chapter 21

Introduction to the Respiratory System

Words to Know

adenoids
alveoli (sing. alveolus)
bronchioles
bronchi (sing. bronchus)
carina
cilia
diaphragm
diffusion
epiglottis
ethmoidal sinuses
frontal sinuses
glottis
hilus
interstitium
larynx
lungs
maxillary sinuses
mediastinum
nasal septum
nasopharynx
oropharynx
paranasal sinuses
parietal pleura
perfusion
pharynx
pleura
pleural space
respiration
sphenoidal sinuses
thoracentesis
tonsils
trachea
turbinates (conchae)
ventilation
visceral pleura
vocal cords

Learning Objectives

On completion of this chapter, the reader will:

- Describe structures of the upper and lower airways.
- Explain the normal physiology of the respiratory system.
- Differentiate respiration, ventilation, diffusion, and perfusion.
- Describe oxygen transport.
- Define forces that interfere with breathing, including airway resistance and lung compliance.
- Identify elements of a respiratory assessment.
- List diagnostic tests that may be performed on the respiratory tract.
- Discuss preparation and care of clients having respiratory diagnostic procedures.

The respiratory system provides oxygen for cellular metabolic needs and removes carbon dioxide (CO_2), a waste product of cellular metabolism. Respiratory disorders and diseases are common, ranging from mild to life-threatening. Disorders that interfere with breathing or the ability to obtain sufficient oxygen greatly affect respiratory and overall health status.

RESPIRATORY ANATOMY

The respiratory system is divided into the upper airway (Fig. 21.1) and lower airway. The following sections briefly describe the anatomic structures of both divisions.

Upper Airway

Nose

Nasal bones and cartilage support the external nose. The nares are the external openings of the nose. The internal nose is divided into two cavities separated by the **nasal septum.** Each nasal cavity has three passages created by the projection of turbinates or conchae from the lateral walls. The vascular and ciliated mucous lining of the nasal cavities warms and humidifies inspired air. Mucus secreted from the nasal mucosa traps small particles (e.g., dust, pollen). **Cilia** (fine hairs) move mucus to the back of the throat. This movement helps prevent irritation to and contamination of the lower airway. The nasal mucosa also contains olfactory sensory cells that are responsible for the sense of smell.

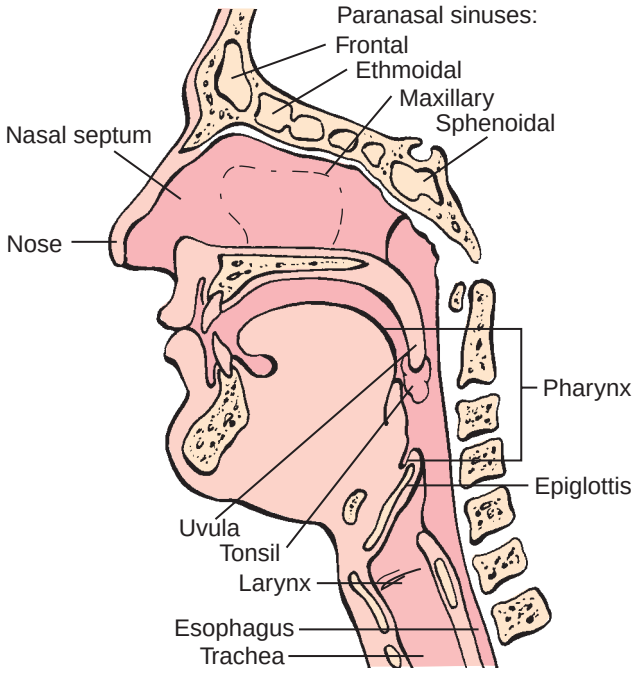

FIGURE 21.1 Major structures of the upper airway.

Paranasal Sinuses

The **paranasal sinuses** are extensions of the nasal cavity located in the surrounding facial bones (see Fig. 21.1). They reduce the weight of the skull and give resonance to the voice. There are four pairs of sinuses. The two **frontal sinuses** lie in the frontal bone extending above the orbital cavities. The ethmoid bone, located between the eyes, contains a honeycomb of small spaces called **ethmoidal sinuses.** The **sphenoidal sinuses** lie behind the nasal cavity. The **maxillary sinuses** are found on either side of the nose in the maxillary bones. They are the largest sinuses and most accessible to treatment.

The lining of the sinuses is continuous with the mucous-membrane lining of the nasal cavity. Mucus traps particles that cilia sweep toward the pharynx. Immunoglobulin A (IgA) antibodies in the mucus protect the lower respiratory tract from infection.

The olfactory area lies at the roof of the nose. The cribriform plate forms part of the roof of the nose and the floor of the anterior cranial fossa. Trauma or surgery in this area carries the risk of injuring or causing infection in the brain.

Turbinate Bones (Conchae)

Turbinates (or **conchae**) are bones that change the flow of inspired air to moisturize and warm it better. As air is inhaled, turbinates deflect it toward the roof of the nose. They have a large, moist, and warm mucous-membrane surface that traps almost all dust and microorganisms. They also contain sensitive nerves that detect odors or induce sneezing to remove irritating particles, such as dust or soot.

Pharynx

The **pharynx,** or throat, carries air from the nose to the larynx, and food from the mouth to the esophagus. The pharynx has three continuous areas: the **nasopharynx** (near the nose and above the soft palate), the **oropharynx** (near the mouth), and the *laryngeal pharynx* (near the larynx). The nasopharynx contains the adenoids and openings of the eustachian tubes, which connect the pharynx to the middle ear. They are the means by which upper respiratory infections spread to the middle ear. The oropharynx contains the tongue. The muscular nature of the pharynx allows for closure of the epiglottis during swallowing and relaxation of the epiglottis during respiration.

Tonsils and **adenoids,** found in the pharynx, do not contribute to respiration but instead protect against infection. Palatine tonsils consist of two pairs of elliptically shaped bodies of lymphoid tissue, located on both sides of the upper oropharynx. Adenoids, or pharyngeal tonsils, also composed of lymphoid tissue, are in the nasopharynx. Chronic throat infections often lead to removal of the tonsils and adenoids. In adults, adenoids may shrink and become nonfunctional.

Larynx

The **larynx,** or voice box, is a cartilaginous framework between the pharynx and trachea. Its primary function is to produce sound. The larynx also protects the lower airway from foreign objects because it facilitates coughing.

Important structures in the larynx include the **epiglottis,** a cartilaginous valve flap covering the opening to the larynx during swallowing; the **glottis,** an opening between the vocal cords; and the **vocal cords** themselves, folds of tissue in the larynx that vibrate and produce sound as air passes through (Fig. 21.2). The pharynx, palate, tongue, teeth, and lips mold the sounds made by the vocal cords into speech.

Lower Airway

The lower respiratory airway consists of the trachea, bronchi, bronchioles, lungs, and alveoli (Fig. 21.3). Accessory structures include the diaphragm, rib cage, sternum, spine, muscles, and blood vessels.

Trachea

The **trachea** is a hollow tube composed of smooth muscle and supported by C-shaped cartilage. The cartilaginous rings are incomplete on the posterior surface. The trachea transports air from the laryngeal pharynx to the bronchi and lungs.

Bronchi and Bronchioles

The trachea divides at the **carina** (lower end of the trachea) to form left and right **bronchi.** Stimulation of

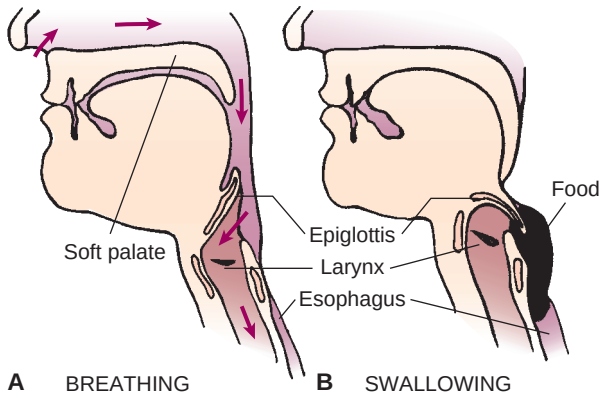

FIGURE 21.2 (**A**) During swallowing, the soft palate elevates to close off air from the nose. Breathing is interrupted momentarily. (**B**) The larynx rises, and the epiglottis shuts off the laryngeal opening until the food has passed down into the esophagus.

the carina causes coughing and *bronchospasm* (bronchial smooth muscle spasm causing narrowing of the lumen). The right mainstem bronchus is shorter, more vertical, and larger than the left. Aspiration of foreign objects is more likely in the right mainstem bronchus and right upper lung. Mucous membrane continues to line this portion of the respiratory tract. Cilia sweep mucus and particles toward the pharynx.

The right and left mainstem bronchi divide into three secondary right bronchi and two secondary left bronchi. Each secondary bronchus supplies air to three right lobes and two left lobes of the lung. The entrance of the bronchi to the lungs is called the **hilus.** The bronchi branch, enter each lobe, and continue to branch to form smaller bronchi and finally terminal **bronchioles** (smaller subdivisions of bronchi).

Lungs and Alveoli

The **lungs** are paired elastic structures enclosed by the thoracic cage. They contain **alveoli,** small, clustered sacs that begin where bronchioles end. Adult lungs contain approximately 300 million alveoli. Each alveolus consists of a single layer of squamous epithelial cells. Capillaries surround these thin-walled alveoli and are the site of oxygen and CO_2 exchange.

The epithelium of the alveoli consists of the following types of cells:

- Type I cells—line most alveolar surfaces
- Type II cells—produce *surfactant,* a phospholipid that alters surface tension of alveoli, preventing collapse during expiration and limiting expansion during inspiration
- Type III cells—destroy foreign material, such as bacteria

The **interstitium** lies between the alveoli and contains pulmonary capillaries and elastic connective tissue. Elastic and collagen fibers allow lungs to have *compliance,*

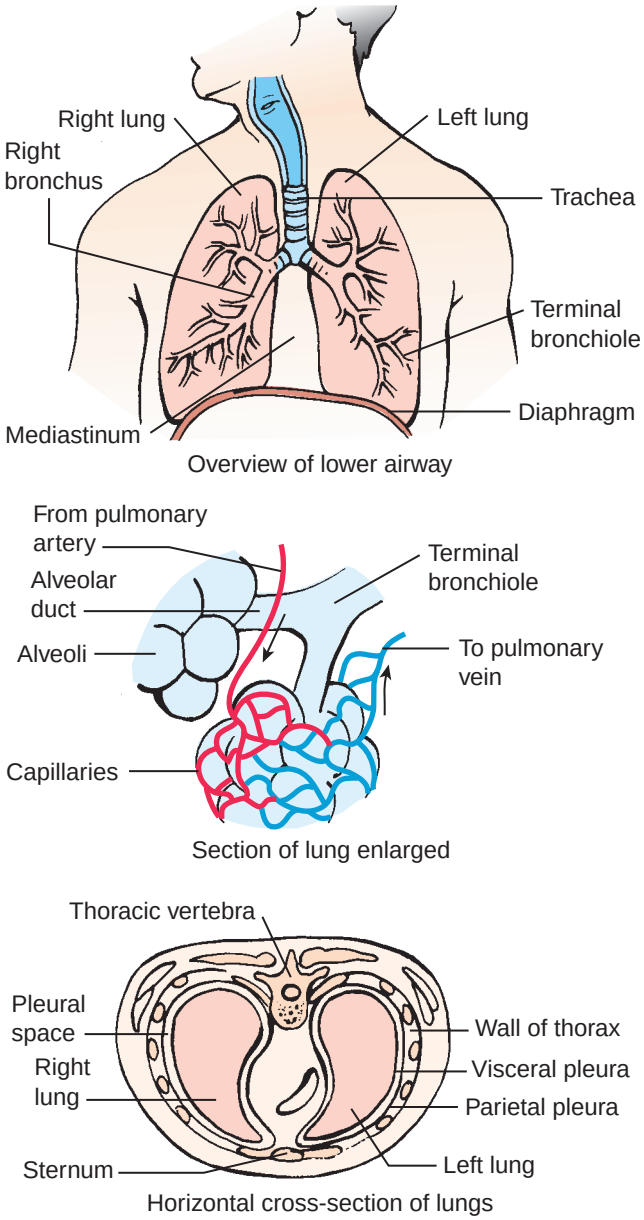

FIGURE 21.3 Lower respiratory tract.

or the ability to expand. Lung expansion creates a negative or subatmospheric pressure, keeping lungs inflated. If air gets into the space between the lungs and thoracic wall, the lungs will collapse.

Accessory Structures

The **diaphragm** separates the thoracic and abdominal cavities. On inspiration, respiratory muscles contract. The diaphragm also contracts and moves downward, enlarging the thoracic space and creating a partial vacuum. On expiration, respiratory muscles relax, and the diaphragm returns to its original position. The **mediastinum** is a wall dividing the thoracic cavity into two halves. This wall has two layers of **pleura,** a saclike serous membrane. The **visceral pleura** covers the lung surface,

and the **parietal pleura** covers the chest wall. Serous fluid within the **pleural space** separates and lubricates the visceral and parietal pleurae. Remaining thoracic structures are located between the two pleural layers.

RESPIRATORY PHYSIOLOGY

The main function of the respiratory system is to exchange oxygen and CO_2 between the atmospheric air and blood and between the blood and cells. This process is called **respiration.** Other terms related to respiration are defined in Table 21.1.

Ventilation

Ventilation is the movement of air in and out of the respiratory tract. Air must reach alveoli for gas exchange. This requires a patent airway and intact and functioning respiratory muscles. Pressure gradients between atmospheric air and alveoli enable ventilation. Air flows from an area of higher pressure to an area of lower pressure.

Mechanics of Ventilation

During inspiration, the diaphragm contracts and flattens, expanding the thoracic cage and increasing the thoracic cavity. Pressure in the thorax decreases to a level below atmospheric pressure. As a result, air moves into the lungs. When inspiration is complete, the diaphragm relaxes, and lungs recoil to their original position. The size of the thoracic cavity decreases, increasing pressure to levels greater than atmospheric pressure. Air then flows out of the lungs into the atmosphere (Fig. 21.4).

Neurologic Control of Ventilation

Several mechanisms control ventilation. Respiratory centers in the medulla oblongata and pons control rate and depth. Central chemoreceptors in the medulla respond to changes in CO_2 levels and hydrogen ion concentrations (pH) in the cerebrospinal fluid. They convey a message to the lungs to change the depth and rate of ventilation. Peripheral chemoreceptors in the aortic arch and carotid arteries respond to changes in pH and levels of oxygen and CO_2 in the blood.

Diffusion

Diffusion is exchange of oxygen and CO_2 through the alveolar–capillary membrane. Concentration gradients determine direction of diffusion. During inspiration, oxygen concentration is higher in alveoli than in capillaries. Thus, oxygen diffuses from the alveoli to the capillaries, and is carried to arteries. Oxygen concentration in the arteries is higher than that in cells; thus, oxygen diffuses into cells.

As cellular CO_2 gradients increase, CO_2 diffuses from cells into capillaries and then into the venous circulatory system. As CO_2 travels to the pulmonary circulation, its concentration is higher there than in alveoli, so CO_2 diffuses into alveoli.

Alveolar Respiration

Alveolar respiration determines CO_2 levels in the body. Increased CO_2, present in body fluids primarily as carbonic acid, causes pH to decrease below the normal 7.4. Decreased CO_2 causes pH to increase above 7.4. The pH affects alveolar respiratory rate by direct action of hydrogen ions on the respiratory center in the medulla oblongata.

Kidneys contribute to maintaining normal pH by excreting excess hydrogen ions, keeping serum bicarbonate levels near normal. Lungs and kidneys combine to maintain the ratio of carbonic acid to bicarbonate at 1:20, fixing the pH at approximately 7.4.

In a critically ill client, various homeostatic mechanisms compensate for alterations. Two mechanisms may occur to maintain normal pH:

TABLE 21.1 TERMS RELATED TO RESPIRATION

TERM	DEFINITION
Ventilation	Movement of air in and out of the lungs sufficient to maintain normal arterial oxygen and carbon dioxide tensions
Inspiration	Movement of oxygen into the lungs
Expiration	Removal of carbon dioxide from the lungs
Diffusion	Transfer of a substance from an area of higher concentration or pressure to an area of lower concentration or pressure; exchange of oxygen and carbon dioxide across the alveolar–capillary membrane and at the cellular level
Perfusion	Flow of blood in the pulmonary circulation
Distribution	Delivery of atmospheric air to the separate gas exchange units in the lungs

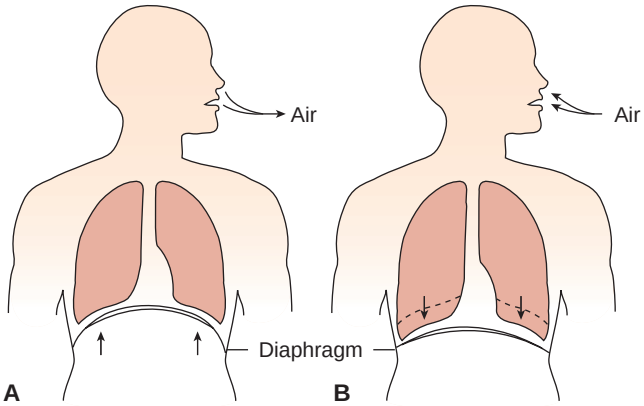

FIGURE 21.4 The mechanics of ventilation. (From Rosdahl, C. B. [2003]. *Textbook of basic nursing* [8th ed.]. Philadelphia: Lippincott Williams & Wilkins.)

- The lungs eliminate carbonic acid by blowing off more CO_2. They also conserve CO_2 by slowing respiratory volume and reabsorbing bicarbonate (HCO_3).
- The kidneys excrete more bicarbonate.

A client's condition remains compensated if the carbonic acid-to-bicarbonate ratio remains 1:20.

Disturbances in pH that involve lungs are considered respiratory. Disturbances in pH involving other mechanisms are termed *metabolic.* At times, respiratory and metabolic disturbances coexist.

Transport of Gases

Oxygen transport occurs in two ways: (1) a small amount is dissolved in water in the plasma, and (2) a greater portion combines with hemoglobin in red blood cells (RBCs; oxyhemoglobin). Dissolved oxygen is the only form that can diffuse across cellular membranes. As this oxygen crosses cellular membranes, oxygen from the hemoglobin rapidly replaces it. Large amounts of oxygen are transported in the blood as oxyhemoglobin.

CO_2 diffuses from the tissue cells to the blood. Bicarbonate ions are then transported to the lungs for excretion. Most CO_2 enters the RBCs, although some combines with hemoglobin to form carbaminohemoglobin. Most CO_2 combines with water in the cells and exits as bicarbonate ions (HCO_3), which the plasma transports to the kidneys. A small portion remains in the plasma and is called *carbonic acid.* The formation of carbonic acid yields hydrogen ions (H^+). The amount of hydrogen ions determines the pH, which also determines the amount of CO_2 for the lungs to excrete. Briefly, acid-base imbalances are compensated in the following ways:

- Respiratory acidosis—kidneys retain more HCO_3 to raise the pH
- Respiratory alkalosis—kidneys excrete more HCO_3 to lower pH
- Metabolic acidosis—lungs "blow off" CO_2 to raise pH
- Metabolic alkalosis—lungs retain CO_2 to lower pH

Pulmonary Perfusion

Perfusion refers to blood supply to the lungs, through which lungs receive nutrients and oxygen. Methods of perfusion are the bronchial and pulmonary circulation.

Bronchial Circulation

Bronchial arteries, which supply blood to the trachea and bronchi, arise in the thoracic aorta and intercostal arteries. Bronchial arteries also supply the lungs' supporting tissues, nerves, and outer layers of the pulmonary arteries and veins. This circulation returns either to the left atrium through the pulmonary veins or to the superior vena cava through the bronchial and azygos veins.

Pulmonary Circulation

The pulmonary artery transports venous blood from the right ventricle to the lungs. It divides into the right and left branches to supply the right and left lungs. Blood circulates through the pulmonary capillary bed, where diffusion of oxygen and CO_2 occurs. Blood then returns to the left atrium through the pulmonary veins.

Pulmonary circulation is referred to as a *low-pressure system* (Smeltzer & Bare, 2004). This means that gravity, alveolar pressure, and pulmonary artery pressure affect pulmonary perfusion. A person in an upright position has less perfusion to the upper lobes. If a person is in a side-lying position, perfusion is greater to the dependent side. Increased alveolar pressure can cause pulmonary capillaries to narrow or collapse, affecting gas exchange. Decreased pulmonary artery pressure results in decreased perfusion to the lungs. Clients with lung and cardiovascular diseases may have decreased pulmonary perfusion.

Problems in Respiratory Physiology

The respiratory system usually has sufficient reserves to maintain normal partial pressures or tension of oxygen and CO_2 in the blood during times of stress. Respiratory insufficiency develops with too much interference with ventilation, diffusion, or perfusion. Abnormalities in these processes can lead to hypoxia, hypoxemia, hypercapnia, and hypocapnia (Table 21.2).

Several factors influence the work of breathing. Pressures needed to overcome the forces interfering with breathing determine the respiratory effort needed. Forces that interfere with breathing include airway resistance and lung compliance.

Airway resistance is related to airway diameter, rate of air flow, and speed of gas flow. As breathing rate increases, so does resistance. A narrowed airway results from increased or thick mucus, bronchospasm, or edema. Conditions that may alter bronchial diameter and affect airway resistance include contraction of bronchial smooth muscle (e.g., asthma); thickening of bronchial mucosa

TABLE 21.2 CONDITIONS RELATED TO ABNORMALITIES IN VENTILATION, PERFUSION, DIFFUSION, AND DISTRIBUTION

CONDITION	DESCRIPTION
Hypoxia	Decreased oxygen in inspired air
Hypoxemia	Decreased oxygen in the blood
Hypercapnia	Increased carbon dioxide in the blood
Hypocapnia	Decreased carbon dioxide in the blood

(e.g., chronic bronchitis); airway obstruction by mucus, a tumor, or a foreign body; and loss of lung elasticity (e.g., emphysema).

Decreased surfactant, fibrosis, edema, and atelectasis (alveolar collapse) affect lung compliance. Greater pressure gradients are needed when lungs are stiff.

ASSESSMENT

Assessment of the respiratory system includes obtaining information about physical and functional issues related to breathing. It also means clarifying how these issues may affect the client's quality of life.

History

Often clients seek medical attention because of respiratory problems related to one or more of the following: dyspnea (labored or difficult breathing), pain on inspiration, increased or more frequent cough, increased sputum production or change in the color/consistency of the mucus, wheezing, or hemoptysis (blood in the sputum). Obtain information about the general health history and family history. Ask clients about the frequency of respiratory illnesses, allergies, smoking history, nature of any cough, sputum production, dyspnea (Box 21-1), and wheezing. Questioning clients about respiratory treatments or medications (prescription and over the counter) is essential. In addition, ask about past pulmonary tests (chest x-ray, tuberculosis test). Include questions about occupation, exercise tolerance, pain, and level of fatigue.

BOX 21-1 ● Questions for the Client With Dyspnea

- What makes you short of breath?
- Do you cough when you are short of breath?
- Do you have other symptoms when you are short of breath?
- Do you get short of breath suddenly or gradually?
- When do you usually have difficulty breathing?
- Can you lie flat in bed?
- Do you get short of breath when you rest? With exercise? Running? Climbing stairs?
- How far can you walk before you get short of breath?

Physical Examination

Physical examination begins with a general examination of overall health and condition. Clients with respiratory problems may show signs of shortness of breath when speaking, or may have a certain posture or position to facilitate breathing. Other observations include skin color; level of consciousness; mental status; respiratory rate, depth, effort, and rhythm; use of accessory muscles; and shape of chest and symmetry of chest movements.

Inspect the nose for signs of injury, inflammation, symmetry, and lesions. Examine the posterior pharynx and tonsils with a tongue blade and light and note evidence of swelling, inflammation, or exudate, and changes in color of the mucous membranes. Also note any difficulty with swallowing or hoarseness.

A physician or nurse practitioner inspects the larynx directly with a laryngoscope or indirectly with a light and laryngeal mirror. Both procedures require local anesthesia to suppress the gag reflex and reduce discomfort.

Inspect and gently palpate the trachea to assess for placement and deviation from the midline. Note any lymph node enlargement. Also examine the chest wall for lesions, symmetry, deformities, skin color, and evidence of muscle weakness or weight loss. Checking contour of the chest walls is important. Normally the anteroposterior diameter of the chest wall is half the transverse diameter; however, some pulmonary conditions (e.g., emphysema) change the chest dimensions (Table 21.3).

An experienced examiner performs percussion of the chest wall to assess normal and abnormal sounds. With the client sitting, the examiner places his or her middle finger on the chest wall and taps that finger with the middle finger of the opposite hand. Table 21.4 describes the types of sounds heard with percussion.

Auscultate breath sounds from side to side, moving from the upper to the lower chest (Fig. 21.5). Listen anteriorly, laterally, and posteriorly. Normal breath sounds include the following:

- Vesicular sounds—Produced by air movement in bronchioles and alveoli, these sounds are heard over the lung fields; they are quiet and low pitched, with long inspiration and short expiration.
- Bronchial sounds—Produced by air movement through the trachea, these sounds are heard over the trachea and are loud with long expiration.
- Bronchovesicular sounds—These normal breath sounds are heard between the trachea and upper lungs; pitch is medium with equal inspiration and expiration.

TABLE 21.3 COMMON ABNORMALITIES OF THE CHEST

CONDITION	DESCRIPTION
Kyphosis	Exaggerated curvature of the thoracic spine; congenital anomaly or associated with injuries and osteoporosis
Scoliosis	Lateral S-shaped curvature of the thoracic and lumbar spine
Barrel chest	Anteroposterior diameter increases to equal the transverse diameter; chest is rounded; ribs are horizontal; sternum is pulled forward; associated with emphysema and aging
Funnel chest	Also known as *pectus excavatum;* the sternum is depressed from the second intercostal space—more pronounced with inspiration; a congenital anomaly
Pigeon chest	Also known as *pectus carinatum;* the sternum abnormally protrudes; the ribs are sloped backward; a congenital anomaly

Adventitious or abnormal breath sounds are categorized as crackles or wheezes. *Crackles* are discrete sounds resulting from delayed opening of deflated airways. They resemble static or sounds made by rubbing hair strands together near one's ear. Sometimes they clear with coughing. They may be present because of inflammation or congestion. Crackles not clearing with coughing may indicate pulmonary edema or fluid in the alveoli.

Wheezes are continuous musical sounds that can be heard during inspiration and expiration. They result from air passing through narrowed or partially obstructed air passages and are heard in clients with increased secretions. Lower pitched wheezes are heard in the trachea and bronchi. Friction rubs are heard as crackling or grating sounds on inspiration or expiration. They occur when the pleural surfaces are inflamed and do not change if the client coughs.

Diagnostic Tests

Arterial Blood Gases

Oxygenation of body tissues depends on the amount of oxygen in arterial blood. Arterial blood gases (ABGs) determine the blood's pH, oxygen-carrying capacity, and levels of oxygen, CO_2, and bicarbonate ion. Blood gas samples are obtained through an arterial puncture at the radial, brachial, or femoral artery, or an indwelling arterial catheter.

ABGs frequently are ordered when a client is acutely ill or has a history of respiratory disorders. If the partial pressure of oxygen in arterial blood (PaO_2) is decreased, body tissues do not receive sufficient oxygen. Table 21.5 presents descriptions and measures of normal ABGs. Clients with respiratory disorders can neither get oxygen into the blood nor get CO_2 out of the blood.

Pulse oximetry is a noninvasive method that uses a light beam to measure the oxygen content of hemoglobin (SaO_2). The monitoring device is attached to the earlobe or fingertip and connects to the oximeter monitor. Wavelengths of light passing through the earlobe or fingertip are registered by the monitor and used to calculate the arterial oxygen saturation, which is displayed on a readout. Normal values are 95% or higher.

Tuberculin Skin Test

The Mantoux test (tuberculin skin test) commonly is done to determine if a client has been infected with *Mycobacterium tuberculosis.* Nurses must remember that this

TABLE 21.4 SOUNDS HEARD WITH CHEST WALL PERCUSSION

SOUND	DESCRIPTION	IMPLICATIONS
Flat	High pitch, little intensity, decreased duration	Heard during percussion of a solid area, such as a mass or pleural effusion
Dull	Medium pitch, medium intensity, medium duration	Heard when no air or fluid is in the lung (e.g., atelectasis, lobar pneumonia)
Tympanic	High pitch, loud intensity, long duration	Normal sounds heard over stomach and bowel; abnormal sounds heard over lungs, such as in a pneumothorax
Resonant	Low pitch, loud intensity, long duration	Normal lung sounds
Hyperresonant	Lower pitch, very loud, longer duration	Abnormal sounds that occur when free air exists in the thoracic cavity (e.g., emphysema, pneumothorax)

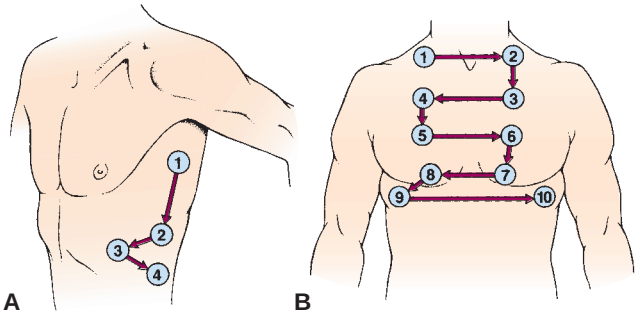

FIGURE 21.5 (**A**) Each side of the chest is auscultated and compared. (**B**) The anterior chest is systematically examined over each lung field.

test does not differentiate between active and dormant disease (Nursing Guidelines 21-1).

Pulmonary Function Studies

Pulmonary function studies measure functional ability of lungs. Measurements are obtained with a spirometer and include:

- Tidal volume—volume of air inhaled and exhaled with a normal breath
- Inspiratory reserve volume—maximum volume of air that normally can be inspired
- Expiratory reserve volume—maximum volume of air that normally can be exhaled by forced expiration
- Residual volume—volume of air left in lungs after maximal expiration
- Vital capacity—maximum amount of air that can be expired after maximal inspiration
- Forced vital capacity—amount of air exhaled forcefully and rapidly after maximal inspiration
- Inspiratory capacity—maximum amount of air that can be inhaled after normal expiration
- Functional residual capacity—amount of air left in the lungs after a normal expiration
- Total lung capacity—total volume of air in the lungs when maximally inflated

Pulmonary function results vary according to age, sex, weight, and height. Maximum lung capacities and volumes are best achieved when the client is sitting or standing. These studies diagnose pulmonary conditions and assess preoperative respiratory status. They also may be used to determine effectiveness of bronchodilators or to screen employees who work in environments hazardous to pulmonary health (Nursing Guidelines 21-2).

Sputum Studies

Sputum specimens are examined for pathogenic microorganisms and cancer cells. Culture and sensitivity tests diagnose infections and determine antibiotics needed. Negative results on examination of sputum smears do not always indicate absence of disease, so collection of sputum for successive days may be done. Sputum is collected by having the client expectorate a specimen, by suctioning the client, or during a bronchoscopy.

Radiography

Chest x-rays show the size, shape, and position of the lungs and other structures of the thorax. Physicians use chest radiography to screen for asymptomatic disease and to diagnose tumors, foreign bodies, and other abnormal conditions. Fluoroscopy helps the physician to view the thoracic cavity with all its contents in motion. It more precisely diagnoses the location of a tumor or lesion. Computed tomography scanning or magnetic resonance imaging may be used to produce axial views of the lungs to detect tumors and other lung disorders during early stages.

Pulmonary Angiography

Pulmonary angiography is a radioisotope study that allows physicians to assess arterial circulation of the lungs, and detect pulmonary emboli. A catheter is introduced into an arm vein and threaded through the right atrium and ventricle into the pulmonary artery. Contrast medium is rapidly injected into the femoral artery, and x-rays are taken to see the distribution of the radiopaque material.

During pulmonary angiography, nurses obtain data about the client's level of anxiety and knowledge of the procedure. They provide additional explanations and inform the client that he or she will experience a feeling of pressure on catheter insertion. When the contrast medium is infused, the client will sense a warm, flushed feeling and an urge to cough.

TABLE 21.5 NORMAL VALUES FOR ARTERIAL BLOOD GASES

BLOOD GAS	NORMAL VALUE
pH, hydrogen ion concentration, acidity or alkalinity of the blood	7.35–7.45
PaO_2, partial pressure of oxygen in arterial blood	80–100 mm Hg
$PaCO_2$, partial pressure of carbon dioxide in arterial blood	35–45 mm Hg
HCO_3, bicarbonate ion concentration in the blood	22–26 mm Hg
SaO_2, arterial oxygen saturation or percentage of the oxygen-carrying capacity of the blood	95%–100%

NURSING GUIDELINES 21-1

Mantoux Test

- Draw up 0.1 mL of intermediate-strength purified protein derivative (PPD) in a tuberculin syringe (½-inch 26- to 27-gauge needle).
- Prepare the injection site on the inner aspect of the forearm, approximately halfway between the elbow and wrist.
- Hold the syringe bevel up, almost parallel to the forearm.
- Inject the PPD to form a pronounced wheal, which indicates proper intradermal injection.
- Record the site, name of PPD, strength, lot number, and date and time of test.
- Read the test site 48 to 72 hours after injection by palpating the site for induration. If induration is present, measure it at its greatest width. Erythema (redness) without induration is not significant. If erythema is present with induration, read the induration only. Interpret the test results as follows:

  Negative reaction—0- to 4-mm induration; no follow-up needed

  Questionable reaction—5- to 9-mm induration; if the client is aware of contact with someone with active tuberculosis, this reaction is seen as significant

  Positive reaction—10 mm or greater induration

Ask if the client has any allergies, particularly to iodine, shellfish, or contrast dye. During the procedure, monitor for signs and symptoms of allergic reactions to the contrast medium, such as itching, hives, or difficulty breathing. Infusion of contrast dye is discontinued immediately if the client has an allergic reaction.

After the procedure, inspect the puncture site for swelling, discoloration, bleeding, or hematoma. Assess distal circulation and sensation to ensure that circulation is unimpaired. If bleeding occurs, apply pressure to the site. Notify the physician about diminished or absent distal pulses, cool skin temperature in the affected limb, poor capillary refill, client complaints of numbness or tingling, and bleeding or hematoma. The client remains on bed rest for 2 to 6 hours after the procedure. The pressure dressing, applied after the catheter is removed, remains in place for this period.

NURSING GUIDELINES 21-2

Pulmonary Function Studies

- Explain the procedure to decrease anxiety and promote cooperation.
- Assure the client that although the spirometry equipment looks complex, the pulmonary function test is simple.
- Explain that the client may be tired after the study.
- Remind the client that the tests should not be performed within 2 hours after a meal.
- Tell the client that bronchodilators may be used during the study.
- Inform the client that he or she will use a nose clip during the study so that air cannot escape through the nose.
- Instruct the client to wear loose-fitting clothing.

Lung Scans

Two types of lung scans may be done for diagnostic purposes: the perfusion scan and the ventilation scan. These procedures may be referred to as a *V-Q scan.* Both require use of radioisotopes and a scanning machine to detect patterns of blood flow and patterns of air movement and distribution in the lungs. V-Q scans are very useful in diagnosing pulmonary emboli. They also detect lung cancer, COPD, and pulmonary edema.

A radioactive contrast medium is administered intravenously for the perfusion scan and by inhalation as a radioactive gas for the ventilation scan. Before the perfusion scan, assess the client for allergies to iodine. During the procedure, the radiologist asks the client to change positions. During inhalation, the client may need to hold his or her breath for short periods as scanning images are obtained. The client needs adequate explanations before the procedure to reduce anxiety. Reassure the client that the amount of radiation from this procedure is less than that used during a chest x-ray.

Bronchoscopy

Bronchoscopy allows for direct visualization of the larynx, trachea, and bronchi using a flexible fiberoptic bronchoscope. The physician introduces the bronchoscope through the nose or mouth or through a tracheostomy or artificial airway. Bronchoscopy is used to diagnose, treat, or evaluate lung disease; obtain a biopsy of a lesion or tumor; obtain a sputum specimen; perform aggressive pulmonary cleansing; or remove a foreign body.

Bronchoscopy is very frightening to clients, who require thorough explanations throughout the procedure. For at least 6 hours before the bronchoscopy, the client abstains from food or drink to decrease risk of aspiration. Risk is increased because the client receives local anesthesia, which suppresses swallow, cough, and gag reflexes.

The client receives medications before the procedure—usually atropine to dry secretions and a sedative or narcotic to depress the vagus nerve. This is important because if the vagus nerve is stimulated during the bronchoscopy, hypotension, bradycardia, or dysrhythmias may occur. Other potential complications include bronchospasm or laryngospasm secondary to edema, hypoxemia, bleeding, perforation, aspiration, cardiac dysrhythmias, and infection. See Nursing Care Plan 21-1 for more information.

Laryngoscopy

Laryngoscopy provides direct visualization of the larynx using a laryngoscope. It is done to diagnose lesions, eval-

Nursing Care Plan 21-1

THE CLIENT UNDERGOING A BRONCHOSCOPY

Assessment

- Assess level of anxiety and understanding of the procedure.
- Obtain baseline vital signs.
- Assess lung sounds.
- Ask client if he or she wears dentures and when he or she last ate or drank.
- Check record to ensure that consent form is signed and witnessed.

Nursing Diagnosis: **Fear** related to lack of knowledge about what to expect during and after procedure

Expected Outcome: Client will exhibit coping behaviors and follow instructions.

Interventions	*Rationales*
Acknowledge client's fear.	Validating fear communicates acceptance.
Provide simple explanations about the procedure after determining what the client knows and his or her misconceptions.	Acknowledging misconceptions provides a starting point for teaching.
Inform client that he or she will receive medications to alleviate anxiety, reduce secretions, and block the vagus nerve.	Information reduces fear and anxiety.
Explain that a tube will be inserted through the nose and throat and into the lungs and that the medication will assist the client.	Thorough explanations reinforce understanding and reduce fear.
Tell client that after the procedure, food and fluids are withheld until the cough reflex returns.	Preoperative sedation and local anesthesia impair the cough reflex and swallowing for several hours.
Inform client that the throat will be irritated and sore for a few days, and that he or she may cough up blood-tinged mucus.	Knowledge about expected signs and symptoms reduces fear after procedure.

Evaluation of Expected Outcome: Client tolerates procedure without untoward effects, follows instructions, and states that fear is minimal.

Nursing Diagnosis: **Risk for Aspiration** related to diminished gag reflex

Expected Outcomes: (1) Client will maintain a patent airway. (2) Risk of aspiration will decrease.

Interventions	*Rationales*
Assess cough and gag reflexes.	Depressed cough or gag reflex increases risk of aspiration.
Keep client NPO until the gag reflex returns (usually 2 to 8 hours).	NPO status reduces risk of aspiration.
Keep suction equipment available.	If the client aspirates, suctioning helps to maintain a patent airway.
Place client in semi-Fowler's position with the head to one side.	Proper positioning decreases the risk of aspiration.
Encourage client to expectorate secretions frequently into an emesis basin.	Expectoration reduces the risk of aspiration.
After the gag reflex returns, offer sips of water or ice chips initially, then progress the diet to soft foods.	Beginning with sips of water or ice chips ensures that the gag reflex has returned. The client can most easily swallow soft foods.

Evaluation of Expected Outcomes: Airway remains patent. Client does not experience aspiration.

(continued)

Nursing Care Plan 21-1 (Continued)

THE CLIENT UNDERGOING A BRONCHOSCOPY

PC: Pneumothorax: dysrhythmia, bronchospasm

Expected Outcome: The nurse will manage and minimize potential complications.

Interventions	*Rationales*
Monitor vital signs and respiratory status, comparing against baseline assessment data.	Comparison helps the nurse determine if the client is experiencing any respiratory distress.
Observe for symmetric chest movements.	Decreased or asymmetric chest expansion is a sign of pneumothorax.
Report hemoptysis, stridor, or dyspnea immediately.	These findings indicate respiratory distress and probable pneumothorax.

Evaluation of Expected Outcome: Client does not experience postprocedure complications.

uate laryngeal function, and determine any inflammation. Physicians also may dilate laryngeal strictures and biopsy lesions. Refer to the preceding section and Nursing Care Plan 21-1 for more information.

Mediastinoscopy

Mediastinoscopy provides visualization of the mediastinum and is done under local or general anesthesia. The physician makes an incision above the sternum and inserts a mediastinoscope. With this procedure, the physician can visualize lymph nodes and obtain biopsy samples. Possible complications include dysrhythmias, myocardial infarction, pneumothorax, and bleeding.

Thoracentesis

A small amount of fluid lies between the visceral and parietal pleurae. When excess fluid or air accumulates, the physician aspirates it from the pleural space by inserting a needle into the chest wall. This procedure, called **thoracentesis,** is performed with local anesthesia. Thoracentesis also may be used to obtain a sample of pleural fluid or a biopsy specimen from the pleural wall for diagnostic purposes, such as a culture and sensitivity or microscopic examination. Bloody fluid suggests trauma. Purulent fluid is diagnostic for infection. Serous fluid may be associated with cancer, inflammatory conditions, or heart failure. When thoracentesis is done for therapeutic reasons, 1 to 2 L of fluid may be withdrawn to relieve respiratory distress. Medication may be instilled directly into the pleural space to treat infection.

Thoracentesis is done at the bedside or in a treatment or examining room. The client sits at the side of the bed or examining table or is in a side-lying position on the unaffected side. If the client is sitting, a pillow is placed on a bedside table, and the client rests her or his arms and head on the pillow. The physician determines the site for aspiration by x-ray and percussion. The site is cleaned and anesthetized with local anesthesia. When the procedure is done, a small pressure dressing is applied. The client remains on bed rest and usually lies on the unaffected side for at least 1 hour to promote lung expansion on the affected side. A chest x-ray is done after the procedure to rule out a pneumothorax. See Nursing Guidelines 21-3 for specific measures. Complications following a thoracentesis are pneumothorax, subcutaneous emphysema (air in subcutaneous tissue), infection, pulmonary edema, and cardiac distress.

Stop, Think, and Respond ● BOX 21-1

Your client had a thoracentesis 2 hours ago. He begins to complain of feeling short of breath and is very anxious. What should you assess?

NURSING MANAGEMENT

In addition to the nursing management of individual tests, clients require informative and appropriate explanations of any diagnostic procedures they will experience. Remember that for many of these clients, breathing may in some way be compromised. Energy levels may be decreased. For that reason, explanations should be brief yet complete and may need to be repeated. Also help ensure adequate rest periods before and after the procedures. After invasive procedures, carefully assess for signs of respiratory distress, chest pain, blood-streaked sputum, and expectoration of blood. Repeat postprocedure instructions to reduce the client's anxiety and to ensure the best possible recovery.

NURSING GUIDELINES 21-3

Thoracentesis

- Explain the procedure to the client.
- Reassure the client that he or she will receive local anesthesia. Explain that the client will still experience a pressure-like pain when the needle pierces the pleura and when fluid is withdrawn.
- Assist client to an appropriate position (sitting with arms and head on padded table or in side-lying position on unaffected side).
- Instruct client not to move during the procedure, including no coughing or deep breathing.
- Provide comfort.
- Inform client about what is happening.
- Maintain asepsis.
- Monitor vital signs during the procedure—also monitor pulse oximetry if client is connected to it.
- During removal of fluid, monitor for respiratory distress, dyspnea, tachypnea, or hypotension.
- Apply small sterile pressure dressing to the site after the procedure.
- Position client on the unaffected side. Instruct client to stay in this position for at least 1 hour and to remain on bed rest for several hours.
- Check that chest radiography is done after the procedure.
- Record the amount, color, and other characteristics of fluid removed.
- Monitor for signs of increased respiratory rate, asymmetry in respiratory movement, syncope or vertigo, chest tightness, uncontrolled cough or cough that produces blood-tinged or frothy mucus (or both), tachycardia, and hypoxemia.

GENERAL GERONTOLOGIC CONSIDERATIONS

Although numbers of alveoli remain stable with age, alveolar walls become thinner and contain fewer capillaries, resulting in decreased gas exchange. Lungs also lose elasticity and become stiffer. These changes place older adults at increased risk for respiratory disease.

Older clients may have difficulty understanding explanations or directions given by the physician or nurse. Repeating or restating information or directions may be necessary before or during a diagnostic test.

Critical Thinking Exercise

1. *Your client had a thoracentesis today. When he returns to your unit, he begins to complain of pain. What risks are associated with this procedure?*

NCLEX-STYLE REVIEW QUESTIONS

1. A 68-year-old client comes to the doctor's office stating that she is having shortness of breath and can hear strange breath sounds when she inhales deeply. Upon auscultation of the lung fields, wheezes are noted. The nurse is most correct in stating that wheezes result from:
    1. Air passing through narrowed passages
    2. Air escaping through a pneumothorax
    3. Air collecting in the pleural cavity
    4. Air between visceral and parietal pleurae
2. The nurse is giving instructions to a client having pulmonary angiography. Which of the following statements is the best evidence that the client understands the nurse's instructions about what will take place during the diagnostic procedure?
    1. "I may have some minor discomfort at the site."
    2. "I may have bleeding or a hematoma following the procedure."
    3. "I will remain on bed rest for 2 to 6 hours following the procedure."
    4. "I will sense a warm, flushed feeling and an urge to cough."

connection

Visit the Connection site at **http://connection.lww.com/go/timbyEssentials** for links to chapter-related resources on the Internet.

References and Suggested Readings

Bullock, B. L., & Henze, R. L. (2000). *Focus on pathophysiology.* Philadelphia: Lippincott Williams & Wilkins.

Carpenito, L. J. (2000). *Nursing diagnosis: Application to clinical practice* (8th ed.). Philadelphia: Lippincott Williams & Wilkins.

Connolly, M. A. (2001). Chest x-ray: Completing the picture. *RN 64*(6), 56–62.

O'Hanlon-Nichols, T. (1998). Basic assessment series: The adult pulmonary system. *American Journal of Nursing, 98*(2), 39–45.

Smeltzer, S. C., & Bare, B. G. (2004). *Brunner & Suddarth's textbook of medical–surgical nursing* (10th ed.). Philadelphia: Lippincott Williams & Wilkins.