Therapy for Acute Otitis Media

Antibiotic	Trade name	Dosage forms ^a	Dosage (for children)	Duration (days)
amoxicillin	Many	c, ch, s	40 mg/kg/day in 3 divided doses, 80–90 mg/kg/day for drug-resistant <i>Streptococcus pneumoniae</i>	10
trimethoprim-sulfamethoxazole	Bactrim®, Septra®	t, s	10 mg/kg/day (trimethoprim) in 2 divided doses	10
amoxicillin/clavulanate	Augmentin®	t, ch, s	80–90 mg/kg/day (amoxicillin) in 3 divided doses	10
azithromycin	Zithromax®	c, s	10 mg/kg on day 1, 5 mg/kg on days 2–5	5
cefpodoxime proxetil	Vantin®	t, s	10 mg/kg/day in 1 dose or 2 divided doses	10
cefprozil	Cefzil®	t, s	30 mg/kg/day in 2 divided doses	10
ceftriaxone	Rocephin®	i	50 mg/kg IM in 1 dose	1
cefuroxime	Ceftin®	t, s	30 mg/kg/day in 2 divided doses	10
clarithromycin	Biaxin®	t, s	15 mg/kg/day in 2 divided doses	10

^at, tablet; c, capsule; i, injectable; s, suspension; ch, chewable.



While it may seem minor, the classification of acute versus chronic is an important distinction that can itself affect antibiotic choice in treating sinusitis and several other infections. The definitions of *acute* and *chronic* are not consistent for all infections.

14.2b Sinusitis

Acute **sinusitis**, an inflammation of the mucosal lining of the paranasal sinuses, affects both children and adults. It is estimated to affect 31–35 million Americans per year and can exacerbate asthma attacks and trigger other pulmonary disease. Children experience an average of six to eight viral infections of the upper respiratory tract each year; adults experience two to three. Of these upper respiratory tract infections, approximately 0.5% will be complicated by acute sinusitis. Bacterial sinusitis can be either acute or chronic. Chronic sinusitis is defined as lasting more than 3 months. It is not known if this is due to more virulent pathogens or an immune function decrease in the patient.



Sinusitis occurs when the mucociliary transport mechanism is impaired and pathogens are allowed to remain in the sinus cavities. Mucopurulent rhinorrhea (discharge from the nasal passages consisting of mucus and pus), postnasal drip, facial pain, maxillary toothache, cough, fever, nausea, and congestion preceded by an upper respiratory infection are typical complaints of patients with acute sinusitis. The persistence of nasal discharge and a cough for more than 10 days following an upper respiratory infection are indicative of sinusitis. Previously clear, thin nasal discharge may become mucoid or purulent, with an increase in both viscosity and quantity.

A poor response of these symptoms to decongestant medication gives clues that sinusitis may be the culprit. Headaches caused by sinusitis respond poorly to analgesics, and the pain usually corresponds directly to the sinuses affected. Adults typically experience the feeling of fullness or dull ache associated with an infection in the frontal sinuses.

Nasal allergies contribute to the edema and swelling of the nasal mucosa, but little evidence is available that actually links allergy to acute sinusitis. Barotrauma from deep-sea diving and airplane travel are also recognized precipitating factors for sinusitis. Chemical irritants such as chlorine may impair secretion clearance and thus foster development of sinusitis.

Diagnosis and Treatment

A computerized tomography (CT) scan is considered the “gold standard” for evaluating sinusitis, but it is a very expensive diagnostic tool. Sinus aspiration is the only definitive way of determining the presence of infection. Sinus x-rays can help the physician detect mucosal thickening, air–fluid levels, or sinus opacification. However, a normal sinus x-ray does not rule out sinusitis, and sinus films have high false-positive and false-negative rates. Transillumination of the frontal and maxillary sinuses is a simple and inexpensive test that is done in a darkened room with a high-intensity light source. The presence of an opacified sinus can be detected in this fashion, which is diagnostic of acute sinusitis in a patient with previously normal sinuses. The diagnosis is most often made clinically based on history and the physical exam.

Microbial Causes

Most cases of acute sinusitis are due to viruses. As noted in Table 14–4, the most common bacterial causes of sinusitis in both children and adults are *Streptococcus pneumoniae* and *Haemophilus influenzae*. Empiric antibiotic coverage is generally focused on these organisms.

Table 14–4 Etiology of Acute Sinusitis

Type	Species	Adults
Bacteria	<i>Streptococcus pneumoniae</i> , <i>Haemophilus influenzae</i>	70%
Bacteria	<i>Moraxella catarrhalis</i>	30%



Children under the age of 5 most likely will not have frontal sinusitis symptoms, as their frontal sinuses have not fully developed. (This is also why they have those cute round faces.)



● ● ● Time for Review

Are *Streptococcus pneumoniae* and *Staphylococcus aureus* gram-positive or gram-negative organisms?



Pharmacologic Treatment

The treatment of sinusitis is most effective when the cause is clearly identified, yet sinus aspiration isn't often done. It is controversial whether antimicrobial treatment should be used for sinuses because viruses are the most frequent culprit. Therapies for chronic sinusitis are focused on control of symptoms, whereas antibiotics are required for acute bacterial sinusitis. The medications used for symptomatic relief have not been proven to reduce the duration of the illness, but at least they can make the patient feel better until the infection resolves. Intranasal cromolyn, antihistamines, intranasal corticosteroids, and topical decongestants are all used to treat or prevent symptoms. Intranasal cromolyn can help protect the sinus mucosa from an allergic response that would contribute to the sinusitis. Oral first-generation antihistamines can also help prevent an allergic response but should be used cautiously because they can make the nasal secretions more viscous, interfering with the clearance of purulent mucous secretions. Intranasal corticosteroids are very effective for allergic rhinitis and may help control chronic sinusitis symptoms. The topical decongestants (phenylephrine and oxymetazoline) may facilitate nasal drainage, but they should only be used for less than 72 hours because they induce tolerance and rebound congestion. Irrigation of the nasal cavity with a saline solution is also effective for providing symptomatic relief, especially when the nasal mucosa are dry.

The Infectious Diseases Society of America (IDSA) recommends withholding antimicrobials and observing patients with mild symptoms for up to 3 days. If symptoms worsen, antimicrobials should be initiated promptly. Empiric therapy should be directed at the common organisms, *Streptococcus pneumoniae* and *Haemophilus influenzae*. Many antibiotics are effective against sinusitis, but we must always consider bacterial resistance and choose therapies that are effective without inducing resistance. Amoxicillin and, in a penicillin-allergic patient, trimethoprim-sulfamethoxazole have long been and are still considered first-line therapies for acute sinusitis when treatment with antimicrobials is recommended. Amoxicillin will be ineffective against β -lactamase-producing microorganisms and/or *Streptococcus pneumoniae* that is highly resistant to penicillin. *Streptococcus pneumoniae* has also developed significant resistance to macrolides and may require treatment with an oral second- or third-generation cephalosporin such as cefuroxime axetil or cefpodoxime, respectively.

If the patient does not respond in 72 hours to amoxicillin or trimethoprim-sulfamethoxazole, antibiotic therapy should be changed to an agent to which bacteria are less likely to have developed a resistance. Usually this means changing



Rebound congestion occurs when topical decongestants are used for more than 3 days in a row. Use beyond the recommended time frame makes the congestion worse, not better. The fancy medical term for this is *rhinitis medicamentosa*.



to high-dose amoxicillin, amoxicillin/clavulanate, a second- or third-generation cephalosporin (cefuroxime axetil, cefixime, cefaclor), or an antistreptococcal quinolone (levofloxacin is generally the preferred quinolone, as ciprofloxacin and ofloxacin have poor *S. pneumoniae* activity). Macrolides (azithromycin, telithromycin, and clarithromycin) are also effective against the common pathogens and are rapidly becoming the drugs of choice. Health-care professionals should use local resistance patterns (e.g., an antibiogram, discussed previously) to understand resistance trends within the community. Table 14–5 describes the antibiotics generally used for acute sinusitis. Duration of therapy recommendations are 10–14 days or at least a week after signs and symptoms are controlled.



The current 2012 IDSA guideline recommends that antimicrobial regimens for sinusitis should be continued for 5–7 days.

Table 14–5 Antimicrobial Regimens for Adult Acute Sinusitis

Antimicrobial agent	Brand name	Oral dose in adults
amoxicillin	Various	500 mg q8h
amoxicillin/clavulanate	Augmentin®	500 mg q8h or 875 mg q12h
azithromycin	Zithromax®	500 mg/day, then 250 mg/day for 4 days
cefuroxime	Ceftin®	250–500 mg q12h
cefaclor	Ceclor®	250–500 mg q8h
cefixime	Suprax®	200–400 mg q12h
clarithromycin	Biaxin®	250–500 mg q12h
levofloxacin	Levaquin®	500 mg q24h
trimethoprim-sulfamethoxazole	Bactrim® DS, Septra® DS*	trimethoprim 160 mg, sulfamethoxazole 800 mg (per tablet) q12h

*Each Bactrim® DS or Septra® DS tablet contains 160 mg of trimethoprim and 800 mg of sulfamethoxazole.

14.2c Pharyngitis

Pharyngitis (sore throat) is an inflammation of the pharynx and surrounding lymphoid tissue that may be caused by bacteria or viruses (see Figure 14–3). The evaluation, diagnosis, and treatment of patients with pharyngitis is a common problem in primary care. The occurrence of a sore throat is associated with more than 10% of physician office visits, while less than 20% of those patients who experience a sore throat actually seek care.



Acetaminophen is the preferred agent for sore throat pain because of some association between nonsteroidal anti-inflammatory drugs and toxic shock syndrome.

Microbial Causes

Viruses cause most pharyngitis; they are generally the same ones that cause the common cold (rhinovirus, coronavirus, adenovirus, and parainfluenza viruses). Other viral causes include herpes simplex virus, influenza virus, coxsackievirus, Epstein-Barr virus, and cytomegalovirus (CMV). However, some pharyngitis (10%–30%) is the result of bacterial infection, most commonly with Group A β -hemolytic streptococci such as *Streptococcus pyogenes*. Acute bacterial pharyngitis can also be caused by Group C and G streptococci, *Arcanobacterium haemolyticum*, and possibly *Mycoplasma pneumoniae* or *Chlamydia pneumoniae*.

Figure 14–3 Severe Pharyngitis

Source: “Pharyngitis” by Dake is available under a CC BY-SA 2.5 license via Wikimedia.

Diagnosis and Treatment

Most often, pharyngitis is self-limiting, lasting from 2–7 days. The major symptom is sore throat, with or without associated dysphagia (difficulty swallowing). Fever is typically present. Examination usually reveals erythema and possible exudate (white patches), and mucosal congestion is present. The presence of exudate with fever usually suggests a bacterial infection, but a culture or rapid antigen detection test (“quick strep test”) should be obtained to confirm the causative organism. The rapid antigen detection test allows the diagnosis of Group A β -hemolytic *Streptococcus* (GAS) infection within 5 minutes. This test is very specific for Group A β -hemolytic *Streptococcus*, and patients with a positive test can be treated immediately without waiting for culture results. Unfortunately, a negative test does not rule out the possibility of a GAS infection, and a throat culture may be necessary. Bacterial eradication occurs in 48–72 hours of treatment, which is important in decreasing transmission.

● ● ● **Time for Review**



How long should children be kept home when they have strep throat, and why?



Complications of untreated pharyngitis include spread of the infection to the tonsils, retropharyngeal abscess, cervical lymphadenitis, otitis media, sinusitis, and mastoiditis. Another complication is acute rheumatic fever (common before the second half of the twentieth century and the advent of antibiotics). The most serious of the sequelae of acute rheumatic fever is heart valve damage.



Pharmacologic Treatment

Penicillin has long been the antibiotic of choice for pharyngitis. Even with the development of antimicrobial resistance, Group A *Streptococcus* remains susceptible to penicillin, and it remains the drug of choice for this infection. Children younger than 12 years of age should receive 50 mg/kg/day, divided into 3 doses, of penicillin V for 10 days or an injection of benzathine penicillin, 50,000 U/kg IM, as a single dose. For adolescents and adults, penicillin V, 500 mg twice daily for 10 days, should be given. In the penicillin-allergic patient, azithromycin 500 mg orally on day 1 followed by 250 mg daily on days 2 through 5 (12 mg/kg/day in kids under 27 kg) or clindamycin are acceptable alternatives. See Table 14–6 for a sample protocol for treating pharyngitis.

Table 14–6 Sample Protocol for Treating Pharyngitis

Number of Criteria Met	Likelihood of Group A β -Hemolytic <i>Streptococcus</i>	Suggested Action
0	2%–3%	No culture indicated and no antibiotics required
1	3%–7%	
2	8%–16%	Culture, treat if culture is positive
3	19%–34%	
4	41%–61%	Culture, treat with antibiotics if clinically indicated regardless of culture results ^a

^aIf patient has a high fever, is clinically unwell, and presents early in disease course.

Question the patient:

- Absence of cough?
- Exudate present?
- History of fever $>38^{\circ}\text{C}$ or $>100^{\circ}\text{F}$?
- Swollen, tender anterior cervical nodes?



• • • Time for Review

Why might it be appropriate for a health-care worker to encourage a patient with a history of respiratory disease and a sore throat to see a physician?



14.3 Other Upper Airway Infections

14.3a Epiglottitis

Epiglottitis is an airway emergency whereby *Haemophilus influenzae* type B causes acute airway obstruction. It is most prevalent in children ages 2–6 and requires rapid recognition and treatment. Since the introduction of the universal *Haemophilus influenzae* type B (Hib) vaccine, the incidence is decreasing.

Diagnosis and Treatment

Onset is fast, and fever and sore throat are usually the first symptoms. Epiglottitis is nonseasonal, and recurrence is rare. Respiratory distress, drooling, inspiratory stridor, loss of voice, and intercostal retractions are common manifestations.



Learning Hint

Respiratory distress, drooling, dysphagia, and dysphonia are the four D's that are signs of the life-threatening disease epiglottitis.

Microbial Causes

Airway maintenance is the mainstay of treatment, with antibiotic therapy empirically selected against *H. influenzae* type B, although other pathogens, such as penicillin-resistant *Pneumococcus*, β -hemolytic streptococci, and *Staphylococcus aureus* (including MRSA), can still cause the disease.

Pharmacologic Treatment

The preferred treatments are cefotaxime (150–225 mg/kg/day) or ceftriaxone (80–100 mg/kg/day) plus clindamycin or vancomycin (added in severely ill patients for staphylococcal coverage).



Learning Hint

Clinical presentation of croup is that of a barking cough and inspiratory stridor.

14.3b Croup

Croup is different from epiglottitis but also results from infections of the laryngeal area. It, too, can cause airway obstruction and is characterized by noisy breathing—especially on inspiration. The medical term for croup is *laryngotracheitis* (now you know why it's easier to just call it croup).

Microbial Causes

Croup is usually caused by viruses; bacterial infection may occur after a previous viral infection. A frequent causative virus is respiratory syncytial virus (RSV). Bacterial causes include *Staphylococcus aureus*, Group A β -hemolytic streptococci, and pneumococci, while milder cases may be caused by mycoplasma. Parainfluenza types 1 and 2 cause viral croup.

Diagnosis and Treatment

Croup progresses slowly, usually at night. Fever is uncommon. It is most common in late spring and late fall. Children younger than 3 years old most commonly get croup. It is characterized by stridor and no drooling. Treatment consists of air humidification and oxygen.

Pharmacologic Treatment

Pharmacologic therapy starts with nebulized racemic epinephrine and corticosteroids to decrease swelling and inflammation. If a subsequent bacterial infection develops, empiric antibiotic treatment for the bacteria may be necessary after appropriate cultures are obtained with a regimen that would be similar to the one recommended above for epiglottitis.

Now that we have discussed upper respiratory tract infections, we will move down to lower respiratory tract infections, including bronchitis, bronchiolitis, pneumonia, and tuberculosis.



Life Span Considerations

Reemergence of Whooping Cough

Bordetella pertussis is a highly contagious infection also known as whooping cough that is often not considered as a cause of upper respiratory tract infections. It should be considered as a potential cause of a prolonged upper respiratory infection and cough that fails to resolve after

2 weeks. This is true even if the childhood DTP vaccination was given. Erythromycin is still the antibiotic of choice and is given for at least 14 days.

14.4 Lower Respiratory Tract Infections

14.4a Acute Bronchitis and Bronchiolitis

Acute **bronchitis** and **bronchiolitis** are inflammatory conditions of the large and small airways of the tracheobronchial tree. They are usually associated with a respiratory infection. The inflammatory/infectious process in these two conditions does not extend to the alveoli. The treatment of chronic bronchitis was covered in Chapter 13, since it is primarily an inflammatory process. Acute bronchitis occurs in all ages and is seen most commonly in the winter months, following a pattern very similar to that of other acute respiratory tract infections. Damp, cold climates, the presence of respiratory pollutants in the air, or cigarette smoke can precipitate acute attacks. Bronchiolitis is the term for this disease in infants.

Diagnosis and Treatment

Acute bronchitis is usually a self-limiting illness and rarely leads to further complications. In general, infection in the trachea and bronchi leads to increased bronchial secretions and may affect bronchial mucociliary function. The secretions may become thick and tenacious, further affecting mucociliary activity. Acute bronchitis generally begins in the upper airways, and patients present with nonspecific complaints including headache, malaise, and sore throat.

The cough may develop slowly or rapidly and the symptoms persist despite resolution of the preceding nasal symptoms or sore throat. The cough usually progresses, becoming productive, with mucopurulent sputum. Fever is not usually present. The chest exam may reveal rhonchi and coarse crackles bilaterally, and the chest x-ray is usually normal. This respiratory condition is almost always caused by a virus, so cultures are not useful.

Most infants have symptoms suggestive of an upper respiratory tract infection for 2–7 days before the onset of bronchiolitis. These infants are usually irritable and restless, with a mild fever. Again, the most common clinical sign is cough. As the infection progresses, the infant may experience vomiting, diarrhea, noisy upper airway breathing, and an increased respiratory rate. Infants who require hospitalization have noisy, labored breathing, with tachypnea and tachycardia. Many of these infants have a mild conjunctivitis, and 5% to 10% may also have otitis media. Because of their increased work of breathing and coughing, combined with fever, the infants are frequently dehydrated. Diagnosis is made according to clinical symptoms and history. There are several other diseases in infants (asthma, foreign body obstruction, gastroesophageal reflux, etc.) that can present with similar clinical symptoms.



Cough is the hallmark symptom that distinguishes bronchitis from other upper airway infections, such as pharyngitis.

In adults, acute bronchitis is almost always self-limiting, and the goals of therapy should be to provide comfort to the patient. Guidelines from the Centers for Disease Control and Prevention state that the only indication for antibiotics is acute bronchitis due to pertussis, also known as *whooping cough*. Unfortunately, whooping cough is making a comeback due to lack of immunizations for children. In the well infant, bronchiolitis is also usually a self-limiting disease, and all that is necessary is to wait for the underlying viral infection to resolve. Hospitalization is necessary for a child suffering from respiratory failure or dehydration.

Microbial Causes

Viruses are the most common infectious agents that cause bronchitis. The common cold viruses, influenza virus, adenovirus, respiratory syncytial virus (RSV), and coronavirus are most often involved. In infants and children, the same pathogens are usually involved. Even though it has been suggested that the same bacterial pathogens that cause pneumonia, such as *Streptococcus pneumoniae*, *Moraxella catarrhalis*, *Haemophilus influenzae*, and *Staphylococcus aureus*, can cause bronchitis, there is no convincing evidence that this is the case.

Bronchiolitis is an acute viral infection of the lower respiratory tract of infants. The peak attack age for children is between the ages of 2–10 months. Incidence spikes in the winter months and persists through the spring. Bronchiolitis is one of the major reasons that infants under the age of 6 months require hospitalization. RSV is the most common cause of bronchiolitis, accounting for over 50% of cases. Certain times of the year can bring almost epidemic incidence of RSV, with over 80% of bronchiolitis cases during those times being caused by the virus. Parainfluenza virus types 1, 2, and 3 cause most of the rest of the cases of bronchiolitis. Bacteria only rarely cause this disease.

Two vaccines (Abrysvo® and Axresvya®) for respiratory syncytial virus (RSV) were approved in 2023 for people 60 and older. Abrysvo® is also indicated for pregnant people in weeks 32–36 of gestation during the months of September–January. Pregnant people receiving the vaccine do so with the understanding that protection will be provided to the unborn infant. Nirsevimab (Beyfortus®) is a monoclonal antibody-based immunization recommended for all infants younger than 8 months of age who are born during or who are entering their first Respiratory Syncytial Virus (RSV) season. Infants younger than 8 months of age do not need nirsevimab if they were born 14 or more days after their mother received the RSV vaccine. Nirsevimab is also recommended for some children aged 8–19 months who are at increased risk for severe RSV disease and entering their second RSV season. Another monoclonal antibody can be used as prophylaxis treatment. Palivizumab (Synagis®) is used in those younger than 24 months of age with certain conditions that place them at increased risk for severe RSV disease. It must be given once a month during RSV season.



Patients should be cautioned not to use any of the over-the-counter combinations that might dry secretions (mostly those containing antihistamines), as they could aggravate the condition and prolong the recovery time.

Pharmacologic Treatment

Acute Bronchitis The most common medications used are for symptomatic therapy. Analgesics, antipyretics, or acetaminophen are helpful in reducing malaise, lethargy, and fever in adults. Patients with acute bronchitis frequently self-medicate with over-the-counter cough and cold remedies, although there is no evidence that any of these various combination therapies are effective.

Persistent cough may require nighttime suppression with dextromethorphan. More severe cough may require intermittent treatment with codeine- or hydrocodone-containing cough mixtures. One should avoid suppressing a productive cough except when it is persistent enough to disrupt sleep.



Bronchiolitis Aerosolized β -adrenergic therapy has been used to treat bronchiolitis, but newer research shows most do not benefit and it is not recommended. Inhaled or systemic corticosteroids have not been shown to be conclusively beneficial. Because bacteria rarely cause bronchiolitis, antibiotics should not be used routinely. Ribavirin may benefit a small number of bronchiolitis cases. This agent is effective against respiratory syncytial virus (RSV). Use of the aerosolized drug requires special nebulizer equipment (a small particle aerosol generator) and specifically trained personnel for administration via an oxygen hood or mist tent. Special care must be taken to avoid drug particle deposition and clogging of respiratory tubing and mechanical ventilator valves.

Controversy

Use of antibiotics for acute bronchitis is not recommended. Unfortunately, antibiotic prescriptions for this condition are common. The clinician should stay vigilant for a bacterial infection such as pneumonia that may develop later. It is important to remember that the cough from acute bronchitis lasts from 1 to 3 weeks. Acute bronchitis from *Bordetella pertussis* (whooping cough) would respond to antibiotics but is only responsible for about 1% of US cases.



Most experts recommend reserving ribavirin for severely ill and/or immunocompromised children, especially those with serious underlying disorders such as bronchopulmonary dysplasia, congenital heart disease, prematurity, or immunodeficiency disorders.

14.4b Pneumonia

Pneumonia is a leading cause of death in the United States as well as one of the most common causes of hospitalization. It is defined as an inflammation of the lung tissue and may be caused by bacteria, viruses, or even noninfectious agents such as drugs or chemicals. The principal site of infection is in the alveoli and surrounding interstitial tissue.

Individuals with pneumonia classically present with high white blood cell counts, high fevers, crackles, rhonchi, bronchial breath sounds, and dullness to percussion over the involved areas of the lung. Patients with pneumonia may have pleural effusions, and their chest x-rays usually reveal infiltrates or signs of consolidation. Patients with pneumonia are far more likely to experience complications such as hypoxia, cardiopulmonary failure, local abscesses or empyemas, and possible spread of infection to other organs by way of the bloodstream. There are several well-defined categories of pneumonia that help to define appropriate therapy, and we will review this disease according to these subclassifications.

Community-Acquired Pneumonia

Community-acquired pneumonia (CAP) is an infection of the lung tissue that, in its purest definition, is contracted outside the institutional setting (institutional meaning nursing homes, hospitals, or any other place that might encourage the transmission of bacteria between compromised individuals). This definition by setting has evolved to be more a description of the likely pathogens than a delineation of where the disease was contracted. *Streptococcus pneumoniae*, *Haemophilus*

influenzae, *Mycoplasma pneumoniae*, *Chlamydophila pneumoniae*, a variety of respiratory viruses, and *Legionella pneumophila* account for most cases of CAP, with *S. pneumoniae* being responsible for a majority of the cases of acute CAP. Gram-negative bacteria and *Staphylococcus aureus* are uncommon causes of CAP but are more likely in patients who have taken antibiotics or who have underlying respiratory diseases.

The most significant problem in the treatment of CAP is the growing resistance of *Streptococcus pneumoniae* to antimicrobials. This increasing resistance, combined with the much wider variety of organisms causing the disease, has made diagnosis and treatment a much greater therapeutic challenge.

Atypical Pneumonia The term *atypical pneumonia* has been in use in the medical literature for over a century to refer to a subset of CAP organisms (e.g., *Legionella pneumophila*, *Chlamydophila pneumoniae*, *Mycoplasma pneumoniae*). Since there is no way to distinguish “typical” versus “atypical” CAP pathogens clinically, this term should no longer be used.

Over the years, many other organisms—including viruses and fungi—have been found to cause pneumonia. All causes other than *S. pneumoniae*, *M. catarrhalis*, and *H. influenzae* were lumped into the classification “atypical pneumonia.” Before the outbreak and identification of a new organism, *Legionella pneumophila*, at the 1976 Philadelphia convention of the American Legion—and the increasingly common incidence of *Chlamydophila pneumoniae* and mycoplasma infections—atypical pneumonia was generally mild and self-limiting, with very low mortality. These new atypical pneumonias were much more deadly and made the “atypical” classification very imprecise. Physicians had to rethink the diagnosis and treatment of community-acquired pneumonia to allow for the presence of these atypical organisms.

Mycoplasma pneumoniae infections tend to follow epidemic patterns, with outbreaks every 4–8 years, making it hard to define the true incidence. *Legionella* tends to infect older and more immunocompromised patients. It also has a more seasonal occurrence, tending to break out in the spring, when air conditioning is started. *Chlamydia* tends to infect young people, such as college students and military recruits.

When you analyze the signs, symptoms, and chest x-rays of patients infected with these three atypical pathogens, very little difference can be seen between atypical and typical pneumonia. *Mycoplasma* may be slower and more insidious and *Legionella* more rapidly progressing, but that is not standard for all. The only real difference between the atypical organisms (*Chlamydia*, *Legionella*, and *Mycoplasma*) and the typical pneumonia organisms (*S. pneumoniae*, *M. catarrhalis*, and *H. influenzae*) is that the atypical organisms cannot be cultured with standard microbiologic media or techniques, and they do not respond to treatment with penicillins or other antibiotics classically used for typical pneumonia.

Whereas “typical” pneumonia tends to affect patients with some other chronic illness and who are older than 50 years of age, atypical pneumonia tends to affect young adults with no underlying illness. Typical pneumonia tends to have a rapid onset and high fever, whereas atypical pneumonia may be more insidious in onset. However, it has become very difficult to distinguish atypical infections from typical infections clinically, since the atypical organisms have become more virulent and *S. pneumoniae* has become more resistant to therapy. Current recommendations from the American Thoracic Society and the Infectious Diseases Society of America for the treatment of CAP are that empiric therapy should cover both the “typical” and “atypical” causative organisms.



Therapy Recommendations for CAP and Atypical Pneumonias In the past, antibiotic therapy for CAP was fairly simple. It was quite likely that *S. pneumoniae* was the causative organism, and the pneumococcus responded very well to treatment with penicillin. However, as early as 1967, resistant pneumococci began to show up. Now 20% to 40% of *S. pneumoniae* strains show resistance to penicillin. *S. pneumoniae* still accounts for the majority of CAP cases, but other organisms are creeping up in incidence. Because eradication of the offending organism is one of our major treatment goals in pneumonia, appropriate empiric antibiotic therapy is a major challenge. Therapy should minimize any associated morbidity and not cause any drug-induced side effects or organ dysfunction.

The first priority in the treatment of pneumonia is to evaluate the patient's respiratory function and to determine if the patient requires hospitalization or can be treated as an outpatient. Patients may require intravenous fluids, oxygen, bronchodilators, chest physiotherapy with postural drainage, or even mechanical ventilation. The second priority in hospitalized patients is to obtain cultures of the sputum and to use other diagnostic procedures to determine the microbiologic cause of the acute disease. Assessing the patient's clinical setting can help the choice of empiric therapy once you understand what pathogens are likely in specific patient populations. Table 14–7 can help you consider these circumstances.

Table 14–7 Empiric Antibiotic Choices for Adult Pneumonias

Clinical setting	Likely pathogen	Therapy
Elderly patient, from nursing home or other care facility (health care–associated pneumonia)	<i>Streptococcus pneumoniae</i> , <i>Moraxella catarrhalis</i> , <i>Haemophilus influenzae</i> , <i>Klebsiella pneumoniae</i> , <i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i>	piperacillin/tazobactam, third- or fourth-generation cephalosporin, imipenem/cilastatin, or meropenem
History of chronic obstructive pulmonary disease (COPD)	<i>Streptococcus pneumoniae</i>	azithromycin, doxycycline or clarithromycin plus either cefpodoxime or cefuroxime, a respiratory fluoroquinolone (levofloxacin or moxifloxacin)
Alcoholic	<i>Streptococcus pneumoniae</i> , <i>Klebsiella pneumoniae</i> , <i>Staphylococcus aureus</i> , <i>Haemophilus influenzae</i> , possibly anaerobes from the oral cavity	ampicillin/sulbactam, piperacillin/tazobactam plus an aminoglycoside, imipenem/cilastatin or meropenem, a fluoroquinolone, vancomycin (if MRSA suspected)
Previously healthy, ambulatory patient (CAP)	<i>Streptococcus pneumoniae</i> , <i>Mycoplasma pneumoniae</i>	clarithromycin, azithromycin, or doxycycline
Aspiration pneumonia	Anaerobes from the oral cavity, <i>Staphylococcus aureus</i> , gram-negative enteric organisms	penicillin, clindamycin, ampicillin/sulbactam
Ventilator-associated (VAP) or hospital-acquired (HAP) pneumonia	Gram-negative bacilli such as <i>Klebsiella pneumoniae</i> , <i>Enterobacter pneumophila</i> , <i>Pseudomonas aeruginosa</i> , <i>Staphylococcus aureus</i>	piperacillin/tazobactam, imipenem/cilastatin or meropenem, or expanded-spectrum cephalosporins such as ceftazidime or cefepime plus an aminoglycoside, fluoroquinolone

Empiric antibiotic choices for the treatment of community-acquired pneumonia are no longer very simple. In the past, all patients with the clinical picture of pneumonia were started on penicillin because *S. pneumoniae* was the most likely and the most aggressive of the likely organisms causing the infection. Since *S. pneumoniae* continues to become more resistant to penicillin and the offending agent is often not identified, empiric therapy is guided by local resistance patterns

in addition to considering the patient's clinical setting, prior exposure to antibiotics, clinical condition, chest x-ray, and underlying state of health.

Guidelines for the treatment of CAP continue to be revised, and the clinician must be careful to review current literature for the most up-to-date recommendations. The American Thoracic Society and the Infectious Diseases Society of America published a joint guideline in 2007. They recommend macrolides (erythromycin, clarithromycin, or azithromycin) or doxycycline (or tetracycline) for children aged 8 years or older or an oral β -lactam with good antipneumococcal activity (cefuroxime axetil, amoxicillin, amoxicillin/clavulanate) as the first-line therapies for CAP. An oral fluoroquinolone with improved activity against *S. pneumoniae* (levofloxacin, moxifloxacin, gatifloxacin) may be used for the treatment of adults for whom one of these regimens has already failed or for those who are allergic to the alternative agents or have a documented infection with a highly drug-resistant pneumococcus. The fluoroquinolones should not be used in children. For children younger than 5 years, in whom atypical pathogens are uncommon and for whom doxycycline and fluoroquinolones should be avoided, β -lactams are the best choice.



Because intubation and mechanical ventilation alter first-line patient respiratory defenses, they greatly increase the risk for health care–associated bacterial pneumonia. There are VAP protocols for mechanically ventilated patients to try to lessen or prevent pneumonia occurrence; these include elevating the head of the bed, using prophylaxis for peptic ulcer disease and deep vein thrombosis (DVT), ensuring daily oral care with chlorhexidine, closed system suctioning, and changing the ventilator circuit when needed.

Health Care–Associated (HCAP), Ventilator–Associated (VAP), or Hospital–Acquired (HAP) Pneumonia

The common thread for these types of pneumonias is exposure to or frequent contact with various health-care settings. Pneumonia is the second most common hospital-acquired infection in the United States and is associated with substantial morbidity and mortality. Most patients who have VAP, HAP, or HCAP have severe underlying disease, are immunosuppressed, are comatose, or are otherwise incapacitated and have cardiopulmonary disease. In addition, some health care–associated pneumonia patients have had thoracic or abdominal surgery. Although patients receiving mechanical ventilation do not represent a major proportion of patients who have pneumonia, they are at highest risk for acquiring VAP.

Pneumonias caused by *Legionella pneumophila*, *Aspergillus pneumophila*, and influenza virus are often caused by inhalation of contaminated aerosols. RSV infection usually occurs after viral inoculation of the conjunctivae or nasal mucosa by contaminated hands. Traditional preventive measures for VAP, HCAP, or HAP include taking precautions to decrease aspiration by the patient, preventing cross-contamination or colonization via hands of personnel, ensuring appropriate disinfection or sterilization of respiratory therapy devices, using available vaccines to protect against particular infections, and educating hospital staff and patients. Figure 14–4 describes the pathogenesis of pneumonia acquired from health-care settings.

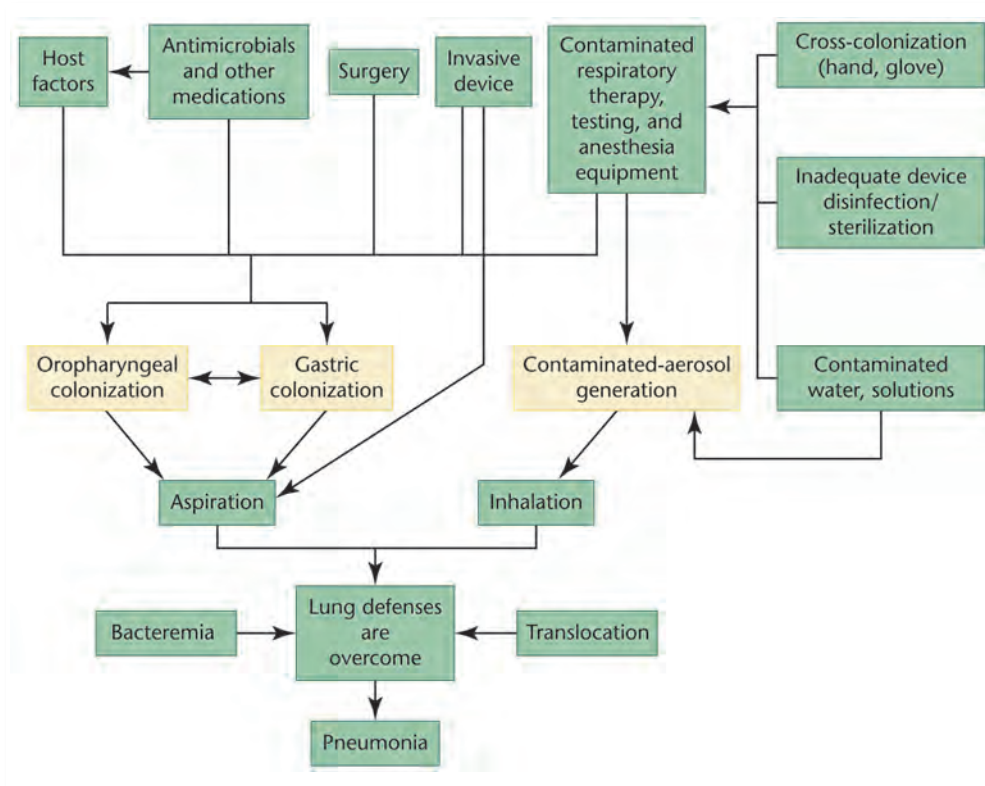
Recent epidemiologic studies have identified other subsets of patients who are at high risk for acquiring health care–associated bacterial pneumonia. Such patients include those who are older than 70 years; those who have endotracheal intubation and/or mechanically assisted ventilation, a depressed level of consciousness (particularly those with closed head injury), or underlying chronic lung disease; and those who have previously had an episode of a large volume aspiration. Other risk factors include 24-hour ventilator circuit changes, hospitalization during the fall or winter, stress bleeding prophylaxis with cimetidine (either with or without antacid), administration of antimicrobials, presence of a nasogastric tube, severe trauma, and recent bronchoscopy.

HCAP, HAP, and VAP have been associated with mortality rates of 20% to 50%. Patients receiving mechanically assisted ventilation have higher mortality rates than patients not receiving ventilation support; however, other factors (e.g., the patient's underlying disease and organ failure) are stronger predictors of death in



patients who have pneumonia. Ventilator-associated pneumonia (VAP) is difficult to diagnose but seems to correlate with the duration of mechanical ventilation.

Figure 14–4 Pathogenesis of Health Care–Associated Bacterial Pneumonia



The high incidence of gram-negative bacillary pneumonia in hospitalized patients might result from factors that promote colonization of the pharynx by gram-negative bacilli and the subsequent entry of these organisms into the lower respiratory tract. Although aerobic gram-negative bacilli are recovered infrequently or are found in low numbers in pharyngeal cultures of healthy people, the likelihood of colonization increases substantially in comatose patients, in patients treated with antimicrobial agents, and in patients who have hypotension, acidosis, azotemia, alcoholism, diabetes mellitus, leukocytosis, leukopenia, pulmonary disease, or nasogastric or endotracheal tubes in place.

Bacteria also can enter the lower respiratory tract of hospitalized patients through inhalation of aerosols generated primarily by contaminated respiratory therapy or anesthesia breathing equipment. Outbreaks related to the use of respiratory therapy equipment have been associated with contaminated nebulizers. When the fluid in the reservoir of a nebulizer becomes contaminated with bacteria, the aerosol produced may contain high concentrations of bacteria that can be deposited deep in the patient's lower respiratory tract. Contaminated aerosol inhalation is particularly hazardous for intubated patients because endotracheal and tracheal tubes provide direct access to the lower respiratory tract.

Several large studies have examined the potential risk factors for bacterial pneumonias acquired in a health-care setting. Although specific risk factors have differed among study populations, they can be grouped into the following general categories: (1) host factors (e.g., extremes of age and severe underlying conditions, including immunosuppression); (2) factors that enhance colonization of the

oropharynx and/or stomach by microorganisms (e.g., administration of antimicrobials, acid suppression medications, admission to an ICU, underlying chronic lung disease, or coma); (3) conditions that favor aspiration or reflux (e.g., endotracheal intubation, insertion of a nasogastric tube, or supine position); (4) conditions that require prolonged use of mechanical ventilatory support with potential exposure to contaminated respiratory equipment and/or contact with contaminated or colonized hands of health-care workers (HCWs); and (5) factors that impede adequate pulmonary toilet (e.g., undergoing surgical procedures that involve the head, neck, thorax, or upper abdomen or being immobilized as a result of trauma or illness).

By sorting out these risk categories, the clinician can better define the likely pathogens and then choose the most appropriate empiric antibiotic therapy. Each patient is different, and individual analyses must be made. Table 14–7 showed some of the likely pathogens causing pneumonia in a health-care setting and the general antibiotic choices. Most of these antibiotics can be considered the “big guns” of the antibiotic world. They are costly, require parenteral therapy, have significant toxicities, and require close monitoring. In general, selection of antibiotics for a patient with HCAP, VAP, or HAP requires an antibiotic to cover gram-negative pathogens as well as the more common pneumonia pathogens. Most patients require more than one antibiotic to cover the entire spectrum of likely organisms. If a culture is obtained and the pathogenic organisms are isolated, the antibiotic regimen may be simplified or narrowed to specifically cover the isolated organisms.

Antibiotic Therapy Recommendations for the Treatment of Pneumonia Acquired in a Health-Care Setting (HCAP, VAP, HAP) Patients with pneumonia acquired in a health-care setting require many supportive and symptomatic therapies. They may be mechanically ventilated, they may be in an ICU, and they may be very sick. It is not possible to go over all their potential therapies in detail; you will need to use your clinical knowledge of respiratory illness to help the prescriber know what symptomatic therapies will be needed. We will focus on the antibiotic therapies at this point.

Antibiotic resistance in hospitals is variable, and specific institutions have their own guidelines. The newer antibiotics for resistant cases tend to be expensive and restricted in use. The 2007 joint American Thoracic Society/Infectious Diseases Society of America guideline recommends that empiric therapy should cover MRSA, *Pseudomonas aeruginosa*, gram-negative bacilli, and *Legionella*. Empiric therapy decisions can be modified based on local data indicating the most frequent bacterial pathogens isolated and their respective susceptibility patterns. Moderately ill patients with pneumonia may receive intravenous ceftriaxone, levofloxacin, or ertapenem. Alternatively, in patients who have been hospitalized for more than 5 days and were receiving antibiotics previously, intravenous cefepime or ceftazidime, meropenem or doripenem, or piperacillin/tazobactam plus either gentamicin or tobramycin should be considered along with a drug that has activity against MRSA, such as vancomycin or linezolid. If a pathogen is identified, the initial broad-spectrum, empiric regimen should be de-escalated by discontinuing drugs that are not necessary.

Aspiration Pneumonia

Aspiration pneumonia can be either chemical (exposure to stomach acid) or bacterial. Bacteria can invade the lower respiratory tract by aspiration of oropharyngeal organisms, inhalation of aerosols containing bacteria, or, less frequently, hematogenous spread from a distant body site. In addition, bacterial translocation from the gastrointestinal tract has been hypothesized recently as a mechanism



for infection. Of these routes, aspiration is believed to be the most important for both health care–associated and community-acquired pneumonia.

Aspiration pneumonia brings a different set of possible pathogens. If the pneumonia is due to acid exposure, antibiotics won't help. Only symptomatic therapy can be used as the lungs heal. Empiric antibiotic therapy generally consists of agents with anaerobic and gram-negative coverage in their spectrums of activity.

Patients who develop aspiration pneumonia in the community setting should be treated with an antibiotic that is effective against gram-positive anaerobes. Such antibiotics include clindamycin or penicillins. If the patient aspirated while hospitalized or is significantly debilitated by coexisting disease, broad-spectrum therapy should be used to expand the coverage to gram-negative pathogens. Generally, clindamycin or a penicillin combined with a β -lactamase inhibitor (such as piperacillin/tazobactam) plus an aminoglycoside (tobramycin, gentamicin, or amikacin) should be considered.



In radioisotope tracer studies, 45% of healthy adults were found to aspirate during sleep. Those who swallow abnormally (e.g., those who have depressed consciousness, respiratory tract instrumentation and/or mechanically assisted ventilation, or GI tract instrumentation or diseases) or who have just undergone surgery are particularly likely to aspirate.



● ● ● Time for Review

Why are gram-negative pathogenic bacteria more common in aspiration?



Pneumocystis jiroveci Pneumonia

Pneumocystis jiroveci pneumonia (PJP), formerly known as *Pneumocystis carinii*, is a complication of HIV infection. It should be noted that it can also occur in non-HIV infected patients. Like tuberculosis, *Pneumocystis* can be asymptomatic and latent.

Diagnosis and Treatment Symptoms, when present, may include fever, cough, tachypnea, and dyspnea. Treatment is divided into acute and chronic. Arterial blood gases are one of the key factors in therapy decisions. The disease can be classified as mild, moderate, or severe on the basis of oxygenation.

Factors to consider when starting drug therapy for PJP are whether it is a first episode, arterial blood gases, history of drug reaction, and route of therapy. Drugs used for acute treatment are intravenous trimethoprim-sulfamethoxazole (TMP-SMX), dapsone, parenteral clindamycin, primaquine, atovaquone, or IV pentamidine. These drugs are toxic. For example, more than 50% of patients who receive trimethoprim-sulfamethoxazole may develop rash, fever, leukopenia, hepatitis, or thrombocytopenia. Pentamidine can cause azotemia, pancreatitis, hypocalcemia, or leukopenia, to name a few complications. Corticosteroids have a role in patients with acute moderate to severe PJP, and calculation of PaO_2 gradient can guide their use.

Cystic Fibrosis and Pneumonia

Cystic fibrosis is a genetic disease of exocrine gland secretions. Recurrent respiratory infections play a big role in this chronic pulmonary disease. At different times during the course of the disease, different pathogens are found. It's common to have multiple bacterial isolates that have different antibiotic sensitivities. Systemic



Giving a bronchodilator before administering aerosolized antibiotics is recommended to prevent or lessen the possibility of bronchospasm.

antibiotics may be used to treat pulmonary infections in cystic fibrosis, frequently in combination therapy. Agents used may be an aminoglycoside combined with an extended-spectrum penicillin or third-generation cephalosporin. Antibiotic use is controversial, and goals differ in individual patients because of resistance, changes in host defense, and bacterial growth patterns. Intuitively, one would expect that suppressive antibiotic therapy would prolong the time between disease exacerbations and slow progression of lung disease.

Because antibiotics penetrate poorly in lung tissue, aerosolized antibiotics have been utilized with some success. One of the limiting factors in aerosol antibiotic administration is the bronchospasm that can result from aerosolized antibiotics. However, aerosolized, preservative-free tobramycin should be considered in cystic fibrosis patients 6 years of age and older with moderate to severe lung disease to reduce exacerbations and to improve lung function.

Therapeutic Guidelines

Because care of patients with pneumonia is quite common, therapeutic guidelines for the care of pneumonia patients are published and updated frequently. Individual institutions may have guidelines as well. It is important to stay updated with the current recommendations. The American Thoracic Society, the British Thoracic Society, the Association of Medical Microbiology and Infectious Disease Canada (AMMI Canada), and the Infectious Diseases Society of America all publish sets of guidelines, and each of those societies updates them regularly.

Patient & Family Education

Aerosol Antibiotic Education



Counseling patients and their families on the proper use of aerosolized antibiotics is important. Education should include providing specific instructions on what to do before using the aerosol and complete directions for use, reviewing safety considerations for aerosol antibiotic therapy, and monitoring.

Prevention of Pneumonia

Prevention of pneumonia may be possible with use of pneumonia and influenza vaccines. Influenza virus vaccine is formulated each year to contain antigens of expected prevalent strains. Immunization is promoted for those who might experience serious complications from influenza, such as patients with underlying heart disease, lung disease, chronic renal disease, and the elderly.

14.4c Tuberculosis

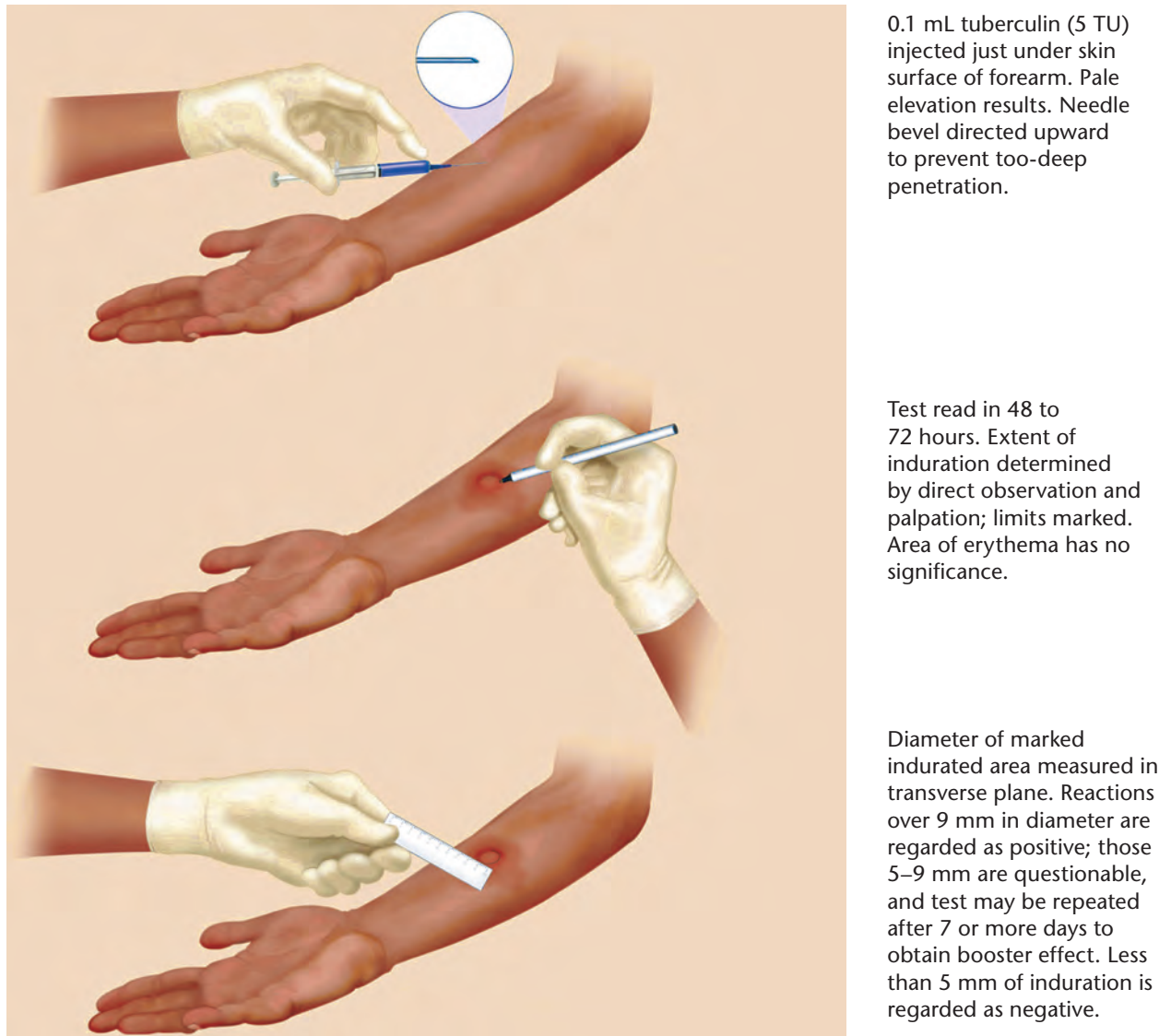
No chapter on respiratory infectious diseases would be complete without a short discussion of **tuberculosis** (TB). Tuberculosis is a chronic disease caused by *Mycobacterium tuberculosis*. Although it can affect any part of the body, it most commonly affects the lungs. There has been a gradual decline in the number of active cases over the years, but there are still millions of people with TB infection that has progressed to active TB. TB is spread by microscopic droplets and is an airborne disease. It can be spread when an infected person coughs or sneezes. Once the droplet is inhaled, it becomes encapsulated, and the infection is latent.



Diagnosis and Treatment

When the infection droplets—called bacilli—escape, the disease becomes active. Symptoms of active TB can range from none to weight loss, fever, night sweats, or bloody sputum. Diagnosis is made with a skin test, blood test, sputum sample, and chest x-ray. See Figure 14–5 for an illustration of the Mantoux skin test or purified protein derivative (PPD) test to diagnose TB. Drug therapy for TB is aimed at preventive therapy for latent infection or treatment of active TB disease.

Figure 14–5 The Mantoux or PPD Testing Procedure to Diagnose TB



Pharmacologic Treatment

Preventive therapy is usually with isoniazid for 6–12 months, which decreases the risk that the infection will progress to disease. Research is always in progress to determine the easiest yet most effective method of prophylaxis. Certain people are at a higher risk for developing TB; this group includes people who are in close contact with others with TB, people with a chest x-ray suggesting previous TB that was not treated, people with HIV, and people who are substance abusers, for example. Patients on corticosteroids also may be at increased risk of disease progression.

Treatment of TB takes 6–24 months. The current recommendations for TB treatment include a combination of case management and directly observed therapy to ensure completion of therapy and minimize drug resistance. Drug treatment must be in combination because resistance is a problem. Drugs used are isoniazid, rifampin, pyrazinamide, ethambutol, and streptomycin. Bedaquiline (Sirturo®) was recently approved by the FDA for multidrug-resistant TB to be used in combination with at least three drugs that are also active against the patient's TB isolate. Because of resistance, adherence to the drug regimen is the key point for TB.



One way to try to reduce TB treatment failures is to use DOT, or directly observed treatment, to make sure a patient is medication compliant. This is now considered a standard component of therapy.

14.4d Avian Influenza

Avian influenza (bird flu) is a type of influenza virus carried in the intestines of wild birds. Although the wild birds themselves may not get sick, they transmit the virus to domestic birds. Poultry industry conditions may make it possible for humans to be exposed and a humanized strain to evolve. Because the human immune system has not been previously exposed, it does not have any antibodies, making for a potentially devastating outbreak. Some of the clinical features that may present after an incubation period of 2–5 days are high fever, cough, rhinorrhea, diarrhea, vomiting, abdominal pain, shortness of breath, myalgia, and headache. Some patients may have lymphopenia, thrombocytopenia, or pulmonary infiltrates. Symptoms appear like a viral pneumonia, with progression to acute respiratory distress syndrome a possibility. There is a lack of treatment for avian influenza, making prophylaxis and supportive treatment the reality.

14.4e COVID-19

Disclaimer: All information in this section is subject to change. This information is current as of December 2023. Updated information can be obtained by using the following resources:

- COVID-19 Vaccination Clinical & Professional Resources: <https://bvtlab.com/h49hX>
- COVID-19 Treatments and Medications: <https://bvtlab.com/s887D>
- NIH COVID-19 Treatment Guidelines: <https://bvtlab.com/uqrCt>

COVID-19 (SARS-COV-2) is a unique and new strain of coronaviruses that causes an upper and/or lower respiratory infection. It is characterized by being highly efficient at passing from person to person with a considerable degree of morbidity and mortality, especially among those patients who are in high-risk populations. Older adults, young children, and people who have severe underlying medical conditions,



such as heart or lung disease or diabetes, have higher risk for developing more serious complications when infected with COVID-19. People with COVID-19 may be asymptomatic or have the following symptoms (ranging from mild symptoms to severe illness). Symptoms may appear 2–14 days after exposure and include fever or chills, cough, shortness of breath or difficulty breathing, fatigue, muscle or body aches, headache, new loss of taste or smell, sore throat, congestion or runny nose, nausea or vomiting, and diarrhea.

Vaccination is recommended for all people 6 months of age and older. The recommendations and vaccine products available for COVID-19 changed drastically and frequently throughout their development. The most recent recommendations are simplified compared to previous recommendations. One of the most important changes in COVID-19 vaccine recommendations is that there is no longer consideration of primary or booster dose(s). Another is that like influenza vaccines, COVID-19 vaccines are expected to be reformulated annually to reflect the most prevalent circulating strains of the virus.

Most people need just a single dose of an updated COVID-19 vaccine (for the current season) to be protected. Special recommendations apply to those who are ≥ 65 years old (should get a second dose annually) and those who are immunocompromised (can receive an additional doses every 2 months). There are three vaccines available in the United States currently. Two mRNA vaccines, one made by Pfizer-BioNTech (COMIRNATY®) and the other made by Moderna (SPIKEVAX®). The other is a protein subunit vaccine made by Novavax (Novavax Vaccine®). Vaccination remains the single best way to protect against developing serious complications from COVID-19.

Recently, the FDA has authorized or approved several antiviral medications used to treat mild to moderate COVID-19 in people who are more likely to get very sick. These antiviral treatments target specific parts of the virus to stop it from multiplying in the body, helping to prevent severe illness and death. Several options are available by prescription for treating COVID-19, and like those antivirals used for influenza, they should be started as soon as possible after symptoms begin or diagnosis occurs. The antiviral options are summarized below in Table 14–8. For patients who are hospitalized with severe infection, other types of treatments may be used, such as supportive care including supplemental oxygen and mechanical ventilator (intubation).



Influenza (flu) and COVID-19 are both contagious respiratory illnesses, but they are caused by different viruses. COVID-19 seems to spread more easily than flu and causes more serious illnesses in some people. It can also take longer before people show symptoms, and people can be contagious for longer. Because some of the symptoms of flu and COVID-19 are similar, it may be hard to tell the difference between them based on symptoms alone, and testing may be needed to help confirm a diagnosis. Patients can get tested for an active COVID-19 infection and can also get tested to see if they previously contracted and recovered from the virus. A viral test is used to tell if the patient has a current infection. Two types of viral tests can be used to diagnose an active COVID-19 infection: nucleic acid amplification tests (NAATs) and antigen tests. An antibody test is used to show if the person had a past infection. Antibody tests should not be used to diagnose a current infection.

Table 14–8 Current Antivirals for COVID-19 in the United States

Treatment	Indicated for (Among persons who are at high risk of getting sick)	Timing	How Administered
Nirmatrelvir with Ritonavir (Paxlovid®)	Adults; children ages 12 years and older	Start as soon as possible; must begin within 5 days of when symptoms start	Taken at home by mouth (orally)
Remdesivir (Veklury®)	Adults and children	Start as soon as possible; must begin within 7 days of when symptoms start	Intravenous (IV) infusions at a health-care facility for 3 consecutive days
Molnupiravir (Lagevrio®)	Adults	Start as soon as possible; must begin within 5 days of when symptoms start	Taken at home by mouth (orally)



Controversy

The lack of a vaccine or proven treatment makes the public and medical community nervous about a bird flu pandemic. What do you think of “hoarding” antiviral medications?

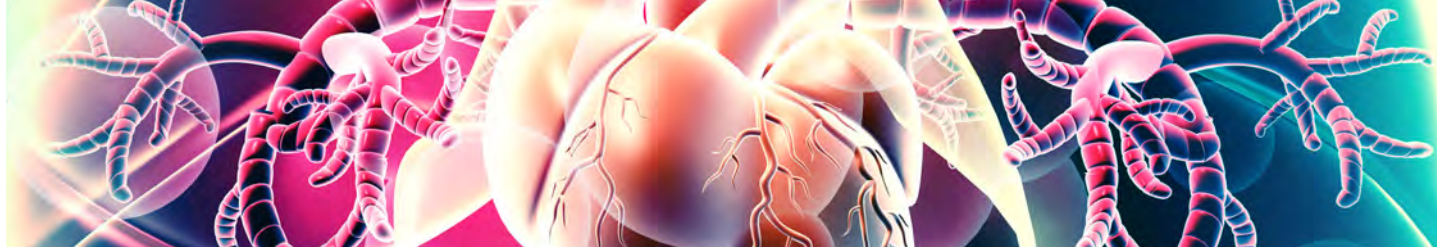
14.5 Chemical Terrorism

Chemical terrorism agents include nerve agents such as cholinesterase inhibitors, pulmonary irritants, and chemical asphyxiants—making them a very pertinent topic. Because antibiotics have a role in treatment and/or prophylaxis, the topic needs to be mentioned in this chapter.

Pulmonary irritants, such as chlorine and phosgene, have been used since World War I. Through biochemical reactions, these irritants can cause laryngospasm and pulmonary edema. Cyanide warfare was used as far back as Napoleon III, who proposed dipping soldiers’ bayonets in the substance; more recently, cyanide was used in the Chicago Tylenol® murders in 1982, which involved drug tampering. Given cutaneous or inhalational exposure, cyanide binds to cytochrome oxidase to interfere with aerobic cell metabolism.

Anthrax also acts as a biologic weapon through cutaneous or inhalational exposure. Inhaled spores are transported lymphatically until they germinate and toxins are produced. Anthrax is best treated prophylactically with antibiotics such as ciprofloxacin.

Plague is a potential bioweapon because it is contagious with close contact and aerosol transmission is possible. Systemic illness warrants parenteral antibiotic therapy with agents such as streptomycin or gentamicin. Postexposure prophylaxis is usually oral treatment with doxycycline and ciprofloxacin. Vaccination was discontinued in 1999.



Summary

Respiratory infections are the major cause of morbidity and mortality from acute illness in the United States. The majority of these infections follow colonization of the upper respiratory tract with potential pathogens. Less commonly, the pathogen may gain access to the lungs via the blood or by inhalation of infected aerosol particles. The patient's own immune status will have much to do with his or her susceptibility to a respiratory tract infection.

Appropriate therapy for respiratory tract infections is a multifaceted decision. The clinician must consider the patient's history, physical examination, chest x-ray, and culture results, as well as local pathogen incidence and resistance patterns. The most common pathogen in respiratory illness is *Streptococcus pneumoniae*, but this is changing. Other pathogens are becoming more virulent and deadly, and *S. pneumoniae* has changed significantly in its resistance to antimicrobial therapy.

Review Questions

1. A usual first-line antibiotic agent for children with acute otitis media is
 - (a) tetracycline
 - (b) metronidazole (Flagyl®)
 - (c) amoxicillin
 - (d) cefaclor (Ceclor®)
 - (e) any of the above
2. Most cases of acute sinusitis develop from what causative organism?
 - (a) anaerobic bacteria
 - (b) *Streptococcus pneumoniae*
 - (c) *Escherichia coli*
 - (d) influenza virus
3. The treatment of choice for pharyngitis is
 - (a) penicillin
 - (b) tetracycline
 - (c) cephalexin
 - (d) erythromycin
4. A patient presents with a high white blood cell count, fever, bronchial breathing, and rhonchi on auscultation. What type of infectious process do you suspect?
 - (a) otitis media
 - (b) sinusitis
 - (c) croup
 - (d) pneumonia
5. Gram-negative bacteria are frequently colonized in
 - (a) healthy people
 - (b) hypertensive patients
 - (c) patients with nasogastric tubes
 - (d) patients with community-acquired pneumonia
 - (e) all of the above
6. What is empiric therapy? What are some of the questions that need to be answered when treating infections?
7. Give an example of an indication when an antibiotic may not be appropriate.
8. Why does an ear or sinus infection have respiratory implications?

9. What is community-acquired pneumonia, and what are some problems with its treatment?
10. A 62-year-old man presents to the walk-in clinic with a chief complaint of headache, sore throat, and cough. A sputum sample isolates *Streptococcus* and *Haemophilus*. The physician is debating whether to treat the patient with an antibiotic. What would you recommend?
11. A child is brought to the emergency department in respiratory distress, and the mother states that the child has difficulty swallowing and has been drooling for the last 3 hours. What infection would you suspect, and what antibiotic therapy would be indicated? What respiratory intervention might be needed?
12. COVID-19 is similar to influenza in terms of presentation of symptoms, so how can clinicians make an accurate diagnosis during an active infection?
 - (a) Viral testing tells the clinician which virus a person is currently infected with
 - (b) Influenza symptoms, while similar to COVID-19 symptoms, do not include loss of taste and smell
 - (c) Antibody testing tells the clinician which virus a person is currently infected with
 - (d) A and C
 - (e) All of the above
13. What is the best way to prevent COVID-19 infections?
 - (a) Get vaccinated with any of the COVID-19 vaccines
 - (b) Use monoclonal antibodies or remdesivir prophylactically
 - (c) Taking nirmatrelvir with Ritonavir (Paxlovid®) 10 days after expected exposure
 - (d) A and B
 - (e) All of the above
14. Which of the following is a vaccine used to protect against COVID-19?
 - (a) Pfizer-BioNTech (COMIRNATY®)
 - (b) Moderna (SPIKEVAX®)
 - (c) Novavax®
 - (d) All of the above

Case Study 14–1

A 60-year-old man

A 60-year-old man is admitted to the hospital from work with fever, cough, tachypnea, and increased sputum production. His past medical history is significant for smoking two packs per day and prn 2-week amoxicillin antibiotic courses for sputum color changes. His blood pressure is 140/85 mmHg and RR 30 breaths/minute. He has an elevated WBC count and crackles in the lower base of the right lung. A Gram stain shows predominant gram-negative rods.

What findings are consistent with pneumonia in this man? What more information would you need to confirm this? What empiric treatment might you consider? How would you decide if inpatient treatment is necessary?