Respiratory System
Rhonda M. Jones

ANATOMY AND PHYSIOLOGY OVERVIEW

The primary function of the respiratory system is to transport air into and out of the lungs so that oxygen can be exchanged for carbon dioxide. The upper respiratory system includes the nose, nasal cavity, sinuses, and pharynx. The lower respiratory system includes the trachea, bronchi, and lungs (Fig. 11–1). In this chapter, only the lower respiratory system is discussed. (For a discussion of the upper respiratory system, see Chapter 10.)

The thoracic cage, or the bones of the chest, consists of 12 thoracic vertebrae, 12 pairs of ribs, and the sternum (Fig. 11–2). The ribs and the sternum form the rib cage and support the thoracic cavity. The spaces between the ribs are termed the intercostals spaces and are numbered according to the superior rib above (e.g., the second intercostal space is located below the second rib). The diaphragm is a muscle that separates the thoracic cavity from the abdomen and is used during inspiration.

Surface Landmarks

Surface landmarks of the thorax are useful in identifying the underlying internal structures and in describing physical findings. They also facilitate documentation and communication of physical findings to other healthcare professionals.

Anterior Thoracic Landmarks

Primary anterior thoracic landmarks include the suprasternal notch, sternum, and manubriosternal angle. The suprasternal notch is the U-shaped depression at the top of the sternum between the clavicles. The sternum, or “breastbone,” consists of the manubrium, the body, and the xiphoid process. The articulation between the manubrium and the body of the sternum is the manubriosternal angle, which is commonly referred to as the angle of Louis. The angle of Louis is continuous with the second rib and is a useful place to start counting the ribs. It is also useful in locating the underlying structures, because the trachea bifurcates into the right and left main bronchi just under the angle of Louis.

Posterior Thoracic Landmarks

Posterior thoracic landmarks include the vertebra prominens, spinous processes, and scapula. The vertebra prominens is the seventh cervical vertebra and is found as the bony spur that protrudes from the base of the neck when the neck is flexed anteriorly. If two vertebrae are observed when the neck is flexed, the su-

GLOSSARY TERMS

- asthma
- bradypnea
- bronchitis
- bronchophony
- chronic obstructive pulmonary disease
- crackles
- cyanosis
- dyspnea
- egophony
- emphysema
- friction rub
- hyperpnea
- hyperresonance
- hypoxemia
- orthopnea
- pallor
- paroxysmal nocturnal dyspnea
- pneumonia
- resonance
- rhonchi
- tachypnea
- tactile fremitus
- wheezes
- whispered pectoriloquy
perior one is C7, and the inferior one is T1. The spinous processes are the knobs on the vertebrae, which form the spinal column. The scapula, or the “shoulder blades,” are located symmetrically on each side of the spinal column. The lower tip of the scapula is usually located at the seventh or eighth rib.

Reference Lines
Reference lines are used to identify and to document findings vertically on the chest. On the anterior chest, these include the midsternal and midclavicular lines (Fig. 11–3). On the posterior chest, these include the vertebral and scapular lines. The lateral chest is divided by the anterior, posterior, and midaxillary lines.

Trachea and Bronchial Tree
Air is inhaled through the mouth and the nose, and then it passes through the pharynx, larynx, and finally, a tough, flexible tube called the trachea (i.e., the windpipe). The trachea is approximately 1 inch in diameter and 4.25 inches in length, and it branches to form the left and right primary bronchi (Fig. 11–4). The left primary bronchus supplies air to the left lung; the right primary bronchus supplies air to the right lung. As the primary bronchi enter the lungs, they divide into smaller passageways, which are called secondary bronchi and bronchioles. The bronchioles are the thinnest segments of the bronchial tree and supply air to the alveoli, which are the exchange surfaces of the lungs. The alveoli are connected to an extensive network of blood vessels, through which oxygen is exchanged for carbon dioxide (see Fig. 11–4).

Lungs
The thoracic cavity is composed of the rib cage (as the “walls”) and the diaphragm (as the “floor”) (Fig. 11–5). The mediastinum separates the two pleural cavities. Each lung is positioned within a single pleural cavity, which is lined with a serous membrane called the pleura. The parietal pleura covers the inner surface of the thoracic wall and extends over the diaphragm and mediastinum. The visceral pleura covers the outer lung surfaces and extends into the fissures between the lobes. The pleural membranes secrete a small amount of pleural fluid, which provides a moist, slippery coating for lubrication during breathing.

The lungs are each divided into distinct lobes. The right lung has three lobes: the superior, the middle, and the inferior. The left lung has only two lobes: the superior, and the inferior. The base of each lung rests on the superior surface of the diaphragm.

Respiration
Respiration is the process of exchanging oxygen and carbon dioxide. Air is brought into the lungs through inspiration and is expelled through expiration. The muscles that assist with respiration are the diaphragm and the external and internal intercostals. During inspiration, downward contraction of the diaphragm increases the volume of the thoracic cavity, causing air to rush into the lungs. The external intercostals assist with inspiration by elevating the ribs. During expiration, the diaphragm relaxes back against the lungs, decreasing the volume of the thoracic cavity and, thereby, forcing air out of the lungs. Simultaneously, the internal intercostals depress the ribs, assisting with expiration.

When the depth and the rate of respiration need to be increased, such as during exercise or with respiratory distress, the accessory muscles in the neck elevate the ribs and sternum, allowing a larger volume of air to enter the lungs during inspiration. These muscles include the sternomastoids, scaleni, and the trapezius (Fig. 11–6). In addition, during expiration, the abdominal muscles powerfully contract, forcing the diaphragm further against the lungs.

Special Considerations

Pediatric Patients
All body systems in the child develop in utero. The respiratory system, however, does not function on its own until birth, and it continues to develop throughout childhood. The diameter and length of the airways increase, as do the number and size of the alveoli. In addition, the infant’s chest is round, whereas the toddler’s chest is more oval, usually reaching the adult shape (i.e., a 1:2 diameter) by the age of 6 years.

Geriatric Patients
Several factors cause a person’s respiratory efficiency to decline with increasing age. During aging, elastic tissue, such as the tissue of the lungs, deteriorates throughout the body. Thus, the lungs’ ability to inflate and deflate slowly declines. Arthritic changes in the ribs and decreased flexibility of costal cartilage also occur with increasing age. These changes, along with decreasing elasticity, cause stiffening and reduction in chest movement that, in turn, decrease respiratory volume. This volume reduction is a significant cause of the decreased exercise performance that occurs in elderly persons.
Pregnant Patients

As the fetus grows inside the uterus, it elevates the diaphragm by approximately 4 cm. Meanwhile, the mother’s higher estrogen levels relax the ligaments of the rib cage, increasing the total rib cage circumference by approximately 6 cm. The growing fetus also increases the oxygen demand on the mother’s body. Typically, the mother compensates by breathing deeper with each breath while maintaining a fairly consistent respiratory rate. The mother may also experience shortness of breath (SOB).

PATHOLOGY OVERVIEW

Numerous respiratory problems can occur. The pharmacist, however, most commonly encounters asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. Pharmacists not only educate patients about the proper use of medications for these diseases (e.g., metered dose inhalers, spacers, and antibiotics), but many also educate patients about the disease itself (i.e., asthma and COPD), its prevention, and self-treatment. Many pharmacists also assist patients in assessing and monitoring their breathing with peak flow meters (discussed later).
Asthma

Asthma is a chronic inflammatory disorder of the airways in which many different cells (mast cells, eosinophils, T lymphocytes, neutrophils, and epithelial cells) play a role. This inflammation causes recurrent episodes of widespread but variable airflow obstruction, which results from an increased responsiveness of the trachea and bronchi to various stimuli (physical, chemical, immunologic, and pharmacologic irritants). Even
emotions such as anxiety and distress can precipitate an episode. Persistent bronchial inflammation, which causes mucus hypersecretion and bronchial smooth muscle hypertrophy, is the primary mechanism causing the hyperreactivity.

Common signs and symptoms associated with asthma are listed in Box 11–1. Because asthma is an obstructive lung disease, airflow limitation primarily occurs during expiration. This causes the classical symptoms of dyspnea (i.e., SOB) and expiratory wheezing. Wheezes are a whistling respiratory sound caused by turbulent airflow through constricted bronchi.

An asthma attack can last anywhere from one to several hours, and it can subside spontaneously or need medications. Asthma severity is classified according to the frequency of symptoms (especially at night) and the lung function (Table 11–1). Factors that contribute to the severity of asthma include rhinitis, sinusitis, gastroesophageal reflux, viral respiratory infections, some medications (sensitivity to aspirin, nonsteroidal anti-inflammatory drugs and sulfites, and β-blockers).
PART II ASSESSMENT OF BODY SYSTEMS

Chest tightness/pressure
Exercise
Decreased FEV₁
Common Signs and Symptoms
Increased heart rate
Decreased FEV₁/FVC
Decreased PEF
Wheezes
Anxiety
Endocrine factors (menses, pregnancy, and thyroid disease)
Food or food additives
Endocrine factors (menses, pregnancy, and thyroid disease)

BOX 11–1 Common Signs and Symptoms of Asthma

<table>
<thead>
<tr>
<th>Signs</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>● Recurrent and episodic</td>
<td>● Wheezes</td>
<td>● Use of accessory muscles to breathe</td>
<td>● Increased respiratory rate</td>
</tr>
<tr>
<td>● Increased heart rate</td>
<td>● Decreased FEV₁</td>
<td>● Decreased FEV₁/FVC</td>
<td>● Decreased PEF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symptoms</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>● Dyspnea (breathlessness)</td>
<td>● Cough (nonproductive)</td>
<td>● Chest tightness/pressure</td>
<td>● Anxiety</td>
</tr>
</tbody>
</table>

FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow.

The primary risk factor for asthma is the exposure of sensitive patients to inhalant allergens. When this occurs, patients can experience an increase in airway inflammation, hyperresponsiveness, asthma symptoms, need for medication, and even death caused by asthma. Common allergens include:

- Viral respiratory infections
- Environmental allergens (environmental tobacco smoke, air pollution, animal dander, dust mites, indoor fungi [molds], and pollen)
- Exercise
- Occupational chemicals or allergens
- Environmental changes (new house, workplace, or vacation) and irritants (tobacco smoke, strong odors, air pollutants, and aerosols)
- Emotions (fear, anxiety, and anger)
- Food or food additives
- Endocrine factors (menses, pregnancy, and thyroid disease)

A stepwise approach to pharmacologic therapy is currently recommended, with the specific type and amount of medication being determined by the severity of the asthma and being directed toward the suppression of airway inflammation (Table 11–2). Medications are categorized into two general classes: quick-relief medications to treat acute symptoms and exacerbations, and long-term control medications to treat persistent asthma. High-dose therapy is initiated at the onset of the asthma attack to establish prompt control; the dose is then cautiously tapered down once control has been achieved. Common quick-relief medications used to treat an acute asthma attack include short-acting bronchodilators (beta₂-agonists), which are administered by oral inhalation, nebulization, or intravenously. Long-term control is best achieved with inhaled corticosteroids. Early intervention with inhaled corticosteroids can improve asthma control, normalize lung function, and possibly prevent irreversible airway injury. Alternatives to inhaled corticosteroids include cromolyn, leukotriene receptor antagonist, nedocromil, or sustained-release theophylline.

Patient education is the cornerstone of asthma management and should be incorporated into routine healthcare, including pharmaceutical care practices. The most effective nonpharmacologic intervention is the identification and avoidance of environmental precipitants or exposures. In other words, environmental control strategies are a key to successful asthma management by decreasing the risk of asthma attacks.

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease is characterized by airflow limitation (primarily expiratory flow) that is not fully reversible. The airflow limitation is progressive and associated with an abnormal inflammatory response to noxious particles or gases, primarily cigarette smoke. The chronic inflammation occurs throughout the airways, parenchyma, and pulmonary vasculature. Activated inflammatory cells (macrophages, T lymphocytes, and neutrophils) release a variety of mediators (leukotrienes, interleukin-8, and tumor necrosis factor) that damage the lung structures and that sustain neutrophilic inflammation. In the trachea, bronchi, and larger bronchioles, chronic inflammation leads to enlarged mucus-secreting glands and an increased number of goblet cells, which cause mucus hypersecretion. In the small bronchi and bronchioles, chronic inflammation leads to repeated cycles of injury and repair of the airway wall. This continual repair process structurally changes the airway wall by increasing its collagen content and creating scar tissue, which narrows the lumen and produces fixed airway obstruction.

Patients with COPD experience symptoms of cough, sputum production, and dyspnea; key characteristic indicators of COPD are listed in Box 11–2. Chronic cough is usually the first symptom of COPD and initially is intermittent but later is present every day (frequently throughout the day). Tenacious sputum is usually produced with the cough. As lung function deteriorates, breathlessness or dyspnea becomes worse, and this is why most persons seek medical attention. The objective signs of COPD are identified by spirometry (see Laboratory and Diagnostic Tests). Specifically, the presence of a forced expiratory volume in 1 second (FEV₁) after bronchodilator therapy less than 80% of the predicted value in combination with an FEV₁/forced vital capacity (FVC) less than 70% illustrates the presence of airflow limitation that is not fully reversible and confirms a diagnosis of COPD.

In addition, COPD is a general term used to describe patients with chronic bronchitis, emphysema, or some combination of both. Chronic bronchitis is characterized by inflammation and edema of the bronchioles, which causes excessive mucus production and airway obstruction. Patients with chronic bronchitis have a persistent productive cough on most days for at least 3 months a year in at least 2 consecutive years. Patients may appear cyanotic (bluish) because of chronic hypoxemia (low oxygen concentration in the blood) and are sometimes referred to as “blue bloaters.” Other common signs and symptoms associated with chronic bronchitis are listed in Box 11–3.
TABLE 11–1  Classifying Asthma Severity in Youths ≥12 Years of Age and Adults

Classifying severity for patients who are not currently taking long-term control medications.

<table>
<thead>
<tr>
<th>Components of Severity</th>
<th>Classification of Asthma Severity (Youths ≥12 years of age and adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Persistent</td>
</tr>
<tr>
<td></td>
<td>Intermittent</td>
</tr>
<tr>
<td>Symptoms</td>
<td>≤2 days/week but not daily</td>
</tr>
<tr>
<td>Nighttime awakenings</td>
<td>≤2×/month</td>
</tr>
<tr>
<td>Short-acting beta₂-agonist use for symptom control</td>
<td>≤2 days/week</td>
</tr>
</tbody>
</table>

Impairment (not prevention of EIB)

<table>
<thead>
<tr>
<th>Normal FEV₁/FVC:</th>
<th>None</th>
<th>Minor limitation</th>
<th>Some limitation</th>
<th>Extremely limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>8–18 yr 85%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–39 yr 80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40–59 yr 75%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60–80 yr 70%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lung function

- Normal FEV₁ between exacerbations
- FEV₁ ≥80% predicted
- FEV₁/FVC normal
- FEV₁/FVC reduced 5%

Exacerbations requiring oral systemic corticosteroids

0–1/year (see note) \(\geq 2\)/year (see note)

Relative annual risk of exacerbations may be related to FEV₁

Risk

- Level of severity is determined by assessment of both impairment and risk. Assess impairment domain by patient’s/caregiver’s recall of previous 2–4 weeks and spirometry. Assign severity to the most severe category in which any feature occurs.
- At present, there are inadequate data to correspond frequencies of exacerbations with different levels of asthma severity. In general, more frequent and intense exacerbations (e.g., requiring urgent, unscheduled care, hospitalization, or ICU admission) indicate greater underlying disease severity. For treatment purposes, patients who had ≥2 exacerbations requiring oral systemic corticosteroids in the past year may be considered the same as patients who have persistent asthma, even in the absence of impairment levels consistent with persistent asthma.
- Classifying severity in patients after asthma becomes well controlled, by lowest level of treatment required to maintain control.*

Lowest level of treatment required to maintain control (see Table 11-2 for treatment steps.)

<table>
<thead>
<tr>
<th>Classification of Asthma Severity</th>
<th>Intermittent</th>
<th>Persistent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Step 2</td>
<td>Step 3 or 4</td>
</tr>
</tbody>
</table>

EIB, exercise-induced bronchospasm; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; ICU, intensive care unit

*NOTES:
- For population-based evaluations, clinical research, or characterization of a patient’s overall asthma severity after control is achieved. For clinical management, the focus is on monitoring the level of control not the level of severity, once treatment is established.

Emphysema is characterized by an abnormal, permanent enlargement of airspaces distal to the bronchioles. This permanent enlargement destroys the alveolar walls. Consequently, elastic recoil decreases, and bronchiolar collapse results during expiration. Dyspnea is usually the first symptom, whereas a cough (usually nonproductive) is variable from patient to patient. Patients frequently need to use accessory muscles to assist their breathing, which usually has a long expiratory phase. Patients are typically not cyanotic and may occasionally be referred to as “pink puffers.” Other signs and symptoms associated with emphysema are listed in Box 11–4.

The classification of COPD is based on the severity of disease (Table 11–3). Stage I (mild COPD) is characterized by mild airflow limitation and usually, but not always, by chronic cough and sputum production. This individual is usually unaware that his/her lung function is abnormal at this stage. Stage II (moderate COPD) is characterized by worsening of airflow limitation and progression of symptoms, specifically SOB, which typically occurs on exertion. Cough and sputum production are also present sometimes. Most individuals seek medical attention during this stage because of the shortness of breath or increasing exacerbations of the disease. As the dyspnea and...
BOX 11–2 Key Indicators for Considering a Diagnosis of COPD

Consider COPD, and perform spirometry, if any of these indicators are present in an individual older than age 40. These indicators are not diagnostic themselves, but the presence of multiple key indicators increases the probability of a diagnosis of COPD. Spirometry is needed to establish a diagnosis of COPD.

**Dyspnea** that is:
- Progressive (worsens over time)
- Usually worse with exercise
- Persistent (present every day)
- Described by the patient as an "increased effort to breathe," "heaviness," "air hunger," or "gasping."

**Chronic cough:**
- May be intermittent and may be unproductive

**Chronic sputum production:**
- Any pattern of chronic sputum production may indicate COPD

**History of exposure to risk factors, especially:**
- Tobacco smoke
- Occupational dusts and chemicals
- Smoke from home cooking and heating fuels


**BOX 11–4 Common Signs and Symptoms of Emphysema**

**Signs**
- Prolonged expiration
- Thin
- Use of accessory muscles to assist breathing
- Tripod position to assist breathing (sitting forward with hands on hips/knees)
- Usually not cyanotic ("pink puffers")
- Barrel chest
- Decreased breath sounds
- Decreased FEV₁/FVC
- Altered blood gases (advanced stages)

**Symptoms**
- Dyspnea (usually severe)
- Weight loss
- Cough (variable; nonproductive)

FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity.

...ized by severe airflow limitation and respiratory failure. Patients may also have clinical signs of cor pulmonale (right heart failure) including elevation of the jugular venous pressure and pitting ankle edema. At this stage, quality of life is significantly impaired and exacerbations may be life-threatening.

**Risk factors for COPD** include both genetic factors (deficiency of α₁-antitrypsin and airway hyperresponsiveness) and environmental exposures. By far, cigarette smoking is the most significant environmental exposure for the development of COPD. Other environmental risk factors include air pollution and heavy exposure to occupational dusts and chemicals.

**TABLE 11–3 Spirometric Classification of COPD Severity Based on Post-Bronchodilator FEV₁**

<table>
<thead>
<tr>
<th>Stage</th>
<th>FEV₁/FVC &lt; 0.70</th>
<th>FEV₁ ≥80% predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I: Mild</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>FEV₁ ≥80% predicted</td>
</tr>
<tr>
<td>Stage II: Moderate</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>50%&lt;FEV₁ &lt;80% predicted</td>
</tr>
<tr>
<td>Stage III: Severe</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>30%&lt;FEV₁ &lt;50% predicted</td>
</tr>
<tr>
<td>Stage IV: Very Severe</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>FEV₁ &lt;30% predicted or FEV₁ &lt;50% predicted plus chronic respiratory failure</td>
</tr>
</tbody>
</table>

FEV₁, forced expiratory volume in one second; FVC, forced vital capacity; respiratory failure: arterial partial pressure of oxygen (PaO₂) less than 8.0 kPa (60 mm Hg) with or without arterial partial pressure of CO₂ (PaCO₂) greater than 6.7 kPa (50 mm Hg) while breathing air at sea level.


**BOX 11–3 Common Signs and Symptoms of Chronic Bronchitis**

**Signs**
- Typically obese
- Hypoxia
- Carbon dioxide retention
- Cyanosis, "Blue bloaters"
- Crackles/rhonchi
- Decreased breath sounds
- Altered pulmonary function tests
- Altered blood gases

**Symptoms**
- Cough (productive; most days for at least 3 months/year for 2 consecutive years)
- Dyspnea
- Frequent respiratory infections
- History of cigarette smoking
pational dusts and chemicals (e.g., grain, coal, and asbestos).

The overall approach to managing stable COPD is individualization of therapy to address symptoms and improve quality of life. Treatment is usually a stepwise increase in pharmacologic therapy based on the severity of disease (Table 11–4). Individualized assessment of disease severity as well as response to various therapies is a key management strategy. Pharmacologic therapy is used to prevent and to control symptoms, to reduce the frequency of exacerbations, and to improve exercise/activity tolerance. Unfortunately, no existing medication has been shown to modify the long-term decline in lung function.

Bronchodilator medications are central to the symptomatic management of COPD. These include beta₂-agonists, anticholinergics and methylxanthines used singly or in combination and are used on an as-needed or scheduled basis depending on the severity of the COPD. Regular treatment with long-acting bronchodilators is more effective and convenient than treatment with short-acting bronchodilators. The addition of regular treatment with inhaled glucocorticosteroids to bronchodilator treatment is appropriate for symptomatic Stage III or IV COPD patients. Scheduled treatments with inhaled steroids are reserved for symptomatic patients with a documented spirometric response to their use or for those with an FEV₁ less than 50% of the predicted value and repeated exacerbations that require treatment with antibiotics, oral glucocorticosteroids, or both. Chronic treatment with oral glucocorticosteroids is not recommended because of unfavorable side effects and no evidence of long-term benefit from their use. Other pharmacologic agents used for symptom control include antibiotics for infectious exacerbations as well as influenza and pneumococcal vaccines.

Nonpharmacologic prevention and treatment includes patient education, smoking cessation, avoidance of environmental factors, exercise training, and oxygen therapy. Patient education is a key component in the management of COPD. Smoking cessation is the single most effective intervention to reduce the risk of developing COPD and to stop its progression. The numerous products available over the counter (OTC) present pharmacists with an ideal opportunity to have a positive impact on patient care by playing an integral part in smoking cessation.

Pneumonia

Pneumonia is an inflammation of the lungs that is most commonly caused by a community-acquired bacterial infection, Streptococcus pneumoniae, which is also generally referred to as pneumococcal pneumonia. Other bacterial pathogens of community- and hospital-acquired pneumonia are listed in Box 11–5. The infection causes interalveolar exudation (slow release of fluid containing proteins and white blood cells) that results in consolidation or solidification of the lungs. Typically, the consolidation is confined to one lobe (e.g., right lower lobe pneumonia). Risk factors for developing pneumonia include:

- Age (elderly and infants)
- Smoking
- Chronic bronchitis
- Chronic illness (e.g., congestive heart failure [CHF], diabetes, and COPD)

TABLE 11–4 Therapy At Each Stage of COPD

<table>
<thead>
<tr>
<th>Stage</th>
<th>FEV₁/FVC</th>
<th>FEV₁ (%)</th>
<th>Therapeutic Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Mild</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>FEV₁ ≥ 80% predicted</td>
<td>Active reduction of risk factor(s); influenza vaccination; Add short-acting bronchodilator (when needed)</td>
</tr>
<tr>
<td>II: Moderate</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>50% ≤ FEV₁ &lt; 80% predicted</td>
<td>Add regular treatment with one or more long-acting bronchodilators (when needed); add rehabilitation.</td>
</tr>
<tr>
<td>III: Severe</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>30% ≤ FEV₁ &lt; 50% predicted</td>
<td>Add inhaled glucocorticosteroids if repeated exacerbations</td>
</tr>
<tr>
<td>IV: Very Severe</td>
<td>FEV₁/FVC &lt; 0.70</td>
<td>FEV₁ &lt; 50% predicted</td>
<td>Add long-term oxygen if chronic respiratory failure; consider surgical treatments</td>
</tr>
</tbody>
</table>

Postbronchodilator FEV₁ is recommended for the diagnosis and assessment of severity of COPD.

CHAPTER 11   RESPIRATORY SYSTEM

Typically, pneumonia follows a viral upper respiratory tract infection, with patients abruptly experiencing high fever; “chills”; productive cough with rust-colored, purulent sputum; and sharp chest pain. Other signs and symptoms associated with pneumonia are listed in Box 11–6. The treatment of bacterial pneumonia initially involves the empirical use of a relatively broad-spectrum antibiotic that is effective against probable pathogens after appropriate cultures and specimens for laboratory evaluations have been obtained. Factors that help to determine the potential pathogens involved include patient age, previous and current medication history, underlying disease(s), major organ function, and present clinical status. Community-acquired pneumonia is commonly treated with a macrolide/azalide (clarithromycin, erythromycin, azithromycin), fluoroquinolone (gatifloxacin, levofloxacin, ciprofloxacin), extended spectrum cephalosporin (ceftriaxone, ceftazidime, cefepime), or doxycycline.

SYSTEM ASSESSMENT

Subjective Information

Patients frequently present to the pharmacist with various subjective respiratory complaints. These patients typically request advice concerning OTC “cough and cold” products. To determine the most probable cause of the respiratory symptoms and the need for a specific OTC product or physician referral, the pharmacist must ask appropriate questions to elicit specific patient data.

Cough


Sputum

INTERVIEW How much sputum do you cough up? What color is it? Does it ever have blood in it? What consistency is it? Thick and purulent? Frothy? Do you have a fever? Any other symptoms?

BOX 11–5 Causes of Bacterial Pneumonia

COMMUNITY-ACQUIRED PNEUMONIA
- Streptococcus pneumoniae
- Haemophilus influenzae
- Staphylococcus aureus
- Klebsiella pneumoniae
- Mycoplasma pneumoniae

HOSPITAL-ACQUIRED (NOSOCOMIAL) PNEUMONIA
- Pseudomonas aeruginosa
- Staphylococcus aureus
- Legionella pneumophila
- Klebsiella pneumoniae

Box 11–6 Signs and Symptoms of Pneumonia

Signs
- Fever
- Tachypnea
- Tachycardia
- Mild hypoxemia
- Diminished breath sounds over the affected area
- Dullness on chest percussion
- Vocal tone changes with auscultation (tactile fremitus, whispered pectoriloquy, and egophony)
- Inspiratory crackles during lung expansion
- Consolidation on chest radiograph
- Elevated white-blood-cell count with a left shift

Symptoms
- Chills
- Productive cough
- Rust-colored, purulent sputum
- Pleuritic (sharp, knife-like) chest pain

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous throughout the day</td>
<td>Respiratory infection</td>
</tr>
<tr>
<td>Nighttime</td>
<td>Postnasal drip, sinusitis, CHF, or ACE inhibitors</td>
</tr>
<tr>
<td>Early morning</td>
<td>Chronic bronchitis or smoking</td>
</tr>
<tr>
<td>Productive</td>
<td>Chronic bronchitis or pneumonia</td>
</tr>
<tr>
<td>Dry, hacking</td>
<td>Viral infection, asthma, mycoplasma pneumonia, or ACE inhibitors</td>
</tr>
<tr>
<td>Barking</td>
<td>Croup</td>
</tr>
<tr>
<td>Wheezing</td>
<td>Asthma or allergies</td>
</tr>
</tbody>
</table>

ACE, angiotensin-converting enzyme; CHF, congestive heart failure.
TABLE 11–6  Sputum Characteristics and Associated Causes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Possible Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucoid</td>
<td>Viral infections</td>
</tr>
<tr>
<td>Purulent</td>
<td>Chronic bronchitis or bacterial infections</td>
</tr>
<tr>
<td>Yellow-green</td>
<td>Chronic bronchitis or bacterial infections</td>
</tr>
<tr>
<td>Rust-colored</td>
<td>Pneumococcal pneumonia or tuberculosis</td>
</tr>
<tr>
<td>Pink, blood-tinged</td>
<td>Pneumococcal or staphylococcal pneumonia</td>
</tr>
<tr>
<td>Pink, frothy</td>
<td>Pulmonary edema</td>
</tr>
<tr>
<td>Profuse, colorless</td>
<td>Carcinoma</td>
</tr>
<tr>
<td>Bloody</td>
<td>Pulmonary emboli, tuberculosis, tumor, or warfarin therapy</td>
</tr>
</tbody>
</table>

**Dyspnea**

**INTERVIEW** When do you become short of breath? Is the onset quick or gradual? What brings it on? Exertion? Rest? Lying down? What relieves it? Does it occur at any specific time of day? At night? If yes, how many pillows do you need to use to sleep comfortably at night? Any other symptoms? Chest pain? Wheezing? Fever? Cough? Any bluish discoloration around the lips, nose, fingers, or toes? Do you smoke? Have you smoked in the past? Have you ever been told you have a respiratory problem such as asthma? Do you use an inhaler? How do you use it? Does anyone in your family have similar problems?

**ABNORMALITIES** Table 11–6 lists sputum characteristics and possible causes.

**Chest Pain with Breathing**

For a complete discussion of chest pain, see Chapter 12.

**INTERVIEW** Describe the pain. Is it sharp and stabbing? Specifically, where does it hurt? When does it occur? When you breathe in? Any other symptoms?

**ABNORMALITIES** Pleuritic chest pain is typically a sharp, stabbing pain that is felt on inspiration and is usually localized to one side. It is caused by inflammation of the parietal pleura.

**Objective Information**

Objective patient data include the physical assessment as well as laboratory and diagnostic tests. Pharmacists most commonly inspect the patient for abnormal respiratory symptoms. The techniques of palpation, percussion, and auscultation are included here for completeness of the respiratory assessment; pharmacists rarely perform these during a physical examination.

**Physical Assessment**

Physical assessment pertaining to the respiratory system includes inspection of the neck and chest as well as palpation, percussion, and auscultation of the posterior chest.

**TECHNIQUE**

**STEP 1 Inspect the Chest**

Inspection is useful to assess the chest’s shape and symmetry, the pattern and ease of respiration, and the appearance of cyanosis.

- Have the patient sit upright, leaning slightly forward with the arms resting comfortably across his or her lap.
- Inspect the chest’s shape and symmetry. Normally, the chest’s anteroposterior diameter is less than the transverse or side-to-side diameter.

Inspect how the chest moves with respiration. Normally, symmetric movement occurs on both sides.

**ABNORMALITIES** A barrel chest has an anteroposterior diameter equal to or greater than the transverse diameter (Fig. 11–7) and is a sign of “air trapping” in the lungs, which can occur with the normal aging process as the lungs lose their elasticity. A barrel chest can also develop, however, from chronic emphysema caused by hyperinflation of the lungs. Patients may sit with their hands on their knees to support the rib cage and allow the lungs to expand further. This position is commonly called the tripod position.
TECHNIQUE

STEP 1 (Continued)

■ Observe the patient's rate, rhythm, depth, and ease of breathing (see Chapter 5 for a detailed description of measuring the respiratory rate). Normally, the patient's respiratory rate should be between 12 and 20 breaths per minute (bpm), the rhythm regular, and the breathing easy and quiet. An occasional sigh is normal.

■ Inspect the patient's neck, and note use of accessory muscles (sternomastoid and scalenes) to assist with inspiration. Abnormalities Use of accessory muscles is a sign of respiratory distress; the patient should be referred immediately to a primary care provider.

Tachypnea is rapid breathing (usually >20 bpm) and is either shallow or has no change in depth. It can be caused by pain, anxiety, fever, or anemia. Bradypnea is slow breathing (usually <12 bpm) and may occur with central nervous system depression induced by oversedation or a cerebral vascular accident (i.e., stroke), elevated intracranial pressure, or hyperkalemia. Hyperpnea, also known as Kussmaul respirations, is fast, deep breathing that occurs normally with exercise; however, it can also occur with forms of metabolic acidosis (e.g., diabetic ketoacidosis). Cheyne-Stokes respirations are an irregular increase in rhythm and decrease in depth (deep and fast, then slow and shallow) interrupted by regular episodes of apnea. They can be normal in elderly patients; however, they can also be associated with severe heart failure, uremia, and neurologic disorders.

ABNORMALITIES Use of accessory muscles is a sign of respiratory distress; the patient should be referred immediately to a primary care provider. Tachypnea is rapid breathing (usually >20 bpm) and is either shallow or has no change in depth. It can be caused by pain, anxiety, fever, or anemia. Bradypnea is slow breathing (usually <12 bpm) and may occur with central nervous system depression induced by oversedation or a cerebral vascular accident (i.e., stroke), elevated intracranial pressure, or hyperkalemia. Hyperpnea, also known as Kussmaul respirations, is fast, deep breathing that occurs normally with exercise; however, it can also occur with forms of metabolic acidosis (e.g., diabetic ketoacidosis). Cheyne-Stokes respirations are an irregular increase in rhythm and decrease in depth (deep and fast, then slow and shallow) interrupted by regular episodes of apnea. They can be normal in elderly patients; however, they can also be associated with severe heart failure, uremia, and neurologic disorders.

ABNORMALITIES A delay in chest expansion or an asymmetric chest expansion may occur with pneumonia, thoracic trauma, or marked atelectasis (lung obstruction). If pain occurs with inhalation, the pleurae may be inflamed.

TECTNIE

STEP 2 Palpate the Posterior Chest

■ Have the patient sit upright, leaning slightly forward with the arms resting comfortably across his or her lap. Ask male patients to disrobe to the waist and female patients to wear a gown with the back open.

■ Place your hands on the chest wall with your thumbs at the level of T9 or T10 (Fig. 11–8).

■ Slide your hands medially, so that a small fold of skin rests between your thumbs.

■ Ask the patient to inhale deeply. As the patient breathes in, your thumbs should move apart symmetrically.

ABNORMALITIES A delay in chest expansion or an asymmetric chest expansion may occur with pneumonia, thoracic trauma, or marked atelectasis (lung obstruction). If pain occurs with inhalation, the pleurae may be inflamed.

TECTNIE

STEP 3 Assess Tactile Fremitus

Tactile fremitus refers to palpable vibrations transmitted through the bronchial tree to the chest wall when a patient speaks.

■ Lightly place the balls of your hands on the patient's posterior chest, with one hand on each side of the chest (Fig. 11–9).

■ Have the patient repeat the number 99.

■ Evaluate the intensity of the vibration.

■ Repeat the above steps across the lung fields as shown in Figure 11–11, comparing side to side simultaneously. Normally, the vibrations should feel the same in the corresponding area on each side.

ABNORMALITIES Consolidation or dense tissue conducts sound better than air does; therefore, conditions such as pneum-
monia intensify the vibrations (increased fremitus). Decreased intensity (decreased fremitus) occurs with obstruction of the vibrations (e.g., pneumothorax, emphysema, and pleural effusion).

TECHNIQUE

STEP 4 Percuss the Posterior Chest

Percussion of the posterior chest helps to evaluate the density of underlying lung tissue to a depth of approximately 5 to 7 cm.

- Starting just above the scapulae, systematically percuss the patient’s posterior chest at 3 to 5 cm intervals, moving from side-to-side and downward (see Fig. 11–10).
- Avoid the scapulae, spine, and ribs, because bones diminish useful percussion by altering the tone obtained.

ABNORMALITIES

Resonance is a long, low-pitched sound that can usually be heard over all the lung fields; however, it is a subjective term and does not have a set, standard sound. Hyperresonance is an abnormally long, low-pitched sound heard with emphysema or a pneumothorax in which a large amount of air is present. Dullness occurs with abnormal, dense tissue in the lungs (e.g., pneumonia, pleural effusion, and atelectasis).

TECHNIQUE

STEP 5 Auscultate the Breath Sounds

Air passing through the tracheobronchial tree creates a characteristic set of sounds that can be heard through the chest wall with a stethoscope. Abnormalities, such as obstruction or parenchyma changes within the lungs, cause these sounds to change.

- Have the patient sit, leaning slightly forward with the arms resting comfortably across his or her lap.
- Instruct the patient to breathe slowly, deeply, and regularly through the mouth.
Standing behind the patient, firmly place the diaphragm of the stethoscope on the posterior chest, over the upper lobes of the lungs and just above the clavicle (Fig. 11–11).

Continue across and down the posterior chest in a Z-shaped pattern.

Listen to at least one full respiration in each location, comparing side-to-side the pitch, intensity, and duration of the breath sound.

Note the presence of adventitious sounds.

Three different types of breath sounds should be heard, depending on the location. Bronchial sounds are high-pitched and loud, with inspiration shorter than expiration, and are normally heard over the trachea and larynx. Bronchovesicular sounds have a medium pitch and intensity, last equally long during inspiration and expiration, and are normally heard over the major bronchi or between the scapulae. Vesicular sounds are low-pitched and soft, with inspiration longer than expiration, and are normally heard over the smaller bronchioles and alveoli or over most of the peripheral lung fields.

ABNORMALITIES Bronchial or bronchovesicular breath sounds heard over the peripheral lung fields may indicate consolidation (e.g., pneumonia). Diminished or absent breath sounds may occur with obesity, COPD, pneumothorax, or pleural effusion. Adventitious sounds are abnormal sounds that are superimposed or added on top of normal breath sounds. They can be heard over any area of the lungs, during both inspiration and expiration, and include crackles, rhonchi, wheezes, and a friction rub (Table 11–7).

TECHNIQUE

STEP 6 Auscultate the Voice Sounds

If abnormalities are detected during the previous physical examination techniques, eliciting voice sounds may help to determine a specific lung pathology. By listening to voice sounds through the stethoscope, the presence of bronchophony, egophony, and whispered pectoriloquy can be determined.

Place the stethoscope in the same locations as those for the auscultation of breath sounds (see Fig. 11–11).

Ask the patient to repeat the number 99 as you listen through the stethoscope.

ABNORMALITIES Normally, the voice transmission should sound soft and muffled. If the words sound clear and loud (i.e., bronchophony), it may be an indication of consolidation or atelectasis.

### TABLE 11–7 Adventitious Sounds

<table>
<thead>
<tr>
<th>Sound</th>
<th>Characteristics</th>
<th>Cause</th>
<th>Clinical Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crackles/rales</td>
<td>Short, popping sounds.</td>
<td>Created when air is forced through bronchial passageways</td>
<td>Can be a sign of infection, inflammation, or CHF</td>
</tr>
<tr>
<td></td>
<td>Pitch and intensity vary.</td>
<td>narrowed by fluid, mucus, or pus, or by the popping open of previously deflated alveoli</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Can be heard during inspiration, expiration, or both</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhonchi</td>
<td>Deep, coarse sounds that have a snoring quality, and</td>
<td>Usually caused by secretions in the large airways and typically clear after coughing</td>
<td>Bronchitis or pneumonia</td>
</tr>
<tr>
<td></td>
<td>are heard primarily during expiration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheezes</td>
<td>High-pitched, musical sounds that can be heard</td>
<td>Airway narrowing</td>
<td>Usually a sign of asthma but can also occur with other causes of airway narrowing, such as COPD and bronchitis</td>
</tr>
<tr>
<td></td>
<td>during inspiration or expiration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friction rub</td>
<td>A deep, harsh, grating or creaking sound that is</td>
<td>Occurs when inflamed pleural surfaces lose their normal lubricating fluid and rub together during respiration</td>
<td>Can be associated with any condition that causes pleural irritation, such as pleuritis or pneumonia</td>
</tr>
</tbody>
</table>
PART II ASSESSMENT OF BODY SYSTEMS

Ask the patient to repeat ee as you listen through the stethoscope.

**ABNORMALITIES** Normally, it should sound like ee. If consolidation is present, the word will sound like ay, which is termed egophony.

Ask the patient to whisper one-two-three as you listen through the stethoscope.

**ABNORMALITIES** Normally, the words should sound very faint and muffled. Consolidation and pleural effusions can cause these sounds to be more distinctive and clear. This is called whispered pectoriloquy.

**Laboratory and Diagnostic Tests**

Pulmonary function tests include blood gas measurements, oxygen saturation (O\(_2\) sat), and spirometry. Arterial blood gas measurements are the best indicators of overall lung function and include PaO\(_2\), PaCO\(_2\), and pH. The adequacy of gas exchange in the lungs determines the values of these gases. Normal values for arterial blood gases are listed in Table 11–8. Oxygen saturation is the ratio between the actual amount of oxygen bound to hemoglobin and the potential amount of oxygen that could be bound to hemoglobin at a given pressure. Normally, the O\(_2\) sat of arterial blood is 97.5% at a PaO\(_2\) of 100 mm Hg. The O\(_2\) sat is very useful in determining the need for supplemental oxygen therapy.

Spirometry includes tests that measure various lung volumes with a spirometer. The tidal volume is the volume of air that is inhaled or exhaled during normal breathing. The vital capacity is the maximum volume of air that a person can exhale after maximum inhalation. The volume of air that remains in the lungs after maximum exhalation is the residual volume. The total lung capacity is the vital capacity plus the residual volume. Because patients with obstructive lung diseases (e.g., asthma or COPD) have difficulty exhaling, they usually have decreased vital capacity, increased residual volume, and normal total lung capacity. In addition to measuring lung volumes, the spirometer can also be used to assess the patient’s ability to move air into and out of the lungs. The forced expiratory volume is the maximal volume of air that is exhaled as forcefully and as completely as possible after maximal inhalation. This volume curve is plotted against time. The FEV\(_1\) of the FVC is commonly used to evaluate the lung’s ability to move air; it is usually documented as the percentage of the total volume of air exhaled, or the FEV\(_1\)/FVC. Normally, FEV\(_1\) is 80% of the FVC.

**TABLE 11–8 Normal Values for Arterial Blood Gases**

<table>
<thead>
<tr>
<th>Arterial Blood Gases</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.36–7.44</td>
</tr>
<tr>
<td>PaO(_2)</td>
<td>90–100 mm Hg</td>
</tr>
<tr>
<td>PaCO(_2)</td>
<td>35–45 mm Hg</td>
</tr>
</tbody>
</table>

The peak expiratory flow (PEF) is the maximal flow rate (L/min) that can be produced during forced expiration. It provides a simple, quantitative, and reproducible measure of the existence and severity of airflow obstruction. Inexpensive, portable, handheld peak flow meters (Fig. 11–12) can be used to easily measure the PEF. Peak flow meters are commonly used to assess the effectiveness of bronchodilator therapy and to monitor asthma control at healthcare facilities, including pharmacies, and by patients at home. In adults, predicted values for the PEF are based on the person’s age, height, and sex. In children and adolescents, predicted PEF values are based on height. Predicted values are useful for monitoring new patients; however, chronic asthma is best monitored according to a patient’s “personal best” values, which are determined by the patient and his or her physician. The peak flow values are then categorized into green, yellow, and red zones (similar to a traffic light) according to the percentage of the patient’s personal-best number (Table 11–9). In addition to the categorized values, Table 11–9 outlines the corresponding asthma management directions in each PEF zone for the patient to follow at home. Many pharmacists educate patients about the proper use of peak flow meters as well as the monitoring of asthma and the effectiveness of chronic bronchodilator therapy. When a patient is well educated and monitors his or her asthma control using a peak flow meter, there is great potential for improved health outcomes.

Chest radiography (x-ray) evaluates lung and cardiac structures and is commonly used as a general screening assessment of the respiratory system. It is useful in assessing inflammation, fluid and air accumulation, and tumors in the lung, pleura, and pericardium.
**TABLE 11-9  Peak Expiratory Flow Rates**

<table>
<thead>
<tr>
<th>Green Zone</th>
<th>Yellow Zone</th>
<th>Red Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good control</td>
<td>Caution/moderate exacerbation</td>
<td>Medical alert/severe exacerbation</td>
</tr>
<tr>
<td>PEF &gt;80% of predicted or personal best</td>
<td>PEF 50% to 80% of predicted or personal best</td>
<td>PEF &lt;50% of predicted or personal best</td>
</tr>
<tr>
<td>No wheezing or SOB</td>
<td>Persistent wheezing and SOB</td>
<td>Severe wheezing and SOB</td>
</tr>
<tr>
<td>Take medication as usual</td>
<td>Take a short-acting, inhaled beta₂-agonist right away, if attacks occur frequently, dosage may need to be increased</td>
<td>Take a short-acting, inhaled beta₂-agonist right away. Call 911 for emergency assistance.</td>
</tr>
</tbody>
</table>

PEF, peak expiratory flow; SOB, shortness of breath.

**Special Considerations**

**Pediatric Patients**

Pediatric patients require additional questions for the child’s parent or guardian.

**INTERVIEW**

How often does the child have a “head cold”? Are there any smokers in the house? Any history of food, environmental, or drug allergies?

**ABNORMALITIES**

More than four to six colds (upper respiratory infections) per year is considered abnormal. Secondhand smoke increases the risk of upper respiratory infections in children. If an infant or toddler has a history of allergies, consider formula or new foods as possible allergens.

The first respiratory assessment of the newborn is the Apgar Scoring System. The five standard parameters of the Apgar system include heart rate, respiratory effort, muscle tone, reflex irritability, and color, which are scored at 1 minute and again at 5 minutes after birth. A 1-minute total Apgar score of 7 to 10 indicates a newborn in good condition who needs only routine care (e.g., suctioning of the nose and mouth). A 1-minute total Apgar score of 3 to 6 indicates a moderately depressed newborn who needs more resuscitation and subsequent close observation. A 1-minute total score of 0 to 2 indicates a severely depressed newborn who needs full resuscitation, ventilatory assistance, and subsequent intensive care.

Newborns normally may breathe rapidly, with interspersed periods of apnea (usually <15 seconds). By 6 weeks of age, however, this irregularity should subside. Irregular breathing after 5 weeks of age is considered to be abnormal and may indicate respiratory distress.

A key component of assessing the child’s respiratory function is cooperation of the child. One way to enhance cooperation is to allow the parent to hold the child during the examination. Try to distract younger children by having them play with a toy during the examination—or by making a game of the examination itself. Allow older children to play with the stethoscope, or invite them to listen to their heart and lung sounds.

Because the child’s thoracic cage is small, breath sounds may be referred from one lung to another. The examiner should use a pediatric-sized stethoscope and the bell side to auscultate a child’s breath sounds, because it detects softer, lower-pitched sounds. Breath sounds are usually louder and harsher in children than in adults because of the child’s thin chest wall and underdeveloped musculature.

**Geriatric Patients**

Geriatric patients also require additional questions of the patient or caregiver.

**INTERVIEW**

What is your usual amount of activity during the day? If you use an inhaler, please show me how you use it.

**ABNORMALITIES**

Older patients frequently have decreased respiratory efficiency and, thus, may not be able to tolerate many activities. Because of arthritic changes and decreased understanding of instructions resulting from poor hearing or eyesight, elderly patients may not use their inhaler correctly.

Because elderly patients have decreased tissue and cartilage elasticity, the chest does not expand as easily as that of a younger adult. During auscultation, an elderly patient may fatigue easily while breathing deeply. The examiner should be careful so the patient does not hyperventilate or become dizzy; allow brief periods of quiet breathing while auscultating the breath sounds.

**Pregnant Patients**

During the third trimester, pregnant patients commonly complain of SOB, which is primarily a result of the expanding uterus impinging on the diaphragm’s ability to fully expand. Because the fetus increases the oxygen demand on the mother’s body, the pregnant patient’s respirations may be deeper, but the respiratory rate should remain normal.

**APPLICATION TO PATIENT SYMPTOMS**

Many times, the pharmacist is the healthcare professional who identifies a respiratory problem in a patient. For example, the pharmacist may notice that a patient is frequently requesting refills of his or her inhaler, is frequently short of breath when conversing with the pharmacist over the phone or in person, or is complaining of a chronic cough. Therefore, the pharmacist must be...
able to evaluate common respiratory symptoms, determine possible causes of these symptoms, and take appropriate action to either further assess the symptom or to correct the problem identified. Common respiratory symptoms include dyspnea, wheezing, and cough.

**Dyspnea (Case Study 11-1)**

Patients with dyspnea may report that they “can’t get enough air” or complain of “breathlessness.” Various causes of dyspnea include:

- **Pulmonary:** COPD, asthma, and emphysema
- **Cardiac:** CHF and coronary artery disease
- **Emotional:** anxiety

**Wheezing (Case Study 11-2)**

Wheezes are usually heard during expiration, but they can occur throughout inspiration or expiration. Wheezes are commonly associated with asthma; however, they can be caused by other disease states (e.g., COPD) and respiratory infections. In addition, some medications can also induce bronchospasm in patients with preexisting bronchial hyperreactivity such as asthma or chronic obstructive lung disease (Box 11–7).

**Cough (Case Study 11-3)**

A cough is very forceful expiration of irritant particles in the airways. Patients may describe it as a tickling sensation, a dry cough, a hacking cough, or a productive cough. Patients may also complain of a fever and chills, nasal congestion, runny nose, sore throat, chest tightness, SOB, or sharp chest pain, depending on the cause of the cough. Various causes of a cough include pneumonia, upper respiratory infection (e.g., head cold), asthma/bronchoconstriction, bronchitis, sinusitis, environmental irritants, and CHF. The pharmacist should also keep in mind that angiotensin-converting enzyme (ACE) inhibitors may also cause a cough. Patients usually complain of a persistent (not episodic), dry, nonproductive cough that is usually worse at night. Patients may also describe it as a tickling sensation. In addition, ACE inhibitor–induced coughs are more common in women than in men.

<table>
<thead>
<tr>
<th>BOX 11–7 Drugs that Induce Bronchospasm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anaphylaxis (IgE-Mediated)</strong></td>
</tr>
<tr>
<td>Penicillins</td>
</tr>
<tr>
<td>Sulfonamides</td>
</tr>
<tr>
<td>Serum</td>
</tr>
<tr>
<td>Cephalosporins</td>
</tr>
<tr>
<td>Papain</td>
</tr>
<tr>
<td>L-Asparaginase</td>
</tr>
<tr>
<td><strong>Direct Airway Irritation</strong></td>
</tr>
<tr>
<td>Bisulfite</td>
</tr>
<tr>
<td>Smoke</td>
</tr>
<tr>
<td>N-Acetylcysteine</td>
</tr>
<tr>
<td><strong>Cyclooxygenase Inhibition</strong></td>
</tr>
<tr>
<td>Aspirin/NSAIDs</td>
</tr>
<tr>
<td><strong>Anaphylactoid Mast-Cell Degranulation</strong></td>
</tr>
<tr>
<td>Iodinated-radiocontrast media</td>
</tr>
<tr>
<td><strong>Pharmacologic Effect</strong></td>
</tr>
<tr>
<td>β-adrenergic receptor blockers</td>
</tr>
</tbody>
</table>

*Relative frequency of reactions: F, frequent; I, infrequent.
AL is a 72-year-old woman with a history of COPD and osteoarthritis. She returns to the pharmacy today requesting a refill of her albuterol inhaler. She states that she feels these inhalers are a waste of money, because they hardly hold any medicine and they don’t really help her breathing anyway. Based on AL’s complaints, the pharmacist suspects she is having respiratory difficulty and asks her to step into the patient care room.

ASSESSMENT OF THE PATIENT

Subjective Information
72-Year-Old White Woman with Frequent Refills of Albuterol Inhaler

DO YOU EXPERIENCE SHORTNESS OF BREATH? Yes.

HOW OFTEN DOES THIS HAPPEN? Nearly every day, when I try to do my housework during the day.

DOES IT APPEAR AT NIGHT? No.

HOW LONG HAS IT BEEN GOING ON, OR IS THIS A RECENT CHANGE? It has been getting worse over the past 2 or 3 months.

WHAT MAKES THE SHORTNESS OF BREATH BETTER OR GO AWAY? Well, I use those inhalers, but they don’t seem to work very well. I usually have to sit down and rest to catch my breath.

DO YOU EXPERIENCE ANY OTHER SYMPTOMS, SUCH AS CHEST PAIN, LIGHT-HEADEDNESS, DIZZINESS, COUGH, FEVER, OR WHEEZING? No. Oh, I do have to cough up a bunch of “gunk” in the morning when I wake up, but that usually goes away by noon.

WHAT COLOR IS THIS “GUNK” THAT YOU COUGH UP? Clear-colored to a whitish color.

WHAT MEDICATIONS DO YOU TAKE? I use a couple of different inhalers to help me breathe.

WHEN DO YOU USE YOUR INHALERS? Whenever I can't breathe very well.

HOW MANY TIMES A DAY DOES THIS TEND TO BE? Usually six to eight times a day.

DO YOU USE A SPACER WITH YOUR INHALER? No.

SHOW ME HOW YOU USE YOUR INHALERS AT HOME. [Patient demonstrates the following use of her albuterol inhaler: does not shake the canister, does not exhale before placing the inhaler in her mouth, presses down on the canister and inhales, does not hold her breath, and quickly exhales.]

I NOTICED THAT YOU USE BOTH AN ALBUTEROL AND AN AZMACORT INHALER. WHEN YOU USE THESE TOGETHER, WHICH ONE DO YOU USE FIRST? Oh, I don't know. I usually don’t pay any attention to it. I just grab whichever one is closest.

DO YOU USE A PEAK FLOW METER TO EVALUATE YOUR BREATHING? No.

DO YOU CURRENTLY SMOKE, OR HAVE YOU SMOKED IN THE PAST? Well, I quit smoking about 5 years ago when I started having problems with my breathing. But I smoked two packs per day for about 50 years before I quit.

Objective Information

Computerized medication profile:
- Albuterol inhaler: two puffs PRN for SOB; No. 1, 17 mg canister; Refills: 5; Patient obtains refills every 2 weeks for the last 2 months.
- Azmacort (triamcinolone) inhaler: two puffs three times daily; No. 1, 20 g canister; Refills: 5; Patient obtains refills every 2 weeks for the last 2 months.
- Ibuprofen: 400 mg, one tablet every 6 hours as needed for arthritis pain; No. 30; Refills: 3; Patient obtains refills once every couple of months.

Patient in no acute distress but currently slightly SOB; no use of accessory muscles; can complete short sentences

Heart rate: 67 bpm
Blood pressure: 138/82 mm Hg
Respiratory rate: 18 rpm
Auscultation: normal breath sounds; no wheezing, crackles, or rhonchi present

DISCUSSION

The concern in this case centers around AL’s frequent SOB with her daily activities and frequent refills of inhalers. The pharmacist needs to determine whether the SOB results from progressing COPD or other disease processes (e.g., CHF) or from improper use of her inhalers. AL states that her SOB occurs with daily activities and not at night. (For a complete description of dyspnea caused by CHF, see Chapter 12.) She does not experience any other symptoms and usually needs to sit down and rest for the SOB to improve, because as she states, the inhalers don’t work very well. AL uses improper technique with her inhalers and sometimes uses the steroid inhaler before the β-agonist inhaler. In addition, she uses the steroid inhaler as she needs it rather than on a scheduled basis.

Along with identifying possible causes of AL's SOB, the pharmacist must determine the severity of the SOB. AL is not in acute respiratory distress, has a normal respiratory rate, and has normal breath sounds with no adventitious sounds. After evaluating all of AL’s subjective and objective information, the pharmacist concludes that she is probably experiencing SOB because of improper use of her inhalers. Because AL is not in any current distress and her vital signs and breath sounds are normal, the pharmacist educates the patient about proper inhaler technique and using the β-agonist inhaler before the steroid inhaler.

CASE STUDY 11-1 (continues)
CASE STUDY 11-1 (continued)

PATIENT CARE PLAN

Patient Name: AL
Date: 7/14/08
Medical Problems:
  - COPD
  - Osteoarthritis
Current Medications:
  - Albuterol inhaler, two puffs PRN for SOB, No. 1, 17 mg canister, Refills: 5, patient obtains refills every 2 weeks for the last several months
  - Azmacort (triamcinolone) inhaler, two puffs three times daily, No. 1, 20 g canister, Refills: 5, patient obtains refills every 2 weeks for the last several months
  - Ibuprofen, 400 mg, one tablet every 6 hours as needed for arthritis pain, No. 30, Refills: 3, patient obtains refills once every couple of months
S: 72-year-old woman complaining of frequent SOB that occurs with daily housework. Has little relief from albuterol or steroid inhalers. Chronic, productive cough every morning with clear to white-colored sputum. Improper use (technique and timing) of inhalers. Frequent request for refills of inhalers.

O: Mild SOB; no use of accessory muscles.
Skin, lips, mucous membranes: Normal color
Heart rate: 67 bpm
Blood pressure: 138/82 mm Hg
Respiratory rate: 18 bpm
Auscultation: Clear; no wheezes, crackles, or rhonchi
A: SOB and uncontrolled COPD, probably caused by improper use of inhalers.
P: 1. Educate patient about proper techniques for inhaler use and to use the albuterol before the Azmacort inhaler.
2. Discuss with the patient use of a peak flow meter to evaluate her breathing, if she is comfortable doing this at home.
3. Follow-up with a phone call in 2 weeks to monitor the patient’s SOB, use of inhalers, and need for refills. If inhaler technique is still difficult for the patient, consider use of a spacer to improve drug delivery.
Pharmacist: Sonya Garcia, Pharm.D.

Self-Assessment Questions
1. Compare and contrast the clinical presentation of asthma, COPD, and pneumonia.
2. What are the various causes of dyspnea?
3. What interview questions are the most useful in differentiating possible causes of SOB?
4. When auscultating the chest, which sounds are classified as adventitious sounds?
5. What signs and symptoms are consistent with respiratory distress?

Critical Thinking Questions
1. How would the pharmacist’s assessment and plan change if AL had been using accessory muscles, had been leaning forward in a tripod position, and had not been able to complete a full sentence?
2. AL comes back to the pharmacy 2 weeks after being educated about the proper use of her inhalers, and she requests another refill of both inhalers. What questions should the pharmacist ask to assess her current health and medication use?
JB is a 10 year old boy with a lifelong history of asthma. He and his mother come into the pharmacy with a new prescription for a steroid inhaler. The pharmacist asks JB and his mother to step into the patient care room to discuss the new medication.

**ASSESSMENT OF THE PATIENT**

**Subjective Information**

**10-Year-Old Boy with a New Prescription for a Steroid Inhaler**

Since you have a new prescription today, I assume that you just came from the doctor's office? Yes, we did.

Has JB been having problems controlling his asthma? Yes. Lately, he has been experiencing wheezing, coughing, and shortness of breath almost every day.

What usually brings on an asthma attack? Usually exerting himself, like when he goes outside to play.

What medications has JB been using? Albuterol inhaler, two puffs every 4 to 6 hours when he needs it to help him breathe. Over the past couple of months, he has been using it nearly every day, and it seems to stop the asthma attack.

Does JB take any other prescription or nonprescription medications? No. Oh, I do give him Tylenol once in awhile for a headache.

JB, show me how you use your inhaler. [JB demonstrates proper technique for using the albuterol inhaler.]

**Objective Information**

Computerized medication profile:

- Albuterol inhaler: two puffs every 4 to 6 hours as needed for wheezing; No. 1; Refills: 11; Patient obtains refills every 3 to 4 weeks
- AeroBid (flunisolide): two puffs twice a day; No. 1; Refills: 11; new prescription today

Patient in no acute distress
Skin, lips, and mucous membranes: Normal color
Heart rate: 60 bpm
Respiratory rate: 20 rpm
Blood pressure: 112/70 mm Hg
Lungs: Bilateral expiratory wheezes
Peak flow meter: 60% of predicted best

**DISCUSSION**

JB is a young boy with a long-standing history of asthma. Recently, his asthma has been uncontrolled, with frequent attacks occurring at home when he goes outside to play. JB uses the albuterol inhaler appropriately, which usually relieves the asthma attack, and he is not taking any medications that may induce an attack. Today, he visited his physician, who prescribed a steroid (AeroBid) inhaler. JB’s vital signs are within normal limits. JB is not in acute distress but does have expiratory wheezes on lung auscultation and is at 60% of his predicted ability with a peak flow meter.

The pharmacist concludes that JB’s asthma attacks probably result from worsening of his asthma, not from improper use of his inhaler or from other medications. The pharmacist also agrees that a scheduled steroid inhaler is the most appropriate therapy for JB at this time. The pharmacist educates JB and his mother about the proper use of the new AeroBid inhaler and continued use of the albuterol inhaler. To monitor JB’s asthma at home, the pharmacist also educates JB and his mother about the appropriate use of a peak flow meter and initiates a home asthma management plan according to what JB’s peak flow meter readings are at home. The pharmacist also scheduled a follow-up assessment with JB and his mom in 1 month to evaluate the frequency of asthma attacks, the effectiveness of the new inhaler, any side effects, and the readings from the peak flow meter.

**PATIENT CARE PLAN**

Patient Name: JB
Date: 10/17/08
Medical Problems:
Asthma
Current Medications:
- Albuterol inhaler, two puffs every 4 to 6 hours as needed for wheezing, No. 1; Refills: 11
- AeroBid (flunisolide), two puffs twice a day, new prescription today

S: 10-year-old boy with frequent wheezing, SOB, and coughing when playing outside. Relieved with albuterol inhaler. Uses inhaler appropriately. Saw physician today; new prescription: AeroBid inhaler, two puffs BID.

O: Patient in no acute distress.

Heart rate: 60 bpm
Respiratory rate: 20 rpm
Blood pressure: 112/70 mm Hg
Lungs: Bilateral expiratory wheezes
Peak flow meter: 60% of predicted best (yellow zone)

A: Progressive worsening of asthma.

P: 1. Educate patient and mother about proper use of AeroBid inhaler with continued use of albuterol inhaler.
2. Educate patient and mother about proper use of peak flow meter.
3. Institute a home asthma management program to monitor and treat JB’s asthma.
4. Follow-up assessment in 1 month to check asthma symptoms, frequency of attacks, efficacy of steroid inhaler, peak flow meter readings, and use of inhalers.

Pharmacist: Joshua Jones, Pharm.D.
CASE STUDY 11-3

BD is a 67-year-old female who comes into the pharmacy and asks the pharmacist to recommend a product for a cough that she has been having. Keeping in mind that there could be several different causes of BD's complaint, the pharmacist asks BD to step into the patient care room so that he can further assess her cough.

ASSESSMENT OF THE PATIENT

Subjective Information

67-Year-Old Woman Complaining of Cough

HOW LONG HAVE YOU HAD THE COUGH? The past week or so. It came on fairly suddenly.

WHAT TYPE OF COUGH IS IT? DRY AND HACKING? PRODUCTIVE? It is productive. I usually cough up a lot of "gunk" from my lungs.

WHAT COLOR IS THE "GUNK" THAT YOU COUGH UP? Sort of rust-colored.

DOES IT OCCUR AT ANY PARTICULAR TIME OF DAY? No. It is all day long.

DO YOU ALSO HAVE THE COUGH DURING THE NIGHT? Once in awhile, but usually not.

WHAT MAKES IT WORSE? Nothing really.

WHAT MAKES IT BETTER? HAVE YOU TRIED ANY MEDICATION TO HELP WITH IT? I haven't tried anything yet. That's why I came here today.

ANY OTHER SYMPTOMS? FEVER? CHILLS? RUNNY NOSE? SHORTNESS OF BREATH? CHEST PAIN? I haven't taken my temperature, so I don't know if I have a fever. I have had the chills the past day or so, but I've been able to breathe okay and I haven't had any chest pain or runny nose.

HAVE YOU BEEN ILL RECENTLY? Yes. With this cough, I just don't feel good.

WHAT MEDICATIONS ARE YOU TAKING? Lisinopril 20 mg once a day, for high blood pressure.

WHEN DID YOU START TAKING THE LISINOPRIL? A couple of years ago.

WHAT NONPRESCRIPTION MEDICATIONS ARE YOU TAKING? None. I don't like taking pills if I don't need to.

Objective Information

Computerized medication profile:

- Lisinopril: 20 mg, one tablet once a day for blood pressure; No. 60; Refills: 11; Patient obtains refills every 25 to 35 days.

Patient frequently coughs (productive, with rust-colored sputum)

- Skin, lips, and mucous membranes: Normal color
- No use of accessory muscles
- Temperature: 102°F
- Heart rate: 104 bpm
- Respiratory rate: 22 rpm
- Blood pressure: 124/78 mm Hg

Lung auscultation: Decreased breath sounds and crackles in right lower lobe;

DISCUSSION

When a patient complains of a cough, the pharmacist must ask several questions to determine a possible cause. In the case of BD, the pharmacist needs to determine if the cough results from a common "cold," a respiratory infection (e.g., pneumonia), a respiratory disease (e.g., asthma, COPD), or the lisinopril, an ACE inhibitor. ACE inhibitor–induced cough has a prevalence of approximately 19% to 25%, occurring predominantly in females. The cough is typically dry, nonproductive, persistent and not paroxysmal. The severity of the cough varies from a tickle to a debilitating cough with insomnia and vomiting. The cough can begin within 3 days or have a delayed onset of up to 12 months following initiation of ACE–inhibitor therapy. The cough usually subsides within 3 days or have a delayed onset of up to 12 months following initiation of ACE–inhibitor therapy. The cough usually subsides within 3 days or have a delayed onset of up to 12 months following initiation of ACE–inhibitor therapy. The cough usually subsides within 3 days or have a delayed onset of up to 12 months following initiation of ACE–inhibitor therapy. The cough usually subsides within 3 days or have a delayed onset of up to 12 months following initiation of ACE–inhibitor therapy.

CASE STUDY 11-3 (continues)
CASE STUDY 11-3 (continued)

After evaluating BD’s subjective and objective information, the pharmacist concludes that all her signs and symptoms are more consistent with pneumonia rather than as a side effect of the lisinopril. The pharmacist recommends that the patient see her physician today for antibiotic therapy. The pharmacist calls BD’s doctor and makes an appointment for her later that morning.

O: Patient frequently coughs (productive, with rust-colored sputum).
Temperature: 102°F
Heart rate: 104 bpm
Respiratory rate: 22 rpm
Blood pressure: 124/78 mm Hg
Auscultation: Decreased breath sounds in right lower lobe.

A: 1. Productive cough, probably caused by a bacterial infection.
2. Hypertension: controlled.

P: 1. Refer patient to physician for antibiotic therapy.
2. Call physician’s office, and schedule an appointment for later this morning
3. Follow-up assessment in 2 weeks to monitor patient signs and symptoms of pneumonia.

Pharmacist: John Davis, Pharm.D.

PATIENT CARE PLAN

Patient Name: BD
Date: 2/28/08
Medical Problems: Hypertension
Current Medication: Lisinopril 20 mg, once a day, No. 60, Refills: 11

S: 67-year-old woman complaining of a productive cough with rust-colored sputum that occurs all day long and does not feel well. Came on suddenly about 1 week ago. Has had chills the last day or two. No SOB or chest pain. Has not tried anything to relieve the cough.

O: Patient frequently coughs (productive, with rust-colored sputum).

Self-Assessment Questions

1. What are useful interview questions to differentiate possible causes of a cough?
2. Differentiate the common characteristics and various causes of a cough and sputum production.
3. What do the terms bronchophony, egophony, and whispered pectoriloquy mean?

Critical Thinking Questions

1. In the case of BD, how would the pharmacist’s assessment and plan change if he had complained of a dry, tickling cough that usually occurred at night and did not have a fever or chills?
2. A 56-year-old woman is taking warfarin, an anticoagulant, and aspirin, a blood “thinner,” for her heart and complains that she has been coughing up a lot of sputum every morning. She also has been smoking two packs per day for the last 40 years. What questions should the pharmacist ask to assess this patient’s cough and sputum production?
BIBLIOGRAPHY


National Heart, Lung, and Blood Institute.


