

# chapter 25

## Respiratory Care Modalities

### LEARNING OBJECTIVES

**On completion of this chapter, the learner will be able to:**

- 1 Describe the nursing management for patients receiving oxygen therapy, intermittent positive-pressure breathing, mini-nebulizer therapy, incentive spirometry, chest physiotherapy, and breathing retraining.
- 2 Describe the patient education and home care considerations for patients receiving oxygen therapy.
- 3 Describe the nursing care for a patient with an endotracheal tube and for a patient with a tracheostomy.
- 4 Demonstrate the procedure of tracheal suctioning.
- 5 Use the nursing process as a framework for care of patients who are mechanically ventilated.
- 6 Describe the process of weaning the patient from mechanical ventilation.
- 7 Describe the significance of preoperative nursing assessment and patient teaching for the patient who is going to have thoracic surgery.
- 8 Explain the principles of chest drainage and the nursing responsibilities related to the care of the patient with a chest drainage system.
- 9 Describe the patient education and home care considerations for patients who have had thoracic surgery.

### GLOSSARY

- airway pressure release ventilation (APRV):** mode of mechanical ventilation that allows unrestricted, spontaneous breaths throughout the ventilatory cycle; on inspiration patient receives preset level of continuous positive airway pressure, and pressure is periodically released to aid expiration
- assist-control ventilation (A/C):** mode of mechanical ventilation in which the patient's breathing pattern may trigger the ventilator to deliver a preset tidal volume; in the absence of spontaneous breathing, the machine delivers a controlled breath at a preset minimum rate and tidal volume
- chest drainage system:** use of a chest tube and closed drainage system to re-expand the lung and to remove excess air, fluid, and blood
- chest percussion:** manually cupping over the chest wall to mobilize secretions by mechanically dislodging viscous or adherent secretions in the lungs
- chest physiotherapy (CPT):** therapy used to remove bronchial secretions, improve ventilation, and increase the efficiency of the respiratory muscles; types include postural drainage, chest percussion, and vibration

### GLOSSARY (Continued)

- continuous positive airway pressure (CPAP):** positive pressure applied throughout the respiratory cycle to a spontaneously breathing patient to promote alveolar and airway stability; may be administered with endotracheal or tracheostomy tube or by mask
- controlled ventilation:** mode of mechanical ventilation in which the ventilator completely controls the patient's ventilation according to preset tidal volumes and respiratory rate; because of problems with synchrony, it is rarely used except in paralyzed or anesthetized patients
- endotracheal intubation:** insertion of a breathing tube through the nose or mouth into the trachea
- fraction of inspired oxygen (FiO<sub>2</sub>):** concentration of oxygen delivered (1.0 = 100% oxygen)
- hypoxemia:** decrease in arterial oxygen tension in the blood
- hypoxia:** decrease in oxygen supply to the tissues and cells
- incentive spirometry:** method of deep breathing that provides visual feedback to help the patient inhale deeply and slowly and achieve maximum lung inflation
- intermittent mandatory ventilation (IMV):** mode of mechanical ventilation that provides a combination of mechanically assisted breaths and spontaneous breaths
- mechanical ventilator:** a positive- or negative-pressure breathing device that supports ventilation and oxygenation
- pneumothorax:** partial or complete collapse of the lung due to positive pressure in the pleural space
- positive end-expiratory pressure (PEEP):** positive pressure maintained by the ventilator at the end of exhalation (instead of a normal zero pressure) to increase functional residual capacity and open collapsed alveoli; improves oxygenation with lower fraction of inspired oxygen
- postural drainage:** positioning the patient to allow drainage from all the lobes of the lungs and airways
- pressure support ventilation (PSV):** mode of mechanical ventilation in which preset positive pressure is delivered with spontaneous breaths to decrease work of breathing
- proportional assist ventilation (PAV):** mode of mechanical ventilation that provides partial ventilatory support in proportion to the patient's inspiratory efforts; decreases the work of breathing
- respiratory weaning:** process of gradual, systematic withdrawal or removal of ventilator, breathing tube, and oxygen
- synchronized intermittent mandatory ventilation (SIMV):** mode of mechanical ventilation in which the ventilator allows the patient to breathe spontaneously while providing a preset number of breaths to ensure adequate ventilation; ventilated breaths are synchronized with spontaneous breathing
- thoracotomy:** surgical opening into the chest cavity
- tracheostomy tube:** indwelling tube inserted directly into the trachea to assist with ventilation
- tracheotomy:** surgical opening into the trachea
- vibration:** a type of massage administered by quickly tapping the chest with the fingertips or alternating the fingers in a rhythmic manner, or by using a mechanical device to assist in mobilizing lung secretions

Numerous treatment modalities are used when caring for patients with various respiratory conditions. The choice of modality is based on the oxygenation disorder and whether there is a problem with gas ventilation, diffusion, or both. Therapies range from simple and noninvasive (oxygen and nebulizer therapy, chest physiotherapy, breathing retraining) to complex and highly invasive treatments (intubation, mechanical ventilation, surgery). Assessment and management of the patient with respiratory disorders are best accomplished when the approach is multidisciplinary and collaborative.

## NONINVASIVE RESPIRATORY THERAPIES

### Oxygen Therapy

Oxygen therapy is the administration of oxygen at a concentration greater than that found in the environmental atmosphere. At sea level, the concentration of oxygen in room air is 21%. The goal of oxygen therapy is to provide adequate transport of oxygen in the blood while decreasing the work of breathing and reducing stress on the myocardium.

Oxygen transport to tissues depends on factors such as cardiac output, arterial oxygen content, concentration of hemoglobin, and metabolic requirements. These factors must be kept in mind when oxygen therapy is considered. (Respiratory physiology and oxygen transport are discussed in Chapter 21.)

### Indications

A change in the patient's respiratory rate or pattern may be one of the earliest indicators of the need for oxygen therapy. These changes may result from hypoxemia or hypoxia. **Hypoxemia**, a decrease in the arterial oxygen tension in the blood, is manifested by changes in mental status (progressing through impaired judgment, agitation, disorientation, confusion, lethargy, and coma), dyspnea, increase in blood pressure, changes in heart rate, dysrhythmias, central cyanosis (late sign), diaphoresis, and cool extremities. Hypoxemia usually leads to **hypoxia**, a decrease in oxygen supply to the tissues, which can also be caused by problems outside the respiratory system. Severe hypoxia can be life-threatening.

The signs and symptoms signaling the need for oxygen may depend on how suddenly this need develops. With rapidly developing hypoxia, changes occur in the central nervous system because the higher neurologic centers are very sensitive to oxygen deprivation. The clinical picture may resemble that of alcohol intoxication, with the patient exhibiting lack of coordination and impaired judgment. With long-standing hypoxia (as seen in chronic obstructive pulmonary disease [COPD] and chronic heart failure), fatigue, drowsiness, apathy, inattentiveness, and delayed reaction time may occur. The need for oxygen is assessed by arterial blood gas analysis, pulse oximetry, and clinical evaluation. More information about hypoxia is presented in Chart 25-1.

### Complications

As with other medications, the nurse administers oxygen with caution and carefully assesses its effects on each patient. Oxygen is a medication, and except in emergency situations it is administered only when prescribed by a physician.

## Chart 25-1 • Types of Hypoxia

Hypoxia can occur from either severe pulmonary disease (inadequate oxygen supply) or from extrapulmonary disease (inadequate oxygen delivery) affecting gas exchange at the cellular level. The four general types of hypoxia are hypoxemic hypoxia, circulatory hypoxia, anemic hypoxia, and histotoxic hypoxia.

### Hypoxemic Hypoxia

Hypoxemic hypoxia is a decreased oxygen level in the blood resulting in decreased oxygen diffusion into the tissues. It may be caused by hypoventilation, high altitudes, ventilation-perfusion mismatch (as in pulmonary embolism), shunts in which the alveoli are collapsed and cannot provide oxygen to the blood (commonly caused by atelectasis), and pulmonary diffusion defects. It is corrected by increasing alveolar ventilation or providing supplemental oxygen.

### Circulatory Hypoxia

Circulatory hypoxia is hypoxia resulting from inadequate capillary circulation. It may be caused by decreased cardiac output, local vascular obstruction, low-flow states such as shock, or cardiac arrest. Although tissue partial pressure of oxygen ( $PO_2$ ) is reduced, arterial oxygen ( $PaO_2$ ) remains normal. Circulatory hypoxia is corrected by identifying and treating the underlying cause.

### Anemic Hypoxia

Anemic hypoxia is a result of decreased effective hemoglobin concentration, which causes a decrease in the oxygen-carrying capacity of the blood. It is rarely accompanied by hypoxemia. Carbon monoxide poisoning, because it reduces the oxygen-carrying capacity of hemoglobin, produces similar effects but is not strictly anemic hypoxia because hemoglobin levels may be normal.

### Histotoxic Hypoxia

Histotoxic hypoxia occurs when a toxic substance, such as cyanide, interferes with the ability of tissues to use available oxygen.

In general, patients with respiratory conditions are given oxygen therapy only to increase the arterial oxygen pressure ( $PaO_2$ ) back to the patient's normal baseline, which may vary from 60 to 95 mm Hg. In terms of the oxyhemoglobin dissociation curve (see Chapter 21), the blood at these levels is 80% to 98% saturated with oxygen; higher **fraction of inspired oxygen ( $FiO_2$ )** flow values add no further significant amounts of oxygen to the red blood cells or plasma. Instead of helping, increased amounts of oxygen may produce toxic effects on the lungs and central nervous system or may depress ventilation (see later discussion).

It is important to observe for subtle indicators of inadequate oxygenation when oxygen is administered by any method. Therefore, the nurse assesses the patient frequently for confusion, restlessness progressing to lethargy, diaphoresis, pallor, tachycardia, tachypnea, and hypertension. Intermittent or continuous pulse oximetry is used to monitor oxygen levels.

### Oxygen Toxicity

Oxygen toxicity may occur when too high a concentration of oxygen (greater than 50%) is administered for an extended period (longer than 48 hours). It is caused by overproduction

of oxygen free radicals, which are by-products of cell metabolism.

If oxygen toxicity is untreated, these radicals can severely damage or kill cells. Antioxidants such as vitamin E, vitamin C, and beta-carotene may help defend against oxygen free radicals. The dietitian can adjust the patient's diet so that it is rich in antioxidants; supplements are also available for patients who have a decreased appetite or who are unable to eat.

Signs and symptoms of oxygen toxicity include substernal discomfort, paresthesias, dyspnea, restlessness, fatigue, malaise, progressive respiratory difficulty, refractory hypoxemia, alveolar atelectasis, and alveolar infiltrates evident on chest x-rays.

Prevention of oxygen toxicity is achieved by using oxygen only as prescribed. If high concentrations of oxygen are necessary, it is important to minimize the duration of administration and reduce its concentration as soon as possible. Often, **positive end-expiratory pressure (PEEP)** or **continuous positive airway pressure (CPAP)** is used with oxygen therapy to reverse or prevent microatelectasis, thus allowing a lower percentage of oxygen to be used. The level of PEEP that allows the best oxygenation without hemodynamic compromise is known as "best PEEP."

**Suppression of Ventilation**

In many patients with COPD, the stimulus for respiration is a decrease in blood oxygen rather than an elevation in carbon dioxide levels. The administration of a high concentration of oxygen removes the respiratory drive that has been created largely by the patient's chronic low oxygen tension. The resulting decrease in alveolar ventilation can cause a progressive increase in arterial carbon dioxide pressure (PaCO<sub>2</sub>). This hypoventilation can, in rare cases, lead to acute respiratory failure secondary to carbon dioxide narcosis,

acidosis, and death. Oxygen-induced hypoventilation is prevented by administering oxygen at low flow rates (1 to 2 L/min) and by closely monitoring the respiratory rate and the oxygen saturation as measured by pulse oximetry (SpO<sub>2</sub>).

**Other Complications**

Because oxygen supports combustion, there is always a danger of fire when it is used. It is important to post "No Smoking" signs when oxygen is in use. Oxygen therapy equipment is also a potential source of bacterial cross-infection; therefore, the nurse (or respiratory therapist) changes the tubing according to infection control policy and the type of oxygen delivery equipment.



**Methods of Oxygen Administration**

Oxygen is dispensed from a cylinder or a piped-in system. A reduction gauge is necessary to reduce the pressure to a working level, and a flow meter regulates the flow of oxygen in liters per minute. When oxygen is used at high flow rates, it should be moistened by passing it through a humidification system to prevent it from drying the mucous membranes of the respiratory tract.

The use of oxygen concentrators is another means of providing varying amounts of oxygen, especially in the home setting. These devices are relatively portable, easy to operate, and cost-effective. However, they require more maintenance than tank or liquid systems and probably cannot deliver oxygen flows in excess of 4 L/min, which provides an FiO<sub>2</sub> of about 36%.

Many different oxygen devices are used, and all deliver oxygen if they are used as prescribed and maintained correctly (Table 25-1). The amount of oxygen delivered is expressed as

**Table 25-1 OXYGEN ADMINISTRATION DEVICES**

Device	Suggested Flow Rate (L/min)	O <sub>2</sub> Percentage Setting	Advantages	Disadvantages
<b>Low-Flow Systems</b>				
Cannula	1-2	23-30	Lightweight, comfortable, inexpensive, continuous use with meals and activity	Nasal mucosal drying, variable FiO <sub>2</sub>
	3-5	30-40		
	6	42		
Oropharyngeal catheter	1-6	23-42	Inexpensive, does not require a tracheostomy	Nasal mucosa irritation; catheter should be changed frequently to alternate nostril
Mask, simple	6-8	40-60	Simple to use, inexpensive	Poor fitting, variable FiO <sub>2</sub> , must remove to eat
Mask, partial rebreather	8-11	50-75	Moderate O <sub>2</sub> concentration	Warm, poorly fitting, must remove to eat
Mask, non-rebreather	12	80-100	High O <sub>2</sub> concentration	Poorly fitting, must remove to eat
<b>High-Flow Systems</b>				
Transtracheal catheter	¼-4	60-100	More comfortable, concealed by clothing, less oxygen liters per minute needed than nasal cannula	Requires frequent and regular cleaning, requires surgical intervention
Mask, Venturi	4-6	24, 26, 28	Provides low levels of supplemental O <sub>2</sub>	Must remove to eat
	6-8	30, 35, 40	Precise FiO <sub>2</sub> , additional humidity available	
Mask, aerosol	8-10	30-100	Good humidity, accurate FiO <sub>2</sub>	Uncomfortable for some
Tracheostomy collar	8-10	30-100	Good humidity, comfortable, fairly accurate FiO <sub>2</sub>	
T-piece	8-10	30-100	Same as tracheostomy collar	Heavy with tubing
Face tent	8-10	30-100	Good humidity, fairly accurate FiO <sub>2</sub>	Bulky and cumbersome
<b>Oxygen Conserving Devices</b>				
Pulse dose (or demand)	10-40 mL/breath		Deliver O <sub>2</sub> only on inspiration, conserve 50% to 75% of O <sub>2</sub> used	Must carefully evaluate function individually

a percentage concentration (eg, 70%). The appropriate form of oxygen therapy is best determined by arterial blood gas levels, which indicate the patient's oxygenation status.

Oxygen delivery systems are classified as low-flow or high-flow delivery systems. Low-flow systems contribute partially to the inspired gas the patient breathes, which means that the patient breathes some room air along with the oxygen. These systems do not provide a constant or known concentration of inspired oxygen. The amount of inspired oxygen changes as the patient's breathing changes. Examples of low-flow systems include nasal cannula, oropharyngeal catheter, simple mask, partial-rebreather, and non-rebreather masks. In contrast, high-flow systems provide the total inspired air. A specific percentage of oxygen is delivered independent of the patient's breathing. High-flow systems are indicated for patients who require a constant and precise amount of oxygen. Examples of such systems include transtracheal catheters, Venturi masks, aerosol masks, tracheostomy collars, T-pieces, and face tents.

A nasal cannula is used when the patient requires a low to medium concentration of oxygen for which precise accuracy is not essential. This method is relatively simple and allows the patient to move about in bed, talk, cough, and eat without interrupting oxygen flow. Flow rates in excess of 6 to 8 L/min may lead to swallowing of air or may cause irritation and drying of the nasal and pharyngeal mucosa.

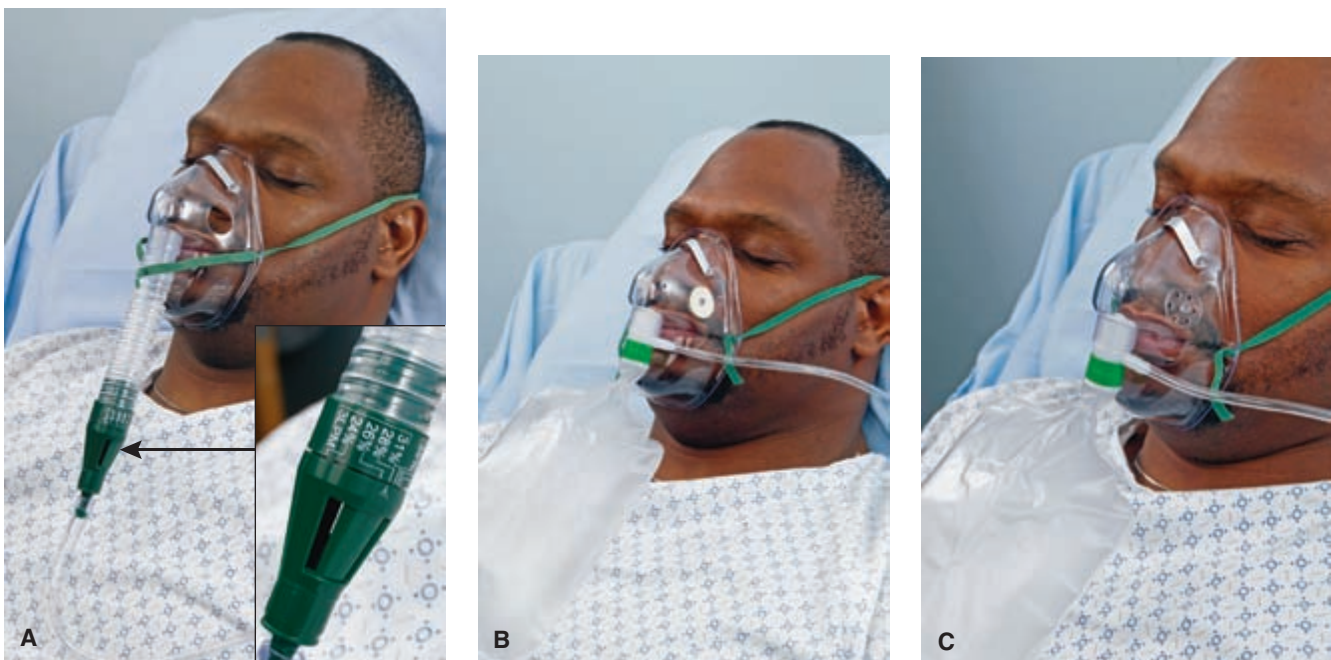
The oropharyngeal catheter is rarely used but may be prescribed for short-term therapy to administer low to moderate concentrations of oxygen. The catheter should be changed every 8 hours, alternating nostrils to prevent nasal irritation and infection.

When oxygen is administered via cannula or catheter, the percentage of oxygen reaching the lungs varies with

the depth and rate of respirations, particularly if the nasal mucosa is swollen or if the patient is a mouth breather.

Oxygen masks come in several forms. Each is used for different purposes (Fig. 25-1). *Simple masks* are used to administer low to moderate concentrations of oxygen. The body of the mask itself gathers and stores oxygen between breaths. The patient exhales directly through openings or ports in the body of the mask. If oxygen flow ceases, the patient can draw air in through these openings around the mask edges. Although widely used, these masks cannot be used for controlled oxygen concentrations and must be adjusted for proper fit. They should not press too tightly against the skin because this can cause a sense of claustrophobia as well as skin breakdown; adjustable elastic bands are provided to ensure comfort and security.

*Partial-rebreathing masks* have a reservoir bag that must remain inflated during both inspiration and expiration. The nurse adjusts the oxygen flow to ensure that the bag does not collapse during inhalation. A high concentration of oxygen can be delivered because both the mask and the bag serve as reservoirs for oxygen. Oxygen enters the mask through small-bore tubing that connects at the junction of the mask and bag. As the patient inhales, gas is drawn from the mask, from the bag, and potentially from room air through the exhalation ports. As the patient exhales, the first third of the exhalation fills the reservoir bag. This is mainly dead space and does not participate in gas exchange in the lungs. Therefore, it has a high oxygen concentration. The remainder of the exhaled gas is vented through the exhalation ports. The actual percentage of oxygen delivered is influenced by the patient's ventilatory pattern (Kacmarek, Dimas & Mack, 2005).



**Figure 25-1** Types of oxygen masks used to deliver varying concentrations of oxygen. **A**, Venturi mask. **B**, Non-rebreathing mask. **C**, Partial-rebreathing mask.

*Non-rebreathing masks* are similar in design to partial-rebreathing masks except that they have additional valves. A one-way valve located between the reservoir bag and the base of the mask allows gas from the reservoir bag to enter the mask on inhalation but prevents gas in the mask from flowing back into the reservoir bag during exhalation. One-way valves located at the exhalation ports prevent room air from entering the mask during inhalation. They also allow the patient's exhaled gases to exit the mask on exhalation. As with the partial-rebreathing mask, it is important to adjust the oxygen flow so that the reservoir bag does not completely collapse on inspiration. In theory, if the non-rebreathing mask fits the patient snugly and both side exhalation ports have one-way valves, it is possible for the patient to receive 100% oxygen, making the non-rebreathing mask a high-flow oxygen system. However, because it is difficult to get an exact fit from the mask on every patient, and some non-rebreathing masks have only one one-way exhalation valve, it is almost impossible to ensure 100% oxygen delivery, making it a low-flow oxygen system.

The *Venturi mask* is the most reliable and accurate method for delivering precise concentrations of oxygen through non-invasive means. The mask is constructed in a way that allows a constant flow of room air blended with a fixed flow of oxygen. It is used primarily for patients with COPD because it can accurately provide appropriate levels of supplemental oxygen, thus avoiding the risk of suppressing the hypoxic drive.

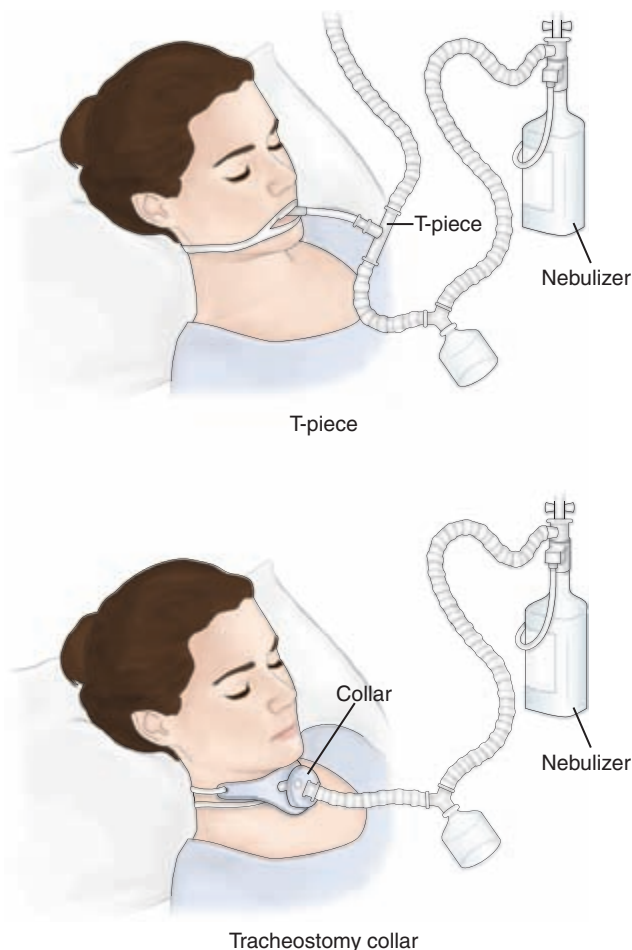
The Venturi mask uses the Bernoulli principle of air entrainment (trapping the air like a vacuum), which provides a high airflow with controlled oxygen enrichment. For each liter of oxygen that passes through a jet orifice, a fixed proportion of room air is entrained. A precise volume of oxygen can be delivered by varying the size of the jet orifice and adjusting the flow of oxygen. Excess gas leaves the mask through the two exhalation ports, carrying with it the exhaled carbon dioxide. This method allows a constant oxygen concentration to be inhaled regardless of the depth or rate of respiration.

The mask should fit snugly enough to prevent oxygen from flowing into the patient's eyes. The nurse checks the patient's skin for irritation. It is necessary to remove the mask so that the patient can eat, drink, and take medications, at which time supplemental oxygen is provided through a nasal cannula.

The *transtracheal oxygen catheter* is inserted directly into the trachea and is indicated for patients with chronic oxygen therapy needs. These catheters are more comfortable, less dependent on breathing patterns, and less obvious than other oxygen delivery methods. Because no oxygen is lost into the surrounding environment, the patient achieves adequate oxygenation at lower rates, making this method less expensive and more efficient.

The *T-piece* connects to the endotracheal tube and is useful in weaning patients from mechanical ventilation (Fig. 25-2).

Other oxygen devices include *aerosol masks*, *tracheostomy collars*, and *face tents*, all of which are used with aerosol devices (nebulizers) that can be adjusted for oxygen concentrations from 27% to 100% (0.27 to 1.00). If the gas mixture flow falls below patient demand, room air is pulled in, diluting the concentration. The aerosol mist must be available for the patient during the entire inspiratory phase.



**Figure 25-2** T-pieces and tracheostomy collars are devices used when weaning patients from mechanical ventilation.

Although most oxygen therapy is administered as continuous flow oxygen, new methods of oxygen conservation are coming into use. The *demand oxygen delivery system* (DODS) interrupts the flow of oxygen during exhalation, when it is otherwise mostly wasted. Several versions of the DODS are being evaluated for their effectiveness. Studies show that DODS models conserve oxygen and maintain oxygen saturation better than continuous-flow oxygen systems when the respiratory rate increases (Langenhof & Fichter, 2005).

Hyperbaric oxygen therapy is the administration of oxygen at pressures greater than 1 atm. As a result, the amount of oxygen dissolved in plasma is increased, which increases oxygen levels in the tissues. During therapy, the patient is placed in a small (single patient use) or large (multiple patient use) cylinder chamber. Hyperbaric oxygen therapy is used to treat conditions such as air embolism, carbon monoxide poisoning, gangrene, tissue necrosis, and hemorrhage. Although controversial, hyperbaric oxygen has also been used to treat multiple sclerosis, diabetic foot ulcers (Londahl, Katzman, Nilsson, et al., 2006; McMillan, Glover, McMillan, et al., 2007), closed head trauma, acute myocardial infarction, and unstable angina (Bennett, Jepson & Lehm, 2005), as well as slow-to-heal bone fractures (Bennett, Stanford & Turner, 2005). Potential side effects include ear trauma, central nervous system disorders, oxygen toxicity, and claustrophobia.



## Gerontologic Considerations

The respiratory system changes throughout the aging process, and it is important for nurses to be aware of these changes when assessing patients who are receiving oxygen therapy. As the respiratory muscles weaken and the large bronchi and alveoli become enlarged, the available surface area of the lungs decreases, resulting in reduced ventilation and respiratory gas exchange. The number of functional cilia is also reduced, decreasing ciliary action and the cough reflex. As a result of osteoporosis and calcification of the costal cartilages, chest wall compliance is decreased. Patients may display increased chest rigidity and respiratory rate and decreased PaO<sub>2</sub> and lung expansion. Nurses should be aware that the older adult is at risk for aspiration and infection related to these changes. In addition, patient education regarding adequate nutrition is essential because appropriate dietary intake can help diminish the excess buildup of carbon dioxide and maintain optimal respiratory functioning.

## Nursing Management

### Promoting Home and Community-Based Care

#### Teaching Patients Self-Care

At times oxygen must be administered to the patient at home. The nurse instructs the patient or family in the methods for administering oxygen safely and informs the patient and family that oxygen is available in gas, liquid, and concentrated forms. The gas and liquid forms come in portable devices so that the patient can leave home while receiving oxygen therapy. Humidity must be provided while

oxygen is used (except with portable devices) to counteract the dry, irritating effects of compressed oxygen on the airway (Chart 25-2).

#### Continuing Care

Home visits by a home health nurse or respiratory therapist may be arranged based on the patient's status and needs. It is important to assess the patient's home environment, the patient's physical and psychological status, and the need for further teaching. The nurse reinforces the teaching points on how to use oxygen safely and effectively, including fire safety tips. To maintain a consistent quality of care and to maximize the patient's financial reimbursement for home oxygen therapy, the nurse ensures that the physician's prescription includes the diagnosis, the prescribed oxygen flow, and conditions for use (eg, continuous use, nighttime use only). Because oxygen is a medication, the nurse reminds the patient receiving long-term oxygen therapy and the family about the importance of keeping follow-up appointments with the physician. The patient is instructed to see the physician every 6 months or more often, if indicated. Arterial blood gas measurements and laboratory tests are repeated annually or more often if the patient's condition changes.

### Incentive Spirometry (Sustained Maximal Inspiration)

**Incentive spirometry** is a method of deep breathing that provides visual feedback to encourage the patient to inhale slowly and deeply to maximize lung inflation and prevent or

CHART  
25-2

### HOME CARE CHECKLIST Oxygen Therapy

At the completion of the home care instruction, the patient or caregiver will be able to:	PATIENT	CAREGIVER
<ul style="list-style-type: none"> <li>State proper care of and administration of oxygen to patient               <ul style="list-style-type: none"> <li>State physician's prescription for oxygen and the manner in which it is to be used</li> <li>Indicate when a humidifier should be used</li> <li>Identify signs and symptoms indicating the need for change in oxygen therapy</li> <li>Describe precautions and safety measures to be used when oxygen is in use</li> <li>Know <b>NOT</b> to smoke while using oxygen</li> <li>Post "No smoking—oxygen in use" signs on doors</li> <li>Notify local fire department and electric company of oxygen use in home</li> <li>Keep oxygen tank at least 15 feet away from matches, candles, gas stove, or other source of flame</li> <li>Keep oxygen tank 5 feet away from TV, radio, and other appliances</li> <li>Keep oxygen tank out of direct sunlight</li> <li>When traveling in automobile, place oxygen tank on floor behind front seat</li> <li>If traveling by airplane, notify air carrier of need for oxygen at least 2 weeks in advance</li> <li>State how and when to place an order for more oxygen</li> <li>Describe a diet that meets energy demands</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>
<ul style="list-style-type: none"> <li>Maintain equipment properly               <ul style="list-style-type: none"> <li>Demonstrate correct adjustment of prescribed flow rate</li> <li>Describe how to clean and when to replace oxygen tubing</li> <li>Identify when a portable oxygen delivery device should be used</li> <li>Demonstrate safe and appropriate use of portable oxygen delivery device</li> <li>Identify causes of malfunction of equipment and when to call for replacement of equipment</li> <li>Describe the importance of determining that all electrical outlets are working properly</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>

reduce atelectasis. The purpose of an incentive spirometer is to ensure that the volume of air inhaled is increased gradually as the patient takes deeper and deeper breaths.

Incentive spirometers are available in two types: volume or flow. In the volume type, the tidal volume is set using the manufacturer's instructions. The patient takes a deep breath through the mouthpiece, pauses at peak lung inflation, and then relaxes and exhales. Taking several normal breaths before attempting another with the incentive spirometer helps avoid fatigue. The volume is periodically increased as tolerated.

In the flow type, the volume is not preset. The spirometer contains a number of movable balls that are pushed up by the force of the breath and held suspended in the air while the patient inhales. The amount of air inhaled and the flow of the air are estimated by how long and how high the balls are suspended.

## Indications

Incentive spirometry is used after surgery, especially thoracic and abdominal surgery, to promote the expansion of the alveoli and to prevent or treat atelectasis.

## Nursing Management

Nursing management of the patient using incentive spirometry includes placing the patient in the proper position, teaching the technique for using the incentive spirometer, setting realistic goals for the patient, and recording the results of the therapy (Chart 25-3). Ideally, the patient assumes a sitting or semi-Fowler's position to enhance diaphragmatic excursion; however, this procedure may be performed with the patient in any position.

## Mini-Nebulizer Therapy

The mini-nebulizer is a handheld apparatus that disperses a moisturizing agent or medication, such as a bronchodilator or mucolytic agent, into microscopic particles and delivers it to the lungs as the patient inhales. The mini-nebulizer is usually air driven by means of a compressor through connecting tubing. In some instances, the nebulizer is oxygen

driven rather than air driven. To be effective, a visible mist must be available for the patient to inhale.

## Indications

The indications for use of a mini-nebulizer include difficulty in clearing respiratory secretions, reduced vital capacity with ineffective deep breathing and coughing, and unsuccessful trials of simpler and less costly methods for clearing secretions, delivering aerosol, or expanding the lungs. The patient must be able to generate a deep breath. Diaphragmatic breathing (Chart 25-4) is a helpful technique to prepare for proper use of the mini-nebulizer. Mini-nebulizers are frequently used for

### CHART 25-4 PATIENT EDUCATION Breathing Exercises

#### General Instructions

- Breathe slowly and rhythmically to exhale completely and empty the lungs completely.
- Inhale through the nose to filter, humidify, and warm the air before it enters the lungs.
- If you feel out of breath, breathe more slowly by prolonging the exhalation time.
- Keep the air moist with a humidifier.

#### Diaphragmatic Breathing

Goal: To use and strengthen the diaphragm during breathing

- Place one hand on the abdomen (just below the ribs) and the other hand on the middle of the chest to increase the awareness of the position of the diaphragm and its function in breathing.
- Breathe in slowly and deeply through the nose, letting the abdomen protrude as far as possible.
- Breathe out through pursed lips while tightening (contracting) the abdominal muscles.
- Press firmly inward and upward on the abdomen while breathing out.
- Repeat for 1 minute; follow with a rest period of 2 minutes.
- Gradually increase duration up to 5 minutes, several times a day (before meals and at bedtime).

#### Pursed-Lip Breathing

Goal: To prolong exhalation and increase airway pressure during expiration, thus reducing the amount of trapped air and the amount of airway resistance.

- Inhale through the nose while slowly counting to 3—the amount of time needed to say "Smell a rose."
- Exhale slowly and evenly against pursed lips while tightening the abdominal muscles. (Pursing the lips increases intratracheal pressure; exhaling through the mouth offers less resistance to expired air.)
- Count to 7 slowly while prolonging expiration through pursed lips—the length of time to say "Blow out the candle."
- While sitting in a chair:  
Fold arms over the abdomen.  
Inhale through the nose while counting to 3 slowly.  
Bend forward and exhale slowly through pursed lips while counting to 7 slowly.
- While walking:  
Inhale while walking two steps.  
Exhale through pursed lips while walking four or five steps.

### CHART 25-3 PATIENT EDUCATION Performing Incentive Spirometry

- The inspired air helps inflate the lungs. The ball or weight in the spirometer rises in response to the intensity of the intake of air. The higher the ball rises, the deeper the breath.
- Assume a semi-Fowler's position or an upright position before initiating therapy.
- Use diaphragmatic breathing.
- Place the mouthpiece of the spirometer firmly in the mouth, breathe air in (inspire) through the mouth, and hold the breath at the end of inspiration for about 3 seconds. Exhale slowly through the mouthpiece.
- Coughing during and after each session is encouraged. Splint the incision when coughing postoperatively.
- Perform the procedure approximately 10 times in succession, repeating the 10 breaths with the spirometer each hour during waking hours.

patients with COPD to dispense inhaled medications, and they are commonly used at home on a long-term basis.

### Nursing Management

The nurse instructs the patient to breathe through the mouth, taking slow, deep breaths, and then to hold the breath for a few seconds at the end of inspiration to increase intrapleural pressure and reopen collapsed alveoli, thereby increasing functional residual capacity. The nurse encourages the patient to cough and to monitor the effectiveness of the therapy. The nurse instructs the patient and family about the purpose of the treatment, equipment setup, medication additive, and proper cleaning and storage of the equipment.

### Intermittent Positive-Pressure Breathing

Intermittent positive-pressure breathing (IPPB) is an older form of assisted or controlled respiration in which compressed gas is delivered under positive pressure into a person's airways until a preset pressure is reached. Passive exhalation is allowed through a valve. It is infrequently used today.

### Chest Physiotherapy

Chest physiotherapy (CPT) includes **postural drainage**, **chest percussion**, and **vibration**, and breathing retraining. In addition, teaching the patient effective coughing technique is an important part of CPT. The goals of CPT are to remove bronchial secretions, improve ventilation, and increase the efficiency of the respiratory muscles.

### Postural Drainage (Segmented Bronchial Drainage)

Postural drainage allows the force of gravity to assist in the removal of bronchial secretions. The secretions drain from the affected bronchioles into the bronchi and trachea and are removed by coughing or suctioning. Postural drainage is used to prevent or relieve bronchial obstruction caused by accumulation of secretions.

Because the patient usually sits in an upright position, secretions are likely to accumulate in the lower parts of the lungs. Several other positions (Fig. 25-3) are used so that the force of gravity helps move secretions from the smaller bronchial airways to the main bronchi and trachea. Each position contributes to effective drainage of a different lobe of the lungs; lower and middle lobe bronchi drain more effectively when the head is down, while the upper lobe bronchi drain more effectively when the head is up. The secretions then are removed by coughing. The nurse instructs the patient to inhale bronchodilators and mucolytic agents, if prescribed, before postural drainage, because these medications improve drainage of the bronchial tree.

### Nursing Management

The nurse should be aware of the patient's diagnosis as well as the lung lobes or segments involved, the cardiac status, and any structural deformities of the chest wall and spine. Auscultating the chest before and after the procedure is used to iden-

tify the areas that need drainage and assess the effectiveness of treatment. The nurse teaches family members who will assist the patient at home to evaluate breath sounds before and after treatment. The nurse explores strategies that will enable the patient to assume the indicated positions at home. This may require the creative use of objects readily available at home, such as pillows, cushions, or cardboard boxes.

Postural drainage is usually performed two to four times daily, before meals (to prevent nausea, vomiting, and aspiration) and at bedtime. Prescribed bronchodilators, water, or saline may be nebulized and inhaled before postural drainage to dilate the bronchioles, reduce bronchospasm, decrease the thickness of mucus and sputum, and combat edema of the bronchial walls. The recommended sequence starts with positions to drain the lower lobes, followed by positions to drain the upper lobes.

The nurse makes the patient as comfortable as possible in each position and provides an emesis basin, sputum cup, and paper tissues. The nurse instructs the patient to remain in each position for 10 to 15 minutes and to breathe in slowly through the nose and out slowly through pursed lips to help keep the airways open so that secretions can drain while in each position. If a position cannot be tolerated, the nurse helps the patient assume a modified position. When the patient changes position, the nurse explains how to cough and remove secretions (Chart 25-5).

If the patient cannot cough, the nurse may need to suction the secretions mechanically. It also may be necessary to use chest percussion and vibration or a high-frequency chest wall oscillation (HFCWO) vest to loosen bronchial secretions and mucus plugs that adhere to the bronchioles and bronchi and to propel sputum in the direction of gravity drainage (see later discussion). If suctioning is required at home, the nurse instructs caregivers in safe suctioning technique and care of the suctioning equipment.

After the procedure, the nurse notes the amount, color, viscosity, and character of the expelled sputum. It is important to evaluate the patient's skin color and pulse the first few times the procedure is performed. It may be necessary to administer oxygen during postural drainage.

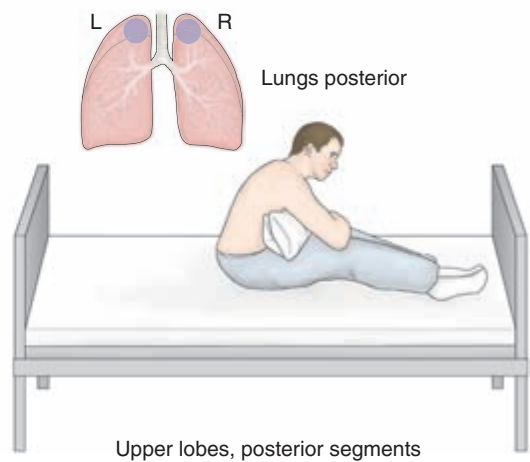
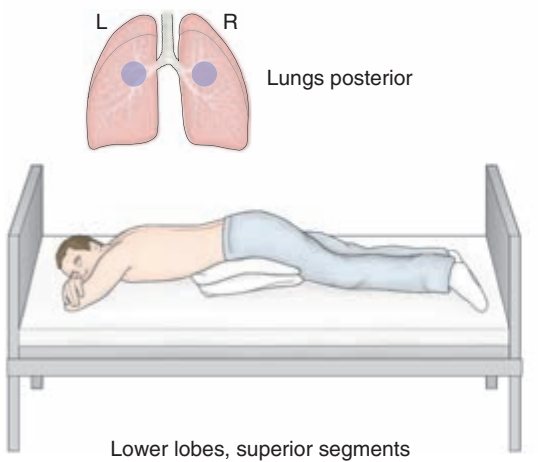
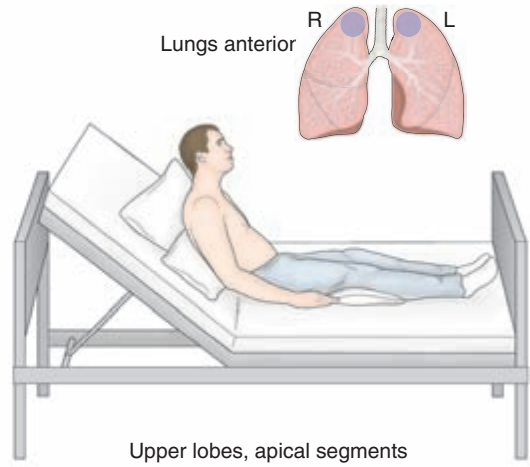
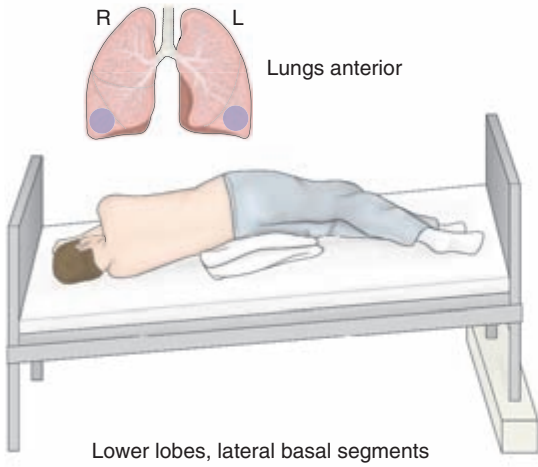
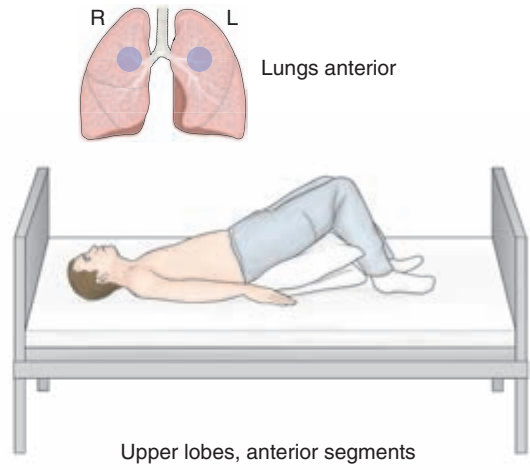
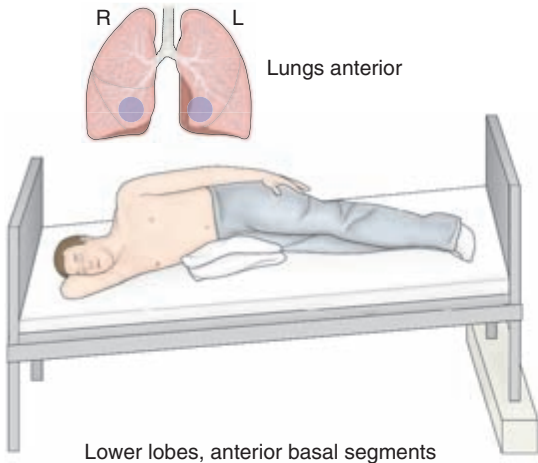
If the sputum is foul-smelling, it is important to perform postural drainage in a room away from other patients or family members. (Deodorizers may be used to counter-

CHART  
25-5

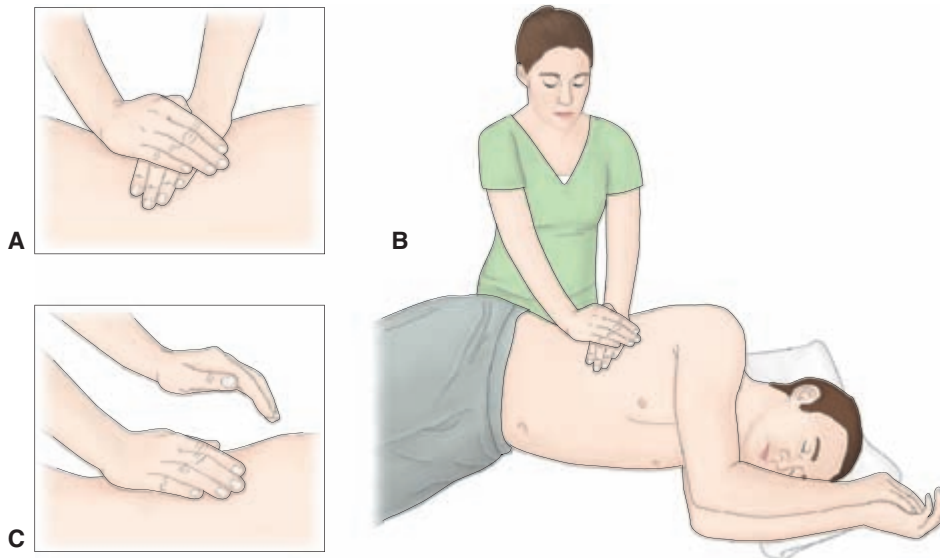


### PATIENT EDUCATION Effective Coughing Technique

- Assume a sitting position and bend slightly forward. This upright position permits a stronger cough.
- Flex your knees and hips to promote relaxation and reduce the strain on the abdominal muscles while coughing.
- Inhale slowly through the nose and exhale through pursed lips several times.
- Cough twice during each exhalation while contracting (pulling in) the abdomen sharply with each cough.
- Splint the incisional area, if any, with firm hand pressure or support it with a pillow or rolled blanket while coughing (see Fig. 25-12). (The nurse can initially demonstrate this by using the patient's hands.)



**Figure 25-3** Postural drainage positions and the areas of lung drained by each position.



**Figure 25-4** Percussion and vibration. **A**, Proper hand position for vibration. **B**, Proper technique for vibration. The wrists and elbows remain stiff; the vibrating motion is produced by the shoulder muscles. **C**, Proper hand position for percussion.

act the odor. Because aerosol sprays can cause bronchospasm and irritation, they should be used sparingly and with caution.) After the procedure, the patient may find it refreshing to brush the teeth and use a mouthwash before resting.

### Chest Percussion and Vibration

Thick secretions that are difficult to cough up may be loosened by tapping (percussing) and vibrating the chest or through use of an HFCWO vest. Chest percussion and vibration help dislodge mucus adhering to the bronchioles and bronchi. A scheduled program of coughing and clearing sputum, together with hydration, reduces the amount of sputum in most patients.

Percussion is carried out by cupping the hands and lightly striking the chest wall in a rhythmic fashion over the lung segment to be drained. The wrists are alternately flexed and extended so that the chest is cupped or clapped in a painless manner (Fig. 25-4). A soft cloth or towel may be placed over the segment of the chest that is being cupped to prevent skin irritation and redness from direct contact. Percussion, alternating with vibration, is performed for 3 to 5 minutes for each position. The patient uses diaphragmatic breathing during this procedure to promote relaxation (see later discussion). As a precaution, percussion over chest drainage tubes, the sternum, spine, liver, kidneys, spleen, or breasts (in women) is avoided. Percussion is performed cautiously in the elderly because of their increased incidence of osteoporosis and risk of rib fracture.

Vibration is the technique of applying manual compression and tremor to the chest wall during the exhalation phase of respiration (see Fig. 25-4). This helps increase the velocity of the air expired from the small airways, thus freeing the mucus. After three or four vibrations, the patient is encouraged to cough, contracting the abdominal muscles to increase the effectiveness of the cough.

The number of times the percussion and coughing cycle is repeated depends on the patient's tolerance and clinical

response. It is important to evaluate breath sounds before and after the procedures.

An inflatable HFCWO vest (Fig. 25-5) may be used to provide chest therapy. The vest uses air pulses to compress the chest wall 8 to 18 times/sec, causing secretions to detach from the airway wall and enabling the patient to expel them by coughing. Vest therapy is considered more effective than manual percussion because it is gentler and acts on all lobes of the lung simultaneously. Research has shown that the vest is equally effective to manual CPT, and some patients prefer it (Main, Prasad & van der Schans, 2005).

To increase the effectiveness of coughing, a flutter valve is sometimes used, especially by people who have cystic fibrosis. The flutter valve looks like a pipe but has a cap covering the bowl, which contains a steel ball. When the patient exhales actively into the valve, movement of the ball causes pressure oscillations, thereby decreasing mucus viscosity, allowing it to move within the airways and be coughed out.



**Figure 25-5** High-frequency chest wall oscillation vest. © 2005 Hill-Rom Services, Inc. Reprinted with permission—all rights reserved.

### Nursing Management

When performing CPT, the nurse ensures that the patient is comfortable, is not wearing restrictive clothing, and has not just eaten. The nurse gives medication for pain, as prescribed, before percussion and vibration and splints any incision and provides pillows for support as needed. The positions are varied, but focus is placed on the affected areas. On completion of the treatment, the nurse assists the patient to assume a comfortable position.

If an HFCWO vest is being used, the patient may assume whatever position is most comfortable and may even continue to perform light activity during therapy within the length of the compressed air hose. It is not necessary for the patient to assume specific positions for the vest to be effective.

The nurse must stop treatment if any of the following occur: increased pain, increased shortness of breath, weakness, lightheadedness, or hemoptysis. Therapy is indicated until the patient has normal respirations, can mobilize secretions, and has normal breath sounds, and until the chest x-ray findings are normal.

### Promoting Home and Community-Based Care

**Teaching Patients Self-Care.** CPT is frequently indicated at home for patients with COPD, bronchiectasis, or cystic fibrosis. The techniques are the same as described previously, but gravity drainage is achieved by placing the hips over a box, a stack of magazines, or pillows (unless a hospital bed is available). The nurse instructs the patient and family in the positions and techniques of percussion and vibration so that therapy can be continued in the home. In addition, the nurse instructs the patient to maintain an adequate fluid intake and air humidity to prevent secretions from becoming thick and tenacious. It also is important to teach the patient to recognize early signs of infection, such as fever and a change in the color or character of sputum. Resting 5 to 10 minutes in each postural drainage position before CPT maximizes the amount of secretions obtained.

**Continuing Care.** CPT may be carried out during visits by a home care nurse. The nurse also assesses the patient's physical status, understanding of the treatment plan, compliance with recommended therapy, and the effectiveness of therapy. It is important to reinforce patient and family teaching during these visits. The nurse reports to the patient's physician any deterioration in the patient's physical status or inability to clear secretions.

### Breathing Retraining

Breathing retraining consists of exercises and breathing practices that are designed to achieve more efficient and controlled ventilation and to decrease the work of breathing. Breathing retraining is especially indicated in patients with COPD and dyspnea. These exercises promote maximal alveolar inflation and muscle relaxation; relieve anxiety; eliminate ineffective, uncoordinated patterns of respiratory muscle activity; slow the respiratory rate; and decrease the work of breathing. Slow, relaxed, rhythmic breathing also helps to control the anxiety that occurs with dyspnea. Specific breathing exercises include diaphragmatic and pursed-lip breathing (see Chart 25-4).

Diaphragmatic breathing can become automatic with sufficient practice and concentration. Pursed-lip breathing,

which improves oxygen transport, helps induce a slow, deep breathing pattern and assists the patient to control breathing, even during periods of stress. This type of breathing helps prevent airway collapse secondary to loss of lung elasticity in emphysema. The nurse instructs the patient in diaphragmatic breathing and pursed-lip breathing, as described in Chart 25-4. Breathing exercises should be practiced in several positions because air distribution and pulmonary circulation vary with the position of the chest.

Many patients require additional oxygen, using a low-flow method, while performing breathing exercises. Emphysema-like changes in the lung occur as part of the natural aging process of the lung; therefore, breathing exercises are appropriate for all elderly patients, whether hospitalized or not, who are sedentary, even without primary lung disease.

### Nursing Management

The nurse instructs the patient to breathe slowly and rhythmically in a relaxed manner and to exhale completely to empty the lungs. The patient is instructed to always inhale through the nose because this filters, humidifies, and warms the air. If short of breath, the patient should be instructed to concentrate on prolonging the length of exhalation; this helps avoid initiating a cycle of increasing shortness of breath and panic. Minimizing the amount of dust or particles in the air and providing adequate humidification may also make it easier for the patient to breathe. Dust and particles in the air can be decreased by removing drapes and upholstered furniture, using air filters, and washing floors, dusting, and vacuuming frequently.

The nurse instructs the patient that an adequate dietary intake promotes gas exchange and increases energy levels. It is important to obtain adequate nutrition without overeating by consuming small, frequent meals and snacks. Having ready-prepared meals and favorite foods available helps encourage nutrient consumption. Gas-producing foods such as beans, legumes, broccoli, cabbage, and brussels sprouts should be avoided to prevent gastric distress. Because many patients lack the energy to eat, they should be taught to rest before and after meals to conserve energy.

## AIRWAY MANAGEMENT

Adequate ventilation is dependent on free movement of air through the upper and lower airways. In many disorders, the airway becomes narrowed or blocked as a result of disease, bronchoconstriction (narrowing of airway by contraction of muscle fibers), a foreign body, or secretions. Maintaining a patent (open) airway is achieved through meticulous airway management, whether in an emergency situation such as airway obstruction or in long-term management, as in caring for a patient with an endotracheal or a tracheostomy tube.



### Emergency Management of Upper Airway Obstruction

Upper airway obstruction has a variety of causes. Acute upper airway obstruction may be caused by food particles, vomitus, blood clots, or anything that obstructs the larynx or

trachea. It also may occur from enlargement of tissue in the wall of the airway, as in epiglottitis, obstructive sleep apnea, laryngeal edema, laryngeal carcinoma, or peritonsillar abscess, or from thick secretions. Pressure on the walls of the airway, as occurs in retrosternal goiter, enlarged mediastinal lymph nodes, hematoma around the upper airway, and thoracic aneurysm, also may result in upper airway obstruction.

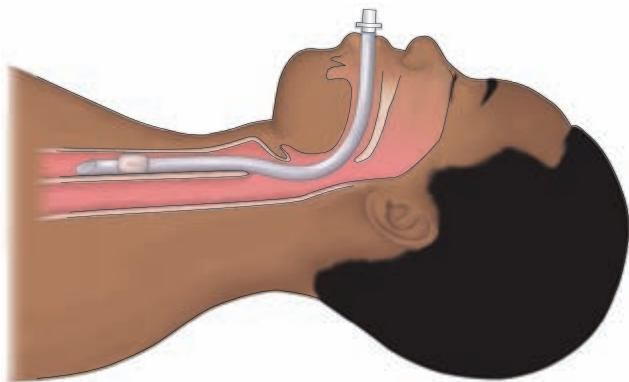
The patient with an altered level of consciousness from any cause is at risk for upper airway obstruction because of loss of the protective reflexes (cough and swallowing) and loss of the tone of the pharyngeal muscles, which causes the tongue to fall back and block the airway.

The nurse makes the following rapid observations to assess for signs and symptoms of upper airway obstruction:

- **Inspection:** Is the patient conscious? Is there any inspiratory effort? Does the chest rise symmetrically? Is there use or retraction of accessory muscles? What is the skin color? Are there any obvious signs of deformity or obstruction (trauma, food, teeth, vomitus)? Is the trachea midline?
- **Palpation:** Do both sides of the chest rise equally with inspiration? Are there any specific areas of tenderness, fracture, or subcutaneous emphysema (crepitus)?
- **Auscultation:** Is there any audible air movement, stridor (inspiratory sound), or wheezing (expiratory sound)? Are breath sounds present over the lower trachea and all lobes?
- As soon as an upper airway obstruction is identified, the nurse takes emergency measures (Chart 25-6). (See Chapter 22 or Chapter 71 for more details on managing a foreign body airway obstruction.)

### Endotracheal Intubation

**Endotracheal intubation** involves passing an endotracheal tube through the mouth or nose into the trachea (Fig. 25-6). Intubation provides a patent airway when the patient is having respiratory distress that cannot be treated with simpler methods and is the method of choice in emergency care. Endotracheal intubation is a means of providing an airway for



**Figure 25-6** Endotracheal tube in place. The tube has been inserted using the oral route. The cuff has been inflated to maintain the tube's position and to minimize the risk of aspiration.

patients who cannot maintain an adequate airway on their own (e.g., comatose patients, patients with upper airway obstruction), for patients needing mechanical ventilation, and for suctioning secretions from the pulmonary tree.

An endotracheal tube usually is passed with the aid of a laryngoscope by specifically trained medical, nursing, or respiratory therapy personnel (see Chapter 71). Once the tube is inserted, a cuff is inflated to prevent air from leaking around the outer part of the tube, to minimize the possibility of aspiration, and to prevent movement of the tube. Chart 25-7 discusses the nursing care of the patient with an endotracheal tube.

Complications can occur from pressure exerted by the cuff on the tracheal wall. Cuff pressures should be maintained between 15 and 20 mm Hg (Morton, Fontaine, Hudak, et al., 2009). High cuff pressure can cause tracheal bleeding, ischemia, and pressure necrosis, whereas low cuff pressure can increase the risk of aspiration pneumonia. Routine deflation of the cuff is not recommended because of the increased risk of aspiration and hypoxia. Tracheobronchial secretions are suctioned through the tube. Warmed, humidified oxygen should always be introduced through the tube, whether the patient is breathing spontaneously or is receiving ventilatory support. Endotracheal intubation may be used for no longer than 3 weeks, by which time a tracheostomy must be considered to decrease irritation of and trauma to the tracheal lining, to reduce the incidence of vocal cord paralysis (secondary to laryngeal nerve damage), and to decrease the work of breathing.

Endotracheal and tracheostomy tubes have several disadvantages. The tubes cause discomfort. The cough reflex is depressed because glottis closure is hindered. Secretions tend to become thicker because the warming and humidifying effect of the upper respiratory tract has been bypassed. The swallowing reflexes (glottic, pharyngeal, and laryngeal reflexes) are depressed because of prolonged disuse and the mechanical trauma produced by the endotracheal or tracheostomy tube, increasing the risk of aspiration. In addition, ulceration and stricture of the larynx or trachea may develop. Of great concern to the patient is the inability to talk and to communicate needs.

Unintentional or premature removal of the tube is a potentially life-threatening complication of endotracheal intubation. Removal of the tube is a frequent problem in intensive care units and occurs mainly during nursing care or by the patient. It is important that nurses instruct and remind patients and family members about the purpose of the tube and the dangers of removing it. Baseline and ongoing assessment of the patient and of the equipment ensures effective care. Providing comfort measures, including opioid analgesia and sedation, can improve the patient's tolerance of the endotracheal tube.

### NURSING ALERT

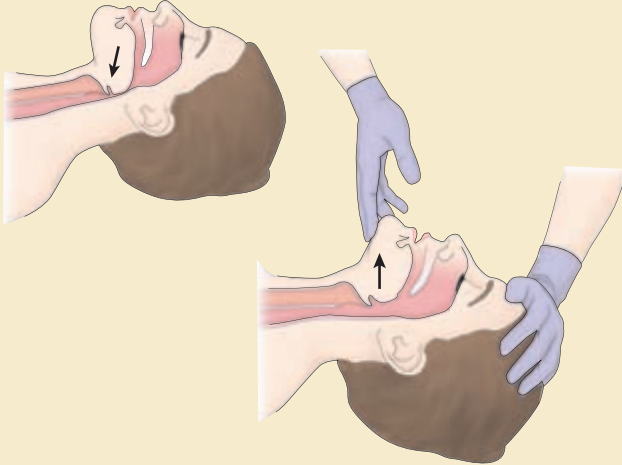
**Inadvertent removal of an endotracheal tube can cause laryngeal swelling, hypoxemia, bradycardia, hypotension, and even death. Measures must be taken to prevent premature or inadvertent removal.**

To prevent tube removal by the patient, the nurse should explain to the patient and family the purpose of the tube, distract the patient through one-to-one interaction or with

**Chart 25-6 • Clearing an Upper Airway Obstruction**

**Clearing the Airway**

Hyperextend the patient's neck by placing one hand on the forehead and placing the fingers of the other hand underneath the jaw and lifting upward and forward. This action pulls the tongue away from the back of the pharynx.



Opening the airway.

- Assess the patient by observing the chest and listening and feeling for the movement of air.
- Use a cross-finger technique to open the mouth and observe for obvious obstructions such as secretions, blood clots, or food particles.
- If no passage of air is detected, apply five quick sharp abdominal thrusts just below the xiphoid process to expel the



Abdominal thrust (Heimlich) maneuver administered to unconscious patient.

obstruction. Repeat this procedure until the obstruction is expelled.

- After the obstruction is expelled, roll the patient as a unit onto the side for recovery.
- When the obstruction is relieved, if the patient can breathe spontaneously but not cough, swallow, or gag, insert an oral or nasopharyngeal airway.

**Bag and Mask Resuscitation**

- Apply the mask to the patient's face and create a seal by pressing the thumb of the nondominant hand on the bridge of the nose and the index finger on the chin.
- Using the rest of the fingers on that hand, pull on the chin and the angle of the mandible to maintain the head in extension.
- Use the dominant hand to inflate the lungs by squeezing the bag to its full volume.



Resuscitation via bag and mask apparatus.

## Chart 25-7 • Care of the Patient With an Endotracheal Tube

### Immediately After Intubation

1. Check symmetry of chest expansion.
2. Auscultate breath sounds of anterior and lateral chest bilaterally.
3. Obtain order for chest x-ray to verify proper tube placement.
4. Check cuff pressure every 6–8 hours.
5. Monitor for signs and symptoms of aspiration.
6. Ensure high humidity; a visible mist should appear in the T-piece or ventilator tubing.
7. Administer oxygen concentration as prescribed by physician.
8. Secure the tube to the patient's face with tape, and mark the proximal end for position maintenance.
  - a. Cut proximal end of tube if it is longer than 7.5 cm (3 inches) to prevent kinking.
  - b. Insert an oral airway or mouth device to prevent the patient from biting and obstructing the tube.
9. Use sterile suction technique and airway care to prevent iatrogenic contamination and infection.
10. Continue to reposition patient every 2 hours and as needed to prevent atelectasis and to optimize lung expansion.
11. Provide oral hygiene and suction the oropharynx whenever necessary.

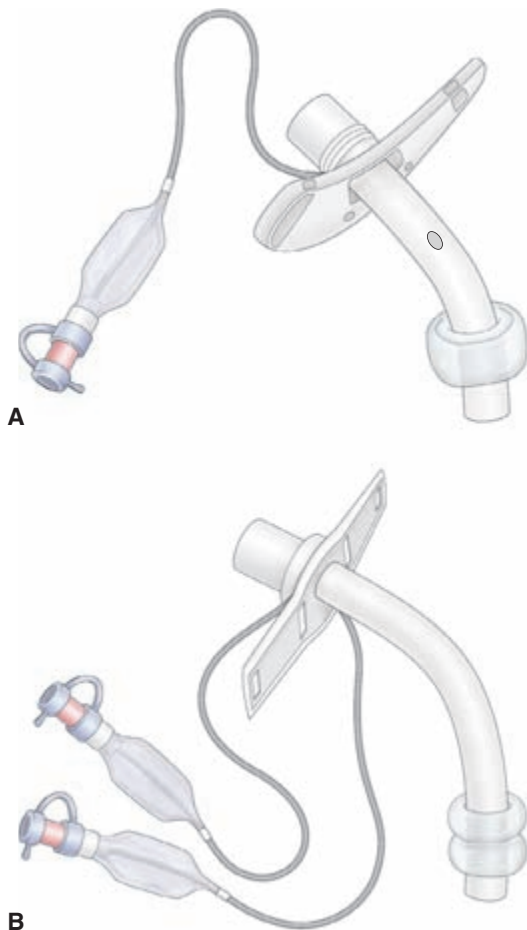
### Extubation (Removal of Endotracheal Tube)

1. Explain procedure.
2. Have self-inflating bag and mask ready in case ventilatory assistance is required immediately after extubation.
3. Suction the tracheobronchial tree and oropharynx, remove tape, and then deflate the cuff.
4. Give 100% oxygen for a few breaths, then insert a new, sterile suction catheter inside tube.
5. Have the patient inhale. At peak inspiration remove the tube, suctioning the airway through the tube as it is pulled out.

*Note:* In some hospitals this procedure can be performed by respiratory therapists; in others, by nurses. Check hospital policy.

### Care of Patient Following Extubation

1. Give heated humidity and oxygen by face mask and maintain the patient in a sitting or high Fowler's position.
2. Monitor respiratory rate and quality of chest excursions. Note stridor, color change, and change in mental alertness or behavior.
3. Monitor the patient's oxygen level using a pulse oximeter.
4. Keep NPO or give only ice chips for next few hours.
5. Provide mouth care.
6. Teach patient how to perform coughing and deep-breathing exercises.



**Figure 25-7** Tracheostomy tubes. **A**, Fenestrated tube, which allows patient to talk. **B**, Double-cuffed tube. Inflating the two cuffs alternately can help prevent tracheal damage.

television, and maintain comfort measures. As a last resort, soft wrist restraints may be used. Discretion and caution must always be used before applying any restraint. If the patient cannot move the arms and hands to the endotracheal tube, restraints are not needed. If the patient is alert, oriented, able to follow directions, and cooperative to the point that it is highly unlikely that he or she will remove the endotracheal tube, restraints are not needed. However, if the nurse determines there is a risk that the patient may try to remove the tube, soft wrist restraints are appropriate with a physician's order (check agency policy). Close monitoring of the patient is essential to ensure safety and prevent harm.

## Tracheostomy

A **tracheostomy** is a surgical procedure in which an opening is made into the trachea. The indwelling tube inserted into the trachea is called a **tracheostomy tube** (Fig. 25-7). A tracheostomy may be either temporary or permanent.

A tracheostomy is used to bypass an upper airway obstruction, to allow removal of tracheobronchial secretions, to permit the long-term use of mechanical ventilation, to prevent aspiration of oral or gastric secretions in the unconscious or paralyzed patient (by closing off the trachea from the esophagus), and to replace an endotracheal tube. Many disease processes and emergency conditions make a tracheostomy necessary.

### Procedure

The surgical procedure is usually performed in the operating room or in an intensive care unit, where the patient's ventilation can be well controlled and optimal aseptic technique can be maintained. A surgical opening is made between the

second and third tracheal rings. After the trachea is exposed, a cuffed tracheostomy tube of an appropriate size is inserted. The cuff is an inflatable attachment to the tracheostomy tube that is designed to occlude the space between the tracheal walls and the tube, to permit effective mechanical ventilation, and to minimize the risk of aspiration. See Figure 25-7 for the different types of tracheostomy tubes.

The tracheostomy tube is held in place by tapes fastened around the patient's neck. Usually a square of sterile gauze is placed between the tube and the skin to absorb drainage and reduce the risk for infection.

## Complications

Complications may occur early or late in the course of tracheostomy tube management. They may even occur years after the tube has been removed. Early complications include bleeding, pneumothorax, air embolism, aspiration, subcutaneous or mediastinal emphysema, recurrent laryngeal nerve damage, and posterior tracheal wall penetration. Long-term complications include airway obstruction from accumulation of secretions or protrusion of the cuff over the opening of the tube, infection, rupture of the innominate artery, dysphagia, tracheoesophageal fistula, tracheal dilation, tracheal ischemia, and necrosis. Tracheal stenosis may develop after the tube is removed. Chart 25-8 outlines measures nurses can take to prevent complications.

## Nursing Management

The patient requires continuous monitoring and assessment. The newly made opening must be kept patent by proper suctioning of secretions. After the vital signs are stable, the patient is placed in a semi-Fowler's position to facilitate ventilation, promote drainage, minimize edema, and prevent strain on the suture lines. Analgesia and sedative agents must be administered with caution because of the risk of suppressing the cough reflex.

Major objectives of nursing care are to alleviate the patient's apprehension and to provide an effective means of communication. The nurse keeps paper and pencil or a Magic Slate and the call light within the patient's reach at all times to ensure a means of communication. Chart 25-9 summarizes the care of the patient with a tracheostomy tube.

### Chart 25-8 • Preventing Complications Associated With Endotracheal and Tracheostomy Tubes

- Administer adequate warmed humidity.
- Maintain cuff pressure at appropriate level.
- Suction as needed per assessment findings.
- Maintain skin integrity. Change tape and dressing as needed or per protocol.
- Auscultate lung sounds.
- Monitor for signs and symptoms of infection, including temperature and white blood cell count.
- Administer prescribed oxygen and monitor oxygen saturation.
- Monitor for cyanosis.
- Maintain adequate hydration of the patient.
- Use sterile technique when suctioning and performing tracheostomy care.

## Suctioning the Tracheal Tube (Tracheostomy or Endotracheal Tube)

When a tracheostomy or endotracheal tube is in place, it is usually necessary to suction the patient's secretions because of the decreased effectiveness of the cough mechanism. Tracheal suctioning is performed when adventitious breath sounds are detected or whenever secretions are obviously present. Unnecessary suctioning can initiate bronchospasm and cause mechanical trauma to the tracheal mucosa.

All equipment that comes into direct contact with the patient's lower airway must be sterile to prevent overwhelming pulmonary and systemic infections. Chart 25-10 presents the procedure for suctioning a patient with a tracheostomy tube. In mechanically ventilated patients, an in-line suction catheter may be used to allow rapid suction when needed and to minimize cross-contamination by airborne pathogens. An in-line suction device allows the patient to be suctioned without being disconnected from the ventilator circuit. In-line suctioning (also called closed suctioning) decreases hypoxemia, sustains PEEP, and can decrease patient anxiety associated with suctioning. Because it protects staff from patient secretions, it can be performed without using personal protective gear.

## Managing the Cuff

The cuff on an endotracheal or tracheostomy tube should be inflated if the patient requires mechanical ventilation or is at high risk for aspiration. The pressure within the cuff should be the lowest possible pressure that allows delivery of adequate tidal volumes and prevents pulmonary aspiration. Usually the pressure is maintained at less than 25 mm Hg to prevent injury and at more than 15 mm Hg to prevent aspiration. Cuff pressure must be monitored at least every 8 hours by attaching a handheld pressure gauge to the pilot balloon of the tube or by using the minimal leak volume or minimal occlusion volume technique. With long-term intubation, higher pressures may be needed to maintain an adequate seal.

## Promoting Home and Community-Based Care

### Teaching Patients Self-Care

If the patient is at home with a tracheostomy tube, the nurse instructs the patient and family about daily care, including techniques to prevent infection, as well as measures to take in an emergency. The nurse provides the patient and family with a list of community contacts for education and support needs.

### Continuing Care

A referral for home care is indicated for ongoing assessment of the patient and of the ability of the patient and family to provide appropriate and safe care. The home care nurse assesses the patient's and family's ability to cope with the physical changes and psychological issues associated with having a tracheostomy. The nurse also identifies resources and makes referrals for appropriate services to assist the patient and family to manage the tracheostomy tube at home.


 CHART  
25-9

## Guidelines for Care of the Patient With a Tracheostomy Tube

### Equipment

- Sterile gloves
- Hydrogen peroxide
- Normal saline solution or sterile water
- Cotton-tipped applicators
- Dressing
- Twill tape
- Type of tube prescribed, if the tube is to be changed

### Implementation

#### Actions

1. Provide patient and family instruction on the key points for tracheostomy care, beginning with how to inspect the tracheostomy dressing for moisture or drainage. A cuffed tube (air injected into cuff) is required during mechanical ventilation. A low-pressure cuff is most commonly used. Patients requiring long-term use of a tracheostomy tube and who can breathe spontaneously commonly use an uncuffed, metal tube.
2. Perform hand hygiene.
3. Explain procedure to patient and family as appropriate.
4. Put on clean gloves; remove and discard the soiled dressing in a biohazard container.
5. Prepare sterile supplies, including hydrogen peroxide, normal saline solution or sterile water, cotton-tipped applicators, dressing, and tape.
6. Put on sterile gloves. (Some physicians approve clean technique for long-term tracheostomy patients in the home.)
7. Cleanse the wound and the plate of the tracheostomy tube with sterile cotton-tipped applicators moistened with hydrogen peroxide. Rinse with sterile saline solution.
8. Soak inner cannula in peroxide or sterile saline, per manufacturer's instructions; rinse with saline solution; and inspect to be sure all dried secretions have been removed. Dry and reinsert inner cannula or replace with a new disposable inner cannula.
9. Place clean twill tape in position to secure the tracheostomy tube by inserting one end of the tape through the side opening of the outer cannula. Take the tape around the back of the patient's neck and thread it through the opposite opening of the outer cannula. Bring both ends around so that they meet on one side of the neck. Tighten the tape until only two fingers can be comfortably inserted under it. Secure with a knot. For a new tracheostomy, two people should assist with tape changes. Remove soiled twill tape after the new tape is in place.
10. Remove old tapes and discard in a biohazard container after the new tape is in place.
11. Although some long-term tracheostomies with healed stomas may not require a dressing, other tracheostomies do. In such cases, use a sterile tracheostomy dressing, fitting it securely under the twill tapes and flange of tracheostomy tube so that the incision is covered, as shown below.

#### Rationale

The tracheostomy dressing is changed as needed to keep the skin clean and dry. To prevent potential breakdown, moist or soiled dressings should not remain on the skin. A cuffed tube prevents air from leaking during positive-pressure ventilation and also prevents tracheal aspiration of gastric contents. An adequate seal is indicated by the disappearance of any air leakage from the mouth or tracheostomy or by the disappearance of the harsh, gurgling sound of air coming from the throat. Low-pressure cuffs exert minimal pressure on the tracheal mucosa and thus reduce the danger of tracheal ulceration and stricture.

Hand hygiene reduces bacteria on hands.

A patient with a tracheostomy is apprehensive and requires ongoing assurance and support.

Observing body substance isolation reduces cross-contamination from soiled dressings.

Having necessary supplies and equipment readily available allows the procedure to be completed efficiently.

Sterile equipment minimizes transmission of surface flora to the sterile respiratory tract. Clean technique may be used in the home because of decreased exposure to potential pathogens.

Hydrogen peroxide is effective in loosening crusted secretions. Rinsing prevents skin residue.

Soaking loosens and removes secretions from the inner lumen of the tracheostomy tube. Retained secretions could harbor bacteria, leading to infection. Some plastic tracheostomy tubes may be damaged by using peroxide.

This taping technique provides a double thickness of tape around the neck, which is needed because the tracheostomy tube can be dislodged by movement or by a forceful cough if left unsecured. A dislodged tracheostomy tube is difficult to reinsert, and respiratory distress may occur. Dislodgement of the tube with a new tracheostomy is a medical emergency.

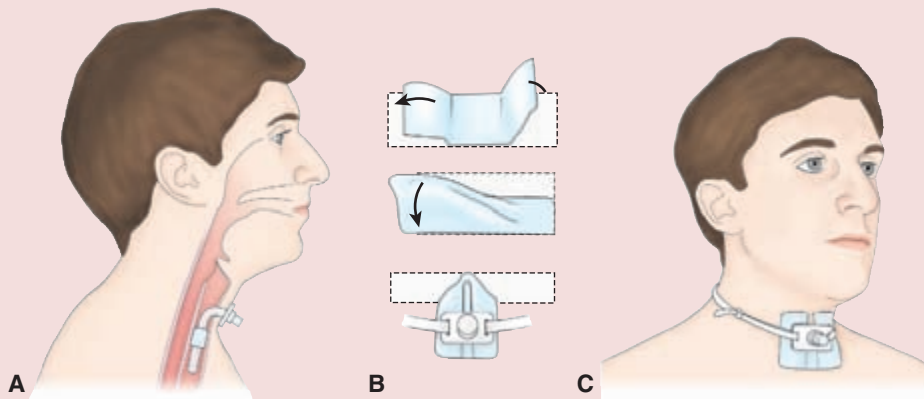
Tapes with old secretions may harbor bacteria.

Healed tracheostomies with minimal secretions do not need a dressing. Dressings that will shred are not used around a tracheostomy because of the risk that pieces of material, lint, or thread may get into the tube, and eventually into the trachea, causing obstruction or abscess formation. Special dressings that do not have a tendency to shred are used.

*Continued on following page*

CHART  
25-9

## Guidelines for Care of the Patient With a Tracheostomy Tube (Continued)



**Figure 25-9.1** **A**, The cuff of the tracheostomy tube fits smoothly and snugly in the trachea in a way that promotes circulation but seals off the escape of secretions and air surrounding the tube. **B**, For a dressing change, a 4- by 4-inch gauze pad may be folded (cutting would promote shredding, placing the patient at risk for aspiration) around the tracheostomy tube and **C**, stabilized by slipping the neck tape ties through the neck plate slots of the tracheostomy tube. The ties may be fastened to the side of the neck to eliminate the discomfort of lying on the knot.

## Mechanical Ventilation

Mechanical ventilation may be required for a variety of reasons: to control the patient's respirations during surgery or during treatment of severe head injury, to oxygenate the blood when the patient's ventilatory efforts are inadequate, and to rest the respiratory muscles, among others. Many patients placed on a ventilator can breathe spontaneously, but the effort needed to do so may be exhausting.

A **mechanical ventilator** is a positive- or negative-pressure breathing device that can maintain ventilation and oxygen delivery for a prolonged period. Caring for a patient on mechanical ventilation has become an integral part of nursing care in critical care or general medical-surgical units, extended care facilities, and the home. Nurses, physicians, and respiratory therapists must understand each patient's specific pulmonary needs and work together to set realistic goals. Positive patient outcomes depend on an understanding of the principles of mechanical ventilation and the patient's care needs as well as open communication among members of the health care team about the goals of therapy, weaning plans, and the patient's tolerance of changes in ventilator settings.

### Indications

If a patient has a continuous decrease in oxygenation ( $\text{PaO}_2$ ), an increase in arterial carbon dioxide levels ( $\text{PaCO}_2$ ), and a persistent acidosis (decreased pH), mechanical ventilation may be necessary. Conditions such as thoracic or abdominal surgery, drug overdose, neuromuscular disorders, inhalation injury, COPD, multiple trauma, shock, multisystem failure, and coma all may lead to respiratory failure and the need for mechanical ventilation. The criteria for mechanical ventilation guide the decision to place a patient on a ventilator (Chart 25-11). A patient with apnea that is not readily reversible also is a candidate for mechanical ventilation.

## Classification of Ventilators

Mechanical ventilators are classified according to the method by which they support ventilation. The two general categories are negative-pressure and positive-pressure ventilators.

### Negative-Pressure Ventilators

Negative-pressure ventilators exert a negative pressure on the external chest. Decreasing the intrathoracic pressure during inspiration allows air to flow into the lung, filling its volume. Physiologically, this type of assisted ventilation is similar to spontaneous ventilation. It is used mainly in chronic respiratory failure associated with neuromuscular conditions, such as poliomyelitis, muscular dystrophy, amyotrophic lateral sclerosis, and myasthenia gravis. It is inappropriate for the patient whose condition is unstable or complex or who requires frequent ventilatory changes. Negative-pressure ventilators are simple to use and do not require intubation of the airway; consequently, they are especially adaptable for home use.

There are several types of negative-pressure ventilators: iron lung, body wrap, and chest cuirass.

#### Iron Lung (Drinker Respirator Tank)

The iron lung is a negative-pressure chamber used for ventilation. It was used extensively during polio epidemics in the past and currently is used by a few polio survivors and patients with other neuromuscular disorders (eg, amyotrophic lateral sclerosis, muscular dystrophy).

#### Body Wrap (Pneumo-Wrap) and Chest Cuirass (Tortoise Shell)

The body wrap and chest cuirass are portable devices that require a rigid cage or shell to create a negative-pressure chamber around the thorax and abdomen. Because of problems with proper fit and system leaks, these types of ventilators are used only with carefully selected patients.


 CHART  
25-10

## Guidelines for Performing Tracheal Suction

### Equipment

- Suction catheters
- Gloves (sterile and nonsterile), gown, mask, and goggles for eye protection
- Basin for sterile normal saline solution for irrigation
- Manual resuscitation bag with supplemental oxygen
- Suction source

### Implementation

#### Step

1. Assess the patient's lung sounds and oxygen saturation via pulse oximeter.
2. Explain the procedure to the patient before beginning and offer reassurance during suctioning.
3. Performing hand hygiene. Put on nonsterile gloves, goggles, gown, and mask.
4. Turn on suction source (pressure should not exceed 120 mm Hg).
5. Open suction catheter kit.
6. Fill basin with sterile water.
7. Put sterile glove on dominant hand.
8. Ventilate the patient with manual resuscitation bag and high-flow oxygen for about 30 seconds or turn on suction mode of ventilator (if available) to hyperoxygenate the patient. Instill normal saline solution into airway only if there are thick, tenacious secretions.
9. Instill normal saline solution into airway if there are thick, tenacious secretions.
10. Pick up suction catheter in sterile gloved hand and connect to suction.
11. Insert suction catheter at least as far as the end of the tube without applying suction, just far enough to stimulate the cough reflex.
12. Apply suction while withdrawing and gently rotating the catheter 360 degrees (no longer than 10 to 15 seconds).
13. Reoxygenate and inflate the patient's lungs for several breaths with manual resuscitation bag, or allow ventilator to reoxygenate patient for several breaths using suction mode.
14. Rinse catheter by suctioning a few milliliters of sterile saline solution from the basin between suction attempts.
15. Repeat steps 9 to 14 until the airway is clear.
16. Suction oropharyngeal cavity after completing tracheal suctioning.
17. Rinse suction tubing and discard catheter, gloves, and basin appropriately.
18. Assess the patient's lung sounds and oxygen saturation via pulse oximeter after procedure.
19. Document the amount, color, and consistency of secretions.

#### Rationale

- Assessment data indicate the need for suctioning and allow the nurse to monitor the effect of suction on the patient's level of oxygenation.
- The patient may be apprehensive about choking and about an inability to communicate.
- Hand hygiene reduces bacteria on hands.
- Suction pressure should be set high enough to be effective without causing trauma to the tissues.
- Having equipment ready prevents interruption of the procedure.
- This provides sterile solution for clearing suction catheter of secretions.
- Equipment that will contact the patient's lower airway must remain sterile to prevent infection.
- This prevents hypoxia during suctioning.
- Solution facilitates their removal.
- Prevents contamination of sterile catheter.
- Inserting the catheter without applying suction permits insertion without causing trauma to the tissues.
- Prolonged suctioning may result in hypoxia and dysrhythmias, leading to cardiac arrest.
- Prevents hypoxia during procedure and restores oxygen supply.
- Keeps suction catheter patent.
- This ensures removal of all tracheal secretions.
- Avoids contamination of trachea with oropharyngeal secretions and organisms.
- Safe disposal of equipment avoids cross-contamination.
- Provides information about effectiveness of procedure.
- Documentation allows monitoring of patient's status over time.

### Positive-Pressure Ventilators

Today, the most common ventilators use positive pressure. Positive-pressure ventilators inflate the lungs by exerting positive pressure on the airway, pushing air in, similar to a bellows mechanism, forcing the alveoli to expand during in-

spiration. Expiration occurs passively. Endotracheal intubation or tracheostomy is usually necessary. These ventilators are widely used in the hospital setting and are increasingly used in the home for patients with primary lung disease. Three types of positive-pressure ventilators are classified by the method of ending the inspiratory phase of respiration:

### Chart 25-11 • Indications for Mechanical Ventilation

PaO<sub>2</sub> <50 mm Hg with FiO<sub>2</sub> >0.60  
 PaO<sub>2</sub> >50 mm Hg with pH <7.25  
 Vital capacity <2 times tidal volume  
 Negative inspiratory force <25 cm H<sub>2</sub>O  
 Respiratory rate >35/min

pressure-cycled, time-cycled, and volume-cycled. The fourth type, noninvasive positive-pressure ventilation, does not require intubation.

#### Pressure-Cycled Ventilators

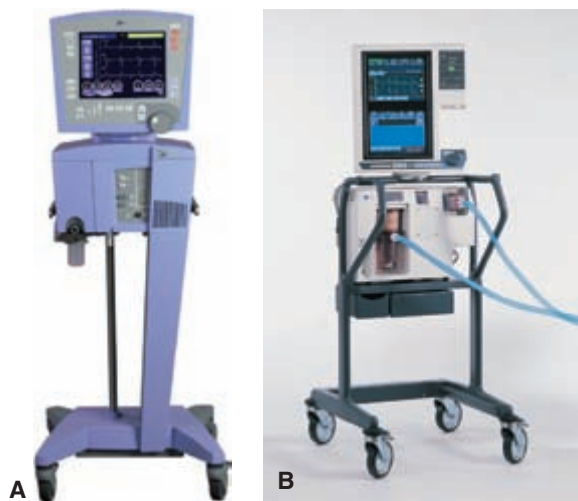
When the pressure-cycled ventilator cycles on, it delivers a flow of air (inspiration) until it reaches a preset pressure, and then cycles off, and expiration occurs passively. Its major limitation is that the volume of air or oxygen can vary as the patient's airway resistance or compliance changes. As a result, the tidal volume delivered may be inconsistent, possibly compromising ventilation. Consequently, in adults, pressure-cycled ventilators are intended only for short-term use. The most common type is the IPPB machine (see earlier discussion).

#### Time-Cycled Ventilators

Time-cycled ventilators terminate or control inspiration after a preset time. The volume of air the patient receives is regulated by the length of inspiration and the flow rate of the air. Most ventilators have a rate control that determines the respiratory rate, but pure time cycling is rarely used for adults. These ventilators are used in newborns and infants.

#### Volume-Cycled Ventilators

Volume-cycled ventilators are by far the most commonly used positive-pressure ventilators today (Fig. 25-8). The



**Figure 25-8** Positive-pressure ventilators. **A**, The AVEA can be used to both ventilate and monitor neonatal, pediatric, and adult patients. It can also deliver noninvasive ventilation with Heliox to adult and pediatric patients. Courtesy of VIASYS Healthcare, Inc., Yorba Linda, CA. **B**, The Puritan-Bennett 840 Ventilator System has volume, pressure, and mixed modes designed for adult, pediatric, and infant ventilation. Courtesy of Tyco Healthcare/Nelicor Puritan Bennett, Pleasanton, CA.

volume of air delivered with each inspiration is preset. Once this preset volume is delivered to the patient, the ventilator cycles off and exhalation occurs passively. From breath to breath, the volume of air delivered by the ventilator is relatively constant, ensuring consistent, adequate breaths despite varying airway pressures.

#### Noninvasive Positive-Pressure Ventilation

Noninvasive positive-pressure ventilation (NIPPV) is a method of positive-pressure ventilation that can be given via face masks that cover the nose and mouth, nasal masks, or other oral or nasal devices such as the nasal pillow (a small nasal cannula that seals around the nares to maintain the prescribed pressure). It eliminates the need for endotracheal intubation or tracheostomy and decreases the risk of nosocomial infections such as pneumonia. The most comfortable mode for the patient is pressure-controlled ventilation with pressure support. This eases the work of breathing and enhances gas exchange. The ventilator can be set with a minimum backup rate for patients with periods of apnea.

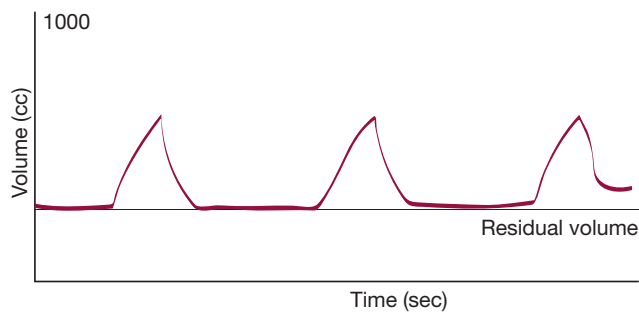
Patients are candidates for NIPPV if they have acute or chronic respiratory failure, acute pulmonary edema, COPD, chronic heart failure, or a sleep-related breathing disorder. The technique also may be used at home to improve tissue oxygenation and to rest the respiratory muscles while patients sleep at night. NIPPV is contraindicated for those who have experienced respiratory arrest, serious dysrhythmias, cognitive impairment, or head or facial trauma. NIPPV may also be used for obstructive sleep apnea, for patients at the end of life, and for those who do not want endotracheal intubation but may need short- or long-term ventilatory support (Bauman, 2009).

Continuous positive airway pressure (CPAP) provides positive pressure to the airways throughout the respiratory cycle. Although it can be used as an adjunct to mechanical ventilation with a cuffed endotracheal tube or tracheostomy tube to open the alveoli, it is also used with a leak-proof mask to keep alveoli open, thereby preventing respiratory failure. CPAP is the most effective treatment for obstructive sleep apnea because the positive pressure acts as a splint, keeping the upper airway and trachea open during sleep. To use CPAP, the patient must be breathing independently.

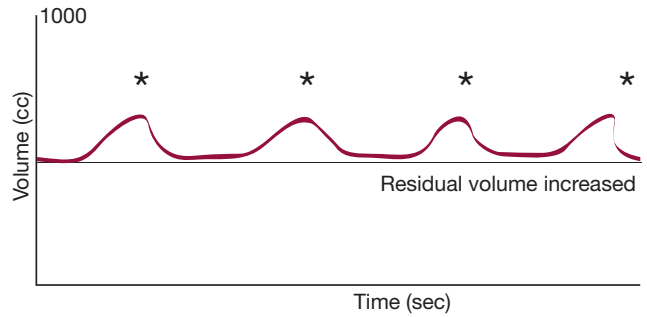
Bilevel positive airway pressure (bi-PAP) ventilation offers independent control of inspiratory and expiratory pressures while providing pressure support ventilation. It delivers two levels of positive airway pressure provided via a nasal or oral mask, nasal pillow, or mouthpiece with a tight seal and a portable ventilator. Each inspiration can be initiated either by the patient or by the machine if it is programmed with a backup rate. The backup rate ensures that the patient receives a set number of breaths per minute. Bi-PAP is most often used for patients who require ventilatory assistance at night, such as those with severe COPD or sleep apnea. Tolerance is variable; bi-PAP usually is most successful with highly motivated patients.

#### Ventilator Modes

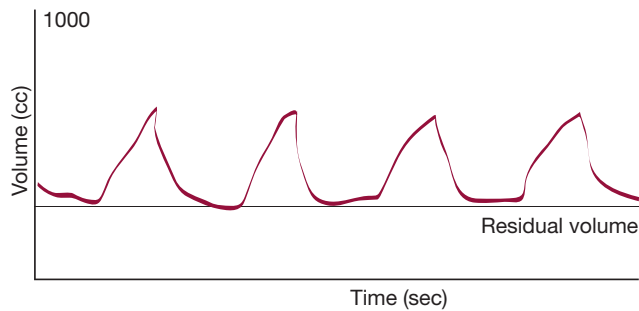
Ventilator mode refers to how breaths are delivered to the patient. The most commonly used modes are assist-control, intermittent mandatory ventilation, synchronized intermittent



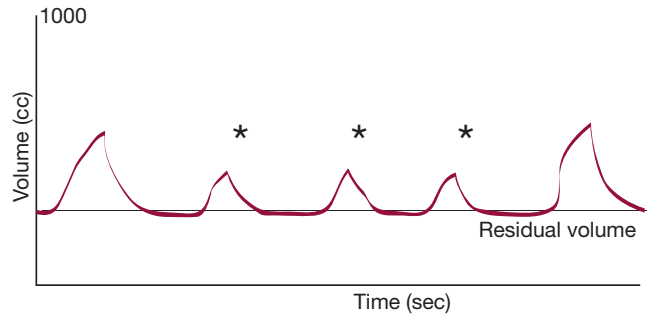
**A. Controlled ventilation**



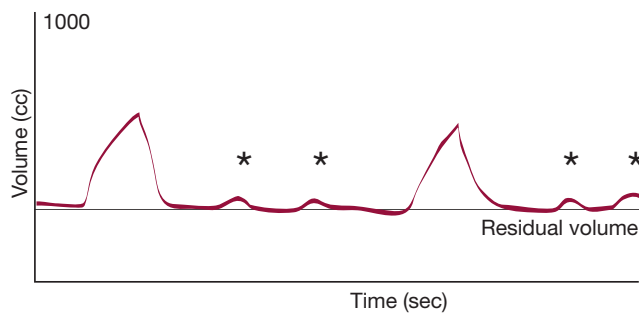
**E. Continuous positive airway pressure (CPAP)**



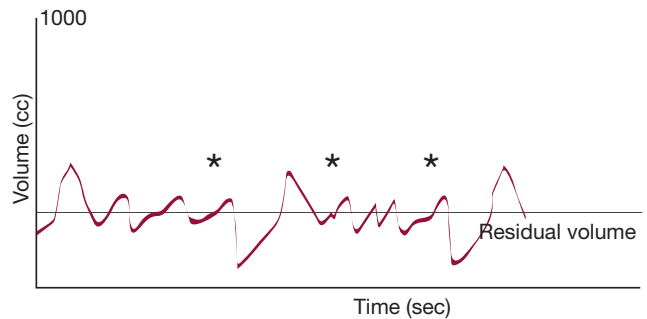
**B. Assist-control (A/C) ventilation**



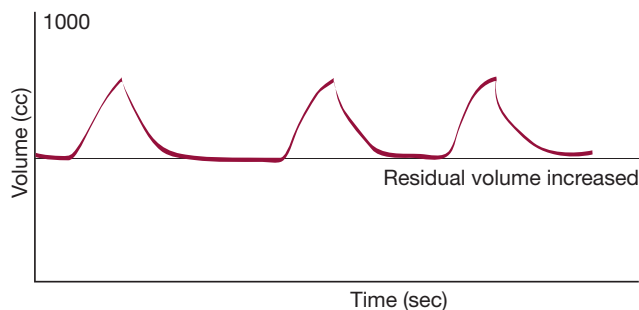
**F. Pressure support with SIMV**



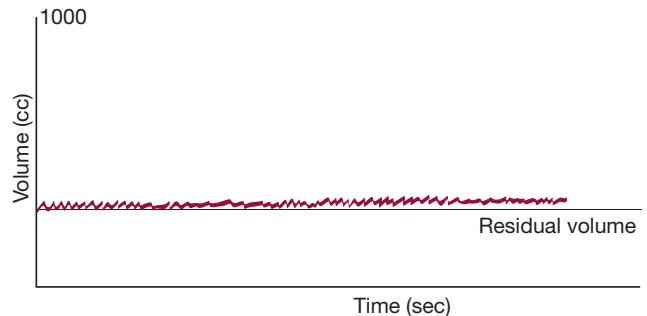
**C. Synchronized intermittent mandatory ventilation (SIMV)**



**G. Airway pressure release ventilation (APRV)**



**D. Positive end expiratory pressure (PEEP)**



**H. High frequency jet ventilation**

**Figure 25-9** Modes of mechanical ventilation with airflow waveforms. Inhalations marked with an asterisk (\*) are spontaneous.

mandatory ventilation, pressure support ventilation, and airway pressure release ventilation (Fig. 25-9).

**Assist-control (A/C) ventilation** provides full ventilatory support by delivering a preset tidal volume and respiratory rate. If the patient initiates a breath between the machine's breaths, the ventilator delivers at the preset volume

(assisted breath). Therefore, every breath is the preset volume.

**Intermittent mandatory ventilation (IMV)** provides a combination of mechanically assisted breaths and spontaneous breaths. Mechanical breaths are delivered at preset intervals and a preselected tidal volume, regardless of the patient's

efforts. Although the patient can increase the respiratory rate by initiating inspiration between ventilator-delivered breaths, these spontaneous breaths are limited to the tidal volume generated by the patient. IMV allows patients to use their own muscles for ventilation to help prevent muscle atrophy. It lowers mean airway pressure, which can assist in preventing barotrauma. However, bucking the ventilator (trying to exhale when the ventilator is delivering a breath) may be increased.

**Synchronized intermittent mandatory ventilation (SIMV)** also delivers a preset tidal volume and number of breaths per minute. Between ventilator-delivered breaths, the patient can breathe spontaneously with no assistance from the ventilator on those extra breaths. Because the ventilator senses patient breathing efforts and does not initiate a breath in opposition to the patient's efforts, bucking the ventilator is reduced. As the patient's ability to breathe spontaneously increases, the preset number of ventilator breaths is decreased and the patient does more of the work of breathing. Like IMV, SIMV can be used to provide full or partial ventilatory support. Nursing interventions for patients receiving IMV or SIMV include monitoring progress by recording respiratory rate, minute volume, spontaneous and machine-generated tidal volume,  $\text{FiO}_2$ , and arterial blood gas levels.

**Pressure support ventilation (PSV)** applies a pressure plateau to the airway throughout the patient-triggered inspiration to decrease resistance within the tracheal tube and ventilator tubing. Pressure support is reduced gradually as the patient's strength increases. A SIMV backup rate may be added for extra support. The nurse must closely observe the patient's respiratory rate and tidal volumes on initiation of PSV. It may be necessary to adjust the pressure support to avoid tachypnea or large tidal volumes.

**Airway pressure release ventilation (APRV)** is a time-triggered, pressure-limited, time-cycled mode of mechanical ventilation that allows unrestricted, spontaneous breathing throughout the ventilatory cycle. The inflation period is long, and breaths may be initiated spontaneously as well as by the ventilator. APRV allows alveolar gas to be expelled through the lungs' natural recoil. Further research is needed on the effectiveness of this mode of mechanical ventilation, but it has been suggested that APRV has the important advantages of causing less ventilator-induced lung injury and fewer adverse effects on cardiocirculatory function and being associated with lower need for sedation and neuromuscular blockade (MacIntyre, 2007).

A relatively new mode of support, **proportional assist ventilation (PAV)**, provides partial ventilatory support in which the ventilator generates pressure in proportion to the patient's inspiratory efforts. With every breath, the ventilator synchronizes with the patient's ventilatory efforts. The more inspiratory pressure the patient generates, the more pressure the ventilator generates, amplifying the patient's inspiratory effort without any specific preselected target pressure or volume. It generally adds "additional muscle" to the patient's effort; the depth and frequency of breaths are controlled by the patient (Ambrosino & Rossi, 2002).

New modes of mechanical ventilation that incorporate computerized control of ventilation are being developed. In some of these modes, the ventilator constantly monitors many variables and adjusts gas delivery during individual breaths; these within-breath adjustment systems include automatic tube compensation, volume-ensured pressure sup-

port, and proportional support ventilation. In other modes, the ventilator evaluates gas delivery during one breath and uses that information to adjust the next breath; these between-breath adjustment systems can be made to ensure a preset tidal volume by adjusting pressure, up to a preset maximum, and include pressure volume support, pressure-regulated volume control, and adaptive support ventilation.

High-frequency oscillatory ventilators deliver small breaths approximately equal to the ventilatory dead space, at rates up to more than 100 times a minute. These small pulses of oxygen-enriched air move down the center of the airways, allowing alveolar air to exit the lungs along the margins of the airways. This ventilatory mode is used to open the alveoli in situations characterized by closed small airways, such as atelectasis and acute respiratory distress syndrome (ARDS), and it is also thought to protect the lung from pressure injury (MacIntyre, 2007).

## Adjusting the Ventilator

The ventilator is adjusted so that the patient is comfortable and breathes "in sync" with the machine. Minimal alteration of the normal cardiovascular and pulmonary dynamics is desired. Figure 25-9 describes modes of mechanical ventilation. If the volume ventilator is adjusted appropriately, the patient's arterial blood gas values will be satisfactory and there will be little or no cardiovascular compromise. Chart 25-12 describes initial ventilator settings.

### Chart 25-12 • Initial Ventilator Settings

The following guide is an example of the steps involved in operating a mechanical ventilator. The nurse, in collaboration with the respiratory therapist, always reviews the manufacturer's instructions, which vary according to the equipment, before beginning mechanical ventilation.

1. Set the machine to deliver the tidal volume required (10 to 15 mL/kg).
2. Adjust the machine to deliver the lowest concentration of oxygen to maintain normal  $\text{PaO}_2$  (80 to 100 mm Hg). This setting may be high initially but will gradually be reduced based on arterial blood gas results.
3. Record peak inspiratory pressure.
4. Set mode (assist-control or synchronized intermittent mandatory ventilation) and rate according to physician order. (See the glossary for definitions of modes of mechanical ventilation.) Set PEEP and pressure support if ordered.
5. Adjust sensitivity so that the patient can trigger the ventilator with a minimal effort (usually 2 mm Hg negative inspiratory force).
6. Record minute volume and obtain ABGs to measure carbon dioxide partial pressure ( $\text{PaCO}_2$ ), pH, and  $\text{PaO}_2$  after 20 minutes of continuous mechanical ventilation.
7. Adjust setting ( $\text{FiO}_2$  and rate) according to results of arterial blood gas analysis to provide normal values or those set by the physician.
8. If the patient suddenly becomes confused or agitated or begins bucking the ventilator for some unexplained reason, assess for hypoxia and manually ventilate on 100% oxygen with a resuscitation bag.

## Assessing the Equipment

The ventilator needs to be assessed to make sure that it is functioning properly and that the settings are appropriate. Although the nurse may not be primarily responsible for adjusting the settings on the ventilator or measuring ventilator parameters (these are usually responsibilities of the respiratory therapist), the nurse is responsible for the patient and therefore needs to evaluate how the ventilator affects the patient's overall status.

When monitoring the ventilator, the nurse notes the following:

- Type of ventilator (eg, volume-cycled, pressure-cycled, negative-pressure)
- Controlling mode (eg, **controlled ventilation**, assist-control ventilation, synchronized intermittent mandatory ventilation)
- Tidal volume and rate settings (tidal volume is usually set at 6 to 12 mL/kg [ideal body weight]; rate is usually set at 12 to 16 breaths/min)
- FiO<sub>2</sub> setting
- Inspiratory pressure reached and pressure limit (normal is 15 to 20 cm H<sub>2</sub>O; this increases if there is increased airway resistance or decreased compliance)
- Sensitivity (a 2-cm H<sub>2</sub>O inspiratory force should trigger the ventilator)
- Inspiratory-to-expiratory ratio (usually 1:3 [1 second of inspiration to 3 seconds of expiration] or 1:2)

- Minute volume (tidal volume × respiratory rate, usually 6 to 8 L/min)
- Sigh settings (usually set at 1.5 times the tidal volume and ranging from 1 to 3 per hour), if applicable
- Water in the tubing, disconnection or kinking of the tubing
- Humidification (humidifier filled with water) and temperature
- Alarms (turned on and functioning properly)
- PEEP and pressure support level, if applicable (PEEP is usually set at 5 to 15 cm H<sub>2</sub>O)

## Problems With Mechanical Ventilation

Because of the seriousness of the patient's condition and the highly complex and technical nature of mechanical ventilation, a number of problems or complications can occur. Such situations fall into two categories: ventilator problems and patient problems (Table 25-2). In either case, the patient must be supported while the problem is identified and corrected.

### NURSING ALERT

If the ventilator system malfunctions and the problem cannot be identified and corrected immediately, the nurse must ventilate the patient with a manual resuscitation bag until the problem is resolved.

**Table 25-2 TROUBLESHOOTING PROBLEMS WITH MECHANICAL VENTILATION**

Problem	Cause	Solution
<b>Ventilator Problems</b>		
Increase in peak airway pressure	Coughing or plugged airway tube	Suction airway for secretions, empty condensation fluid from circuit
	Patient "bucking" ventilator	Adjust sensitivity
	Decreasing lung compliance	Manually ventilate patient
		Assess for hypoxia or bronchospasm
Decrease in pressure or loss of volume	Tubing kinked	Check arterial blood gas values
	Pneumothorax	Sedate only if necessary
	Atelectasis or bronchospasm	Check tubing; reposition patient; insert oral airway if necessary
	Increase in compliance	Manually ventilate patient; notify physician
Patient Problems	Leak in ventilator or tubing; cuff on tube/humidifier not tight	Clear secretions
		None
		Check entire ventilator circuit for patency
		Correct leak
Cardiovascular compromise	Decrease in venous return due to application of positive pressure to lungs	Assess for adequate volume status by measuring heart rate, blood pressure, central venous pressure, pulmonary capillary wedge pressure, and urine output; notify physician if values are abnormal
Barotrauma/pneumothorax	Application of positive pressure to lungs; high mean airway pressures lead to alveolar rupture	Notify physician
Pulmonary infection	Bypass of normal defense mechanisms; frequent breaks in ventilator circuit; decreased mobility; impaired cough reflex	Prepare patient for chest tube insertion
		Avoid high pressure settings for patients with COPD, ARDS, or history of pneumothorax
		Use meticulous aseptic technique
		Provide frequent mouth care
		Optimize nutritional status

ARDS, acute respiratory distress syndrome; COPD, chronic obstructive pulmonary disease.

### Bucking the Ventilator

The patient is “in sync” with the ventilator when thoracic expansion coincides with the inspiratory phase of the machine and exhalation occurs passively. The patient is said to fight or buck the ventilator when he or she is out of phase with the machine. This is manifested when the patient attempts to breathe out during the ventilator’s mechanical inspiratory phase or when there is jerky and increased abdominal muscle effort. Anxiety, hypoxia, increased secretions, hypercapnia, inadequate minute volume, long expiratory time, and pulmonary edema can all contribute to this problem. These problems must be corrected before resorting to the use of paralyzing agents to reduce bucking; otherwise, the underlying problem is simply masked and the patient’s condition will continue to deteriorate.

Muscle relaxants, tranquilizers, analgesic agents, and paralyzing agents are sometimes administered to patients receiving mechanical ventilation. Their purpose is ultimately to increase the patient–machine synchrony by decreasing the patient’s anxiety, hyperventilation, or excessive muscle activity. The selection and dose of the appropriate medication are determined by the patient’s requirements and the cause of his or her restlessness. Paralyzing agents are always used as a last resort, and they are administered with a sedative medication and often an analgesic medication.

## NURSING PROCESS

### THE PATIENT RECEIVING MECHANICAL VENTILATION

#### Assessment

The nurse plays a vital role in assessing the patient’s status and the functioning of the ventilator. In assessing the patient, the nurse evaluates the patient’s physiologic status and how he or she is coping with mechanical ventilation. Physical assessment includes systematic assessment of all body systems, with an in-depth focus on the respiratory system. Respiratory assessment includes vital signs, respiratory rate and pattern, breath sounds, evaluation of spontaneous ventilatory effort, and potential evidence of hypoxia (eg, skin color). Increased adventitious breath sounds may indicate a need for suctioning. The nurse also evaluates the settings and functioning of the mechanical ventilator, as described previously.

Assessment also addresses the patient’s neurologic status and effectiveness of coping with the need for assisted ventilation and the changes that accompany it. The nurse assesses the patient’s comfort level and ability to communicate as well. Because weaning from mechanical ventilation requires adequate nutrition, it is important to assess the patient’s gastrointestinal system and nutritional status.

#### Diagnosis

##### Nursing Diagnoses

Based on the assessment data, the patient’s major nursing diagnoses may include:

- Impaired gas exchange related to underlying illness, ventilator setting adjustments, or weaning.
- Ineffective airway clearance related to increased mucus production associated with presence of the tube in trachea or continuous positive-pressure mechanical ventilation
- Risk for trauma and infection related to endotracheal intubation or tracheostomy
- Impaired physical mobility related to ventilator dependency
- Impaired verbal communication related to endotracheal tube or tracheostomy tube and attachment to ventilator
- Defensive coping and powerlessness related to ventilator dependency

#### Collaborative Problems/Potential Complications

Based on the assessment data, potential complications may include the following:

- Alterations in cardiac function
- Barotrauma (trauma to the trachea or alveoli secondary to positive pressure) and pneumothorax
- Pulmonary infection
- Sepsis

#### Planning and Goals

The major goals for the patient may include achievement of optimal gas exchange, maintenance of a patent airway, absence of trauma or infection, attainment of optimal mobility, adjustment to nonverbal methods of communication, acquisition of successful coping measures, and absence of complications.

#### Nursing Interventions

Nursing care of the mechanically ventilated patient requires expert technical and interpersonal skills. Nursing interventions are similar regardless of the setting; however, the frequency of interventions and the stability of the patient vary from setting to setting. Nursing interventions for the mechanically ventilated patient are not uniquely different from those for patients with other pulmonary disorders; but astute nursing assessment and a therapeutic nurse–patient relationship are critical. The specific interventions used by the nurse are determined by the underlying disease process and the patient’s response.

Two general nursing interventions that are important in the care of the mechanically ventilated patient are pulmonary auscultation and interpretation of arterial blood gas measurements. The nurse is often the first to note changes in physical assessment findings or significant trends in blood gases that signal the development of a serious problem (eg, pneumothorax, tube displacement, pulmonary embolus).

#### Enhancing Gas Exchange

The purpose of mechanical ventilation is to optimize gas exchange by maintaining alveolar ventilation and oxygen delivery. The alteration in gas exchange may be caused by the underlying illness or by mechanical factors related to adjustment of the machine to the patient. The health care team, including the nurse, physician, and respiratory therapist,

continually assesses the patient for adequate gas exchange, signs and symptoms of hypoxia, and response to treatment. Therefore, the nursing diagnosis of impaired gas exchange is, by its complex nature, multidisciplinary and collaborative. The team members must share goals and information freely. All other goals directly or indirectly relate to this primary goal.

Nursing interventions to promote optimal gas exchange include judicious administration of analgesic agents to relieve pain without suppressing the respiratory drive and frequent repositioning to diminish the pulmonary effects of immobility. The nurse also monitors for adequate fluid balance by assessing for the presence of peripheral edema, calculating daily intake and output, and monitoring daily weights. The nurse administers medications prescribed to control the primary disease and monitors for their side effects.

### **Promoting Effective Airway Clearance**

Continuous positive-pressure ventilation increases the production of secretions regardless of the patient's underlying condition. The nurse assesses for the presence of secretions by lung auscultation at least every 2 to 4 hours. Measures to clear the airway of secretions include suctioning, CPT, frequent position changes, and increased mobility as soon as possible. Frequency of suctioning should be determined by patient assessment. If excessive secretions are identified by inspection or auscultation techniques, suctioning should be performed. Sputum is not produced continuously or every 1 to 2 hours but as a response to a pathologic condition. Therefore, there is no rationale for routine suctioning of all patients every 1 to 2 hours. Although suctioning is used to aid in the clearance of secretions, it can damage the airway mucosa and impair cilia action.

The sigh mechanism on the ventilator may be adjusted to deliver at least 1 to 3 sighs per hour at 1.5 times the tidal volume if the patient is receiving assist-control ventilation. Periodic sighs prevent atelectasis and the further retention of secretions. Because of the risk for hyperventilation and trauma to pulmonary tissue from excess ventilator pressure (barotrauma, pneumothorax), the sigh feature is not used frequently. If the SIMV mode is being used, the mandatory ventilations act as sighs because they are of greater volume than the patient's spontaneous breaths.

Humidification of the airway via the ventilator is maintained to help liquefy secretions so that they are more easily removed. Bronchodilators are administered to dilate the bronchioles and are classified as adrenergic or anticholinergic. Adrenergic bronchodilators (see Chapter 24) are mostly inhaled and work by stimulating the beta-receptor sites, mimicking the effects of epinephrine in the body. The desired effect is smooth muscle relaxation, which dilates the constricted bronchial tubes. Anticholinergic bronchodilators produce airway relaxation by blocking cholinergic-induced bronchoconstriction. Patients receiving bronchodilator therapy of either type should be monitored for adverse effects, including dizziness, nausea, decreased oxygen saturation, hypokalemia, increased heart rate, and urine retention. Mucolytic agents are administered to liquefy secretions so that they are more easily mobilized. Nursing management of patients receiving mucolytic therapy includes assessment for an adequate cough reflex, sputum characteristics, and (in patients not receiving mechanical

ventilation) improvement in incentive spirometry. Side effects include nausea, vomiting, bronchospasm, stomatitis (oral ulcers), urticaria, and rhinorrhea (runny nose).

### **Preventing Trauma and Infection**

Maintaining the endotracheal or tracheostomy tube is an essential part of airway management. The nurse positions the ventilator tubing so that there is minimal pulling or distortion of the tube in the trachea, reducing the risk of trauma to the trachea. Cuff pressure is monitored every 6 to 8 hours to maintain the pressure at less than 25 mm Hg (optimal cuff pressure is 15 to 20 mm Hg). The nurse assesses for the presence of a cuff leak at the same time.

Patients with an endotracheal or tracheostomy tube do not have the normal defenses of the upper airway. In addition, these patients frequently have multiple additional body system disturbances that lead to immunocompromise. Tracheostomy care is performed at least every 8 hours, and more frequently if needed, because of the increased risk for infection. The ventilator circuit tubing and in-line suction tubing are replaced periodically, according to infection control guidelines, to decrease the risk for infection.

The nurse administers oral hygiene frequently because the oral cavity is a primary source of contamination of the lungs in the intubated and compromised patient (American Thoracic Society, 2005). The presence of a nasogastric tube in the intubated patient can increase the risk for aspiration, leading to nosocomial pneumonia. The nurse positions the patient with the head elevated above the stomach as much as possible. Although antiulcer medications such as cimetidine (Tagamet) or ranitidine (Zantac) are sometimes administered, an oral antiulcer medication such as sucralfate (Carafate) is preferable because it maintains normal gastric pH, decreasing the incidence of aspiration pneumonia.

### **Promoting Optimal Level of Mobility**

Being connected to a ventilator limits the patient's mobility. The nurse helps the patient whose condition has become stable to get out of bed and move to a chair as soon as possible. Mobility and muscle activity are beneficial because they stimulate respirations and improve morale. If the patient is unable to get out of bed, the nurse encourages performance of active range-of-motion exercises every 6 to 8 hours. If the patient cannot perform these exercises, the nurse performs passive range-of-motion exercises every 8 hours to prevent contractures and venous stasis.

### **Promoting Optimal Communication**

It is important to develop alternative methods of communication for the patient who is receiving mechanical ventilation. The nurse assesses the patient's communication abilities to evaluate for limitations. Questions to consider when assessing the ventilator-dependent patient's ability to communicate include the following:

- Is the patient conscious and able to communicate? Can the patient nod or shake his or her head?
- Is the patient's mouth unobstructed by the tube so that words can be mouthed?

- Is the patient's dominant hand strong and available for writing? For example, if the patient is right-handed, the intravenous (IV) line should be placed in the left arm if possible so that the right hand is free.
- Is the patient a candidate for a fenestrated tracheostomy tube or a one-way speaking valve (such as Passy-Muir valve or Olympic Trach-Talk) that permit talking?

Once the patient's limitations are known, the nurse offers several appropriate communication approaches: lip or speech reading (use single key words), pad and pencil or Magic Slate, communication board, gesturing, sign language, or electric larynx. Use of a "talking" or fenestrated tracheostomy tube or one-way valve may be suggested to the physician; these allow the patient to talk while on the ventilator. The nurse makes sure that the patient's eyeglasses, hearing aid, sign interpreter, and language translator are available if needed to enhance the patient's ability to communicate.

Some communication methods may be frustrating to the patient, family, and nurse; these need to be identified and minimized. A speech therapist can assist in determining the most appropriate method.

### Promoting Coping Ability

Dependence on a ventilator is frightening to both the patient and the family and disrupts even the most stable fam-

ilies. Encouraging the family to verbalize their feelings about the ventilator, the patient's condition, and the environment in general is beneficial. Explaining procedures every time they are performed helps reduce anxiety and familiarizes the patient with ventilator procedures. To restore a sense of control, the nurse encourages the patient to participate in decisions about care, schedules, and treatment when possible. The patient may become withdrawn or depressed while receiving mechanical ventilation, especially if its use is prolonged (Chart 25-13). To promote effective coping, the nurse informs the patient about progress when appropriate. It is important to provide diversions such as watching television, playing music, or taking a walk (if appropriate and possible). Stress reduction techniques (eg, a back rub, relaxation measures) relieve tension and help the patient deal with anxieties and fears about both the condition and the dependence on the ventilator.

### Monitoring and Managing Potential Complications

**ALTERATIONS IN CARDIAC FUNCTION.** Alterations in cardiac output may occur as a result of positive-pressure ventilation. The positive intrathoracic pressure during inspiration compresses the heart and great vessels, thereby reducing venous return and cardiac output. This is usually corrected during exhalation when the positive pressure is off. The patient

#### CHART 25.13

### NURSING RESEARCH PROFILE *What It's Like to Live on a Ventilator*

Johnson, P., St. John, W. & Moyle, W. (2006). Long-term mechanical ventilation in a critical care unit: Existing in an uneveryday world. *Journal of Advanced Nursing*, 53(5), 551–558.

#### Purpose

Because of the aging of the population and improvements in health care technology, more patients are undergoing mechanical ventilation for long periods—that is, for 7 or more days. This use of technology may be uncomfortable and frightening to the patient, who may also feel helpless and anxious; the patient may even experience episodes of panic, nightmares, or hallucinations. Researchers conducted this study to learn what it means to the patient to be dependent on long-term mechanical ventilation.

#### Design

Data collection for this qualitative study consisted of interviews with nine people, 21 to 69 years of age, who had required mechanical ventilation for at least 7 days while in a critical care unit. Participants had been conscious for some of the time while on the ventilator and were able to recall and discuss their experience. The interviews lasted 45 to 140 minutes. The investigators read transcriptions of the interviews several times and found four major themes that ran through the interviews. The investigators then went back to five of the participants and reviewed their preliminary findings to ensure that they had interpreted the data correctly.

#### Findings

Participants' reactions had four themes, including "existing in an uneveryday world." The participants' fluctuating levels of

consciousness, difficulty distinguishing reality, and losing track of time caused them to feel removed from the real world. Hallucinations and unpleasant dreams remained vivid even following discharge. Their bodies felt strange and unfamiliar, and their inability to communicate effectively was frustrating. The technology that they depended on was irritating at times and made them feel vulnerable; they wondered if they would survive.

#### Nursing Implications

Despite the near universal complaint of discomfort, there was little mention of pain in this sample. This may be related to adequate management of pain. However, participants described other unpleasant sensations, such as those associated with suctioning. Therefore, it is vital that nurses caring for patients on long-term mechanical ventilation comfort and support them; in addition, the nurses must carry out interventions with sensitivity and gentleness. Because participants had not been able to make sense of what occurred while they were in the critical care unit, they found the interviews therapeutic; discussing their memories of the critical care unit helped them understand what had happened. The authors recommend, therefore, that nurses provide opportunities for patients to discuss their hospitalization following discharge. More research is needed to determine optimal care and postdischarge services for people who need to be mechanically ventilated while in intensive care.

may have decreased cardiac output and resultant decreased tissue perfusion and oxygenation.

To evaluate cardiac function, the nurse first observes for signs and symptoms of hypoxia (restlessness, apprehension, confusion, tachycardia, tachypnea, pallor progressing to cyanosis, diaphoresis, transient hypertension, and decreased urine output). If a pulmonary artery catheter is in place, cardiac output, cardiac index, and other hemodynamic values can be used to assess the patient's status.

**BAROTRAUMA AND PNEUMOTHORAX.** Excessive positive pressure can cause lung damage, or barotrauma, which may result in a spontaneous **pneumothorax**, which may quickly develop into a tension pneumothorax, further compromising venous return, cardiac output, and blood pressure. The nurse considers any sudden changes in oxygen saturation or the onset of respiratory distress to be a life-threatening emergency requiring immediate action.

**PULMONARY INFECTION.** The patient is at high risk for infection, as described earlier. The nurse reports fever or a change in the color or odor of sputum to the physician for follow-up.

#### *Promoting Home and Community-Based Care*

Increasingly, patients are being cared for in extended care facilities or at home while receiving mechanical ventilation, with a tracheostomy tube, or receiving oxygen therapy. Patients receiving home ventilator care usually have a chronic neuromuscular condition or COPD. Providing the opportunity for ventilator-dependent patients to return home to live with their families in familiar surroundings can be a positive experience. The ultimate goal of home ventilator therapy is to enhance the patient's quality of life, not simply to support or prolong life.

**TEACHING PATIENTS SELF-CARE.** Caring for the patient with mechanical ventilator support at home can be accomplished successfully. A home care team consisting of the nurse, physician, respiratory therapist, social service or home care agency, and equipment supplier is needed. The home is evaluated to determine whether the electrical equipment needed can be operated safely. Chart 25-14 summarizes the basic assessment criteria needed for successful home care.

Once the decision to initiate mechanical ventilation at home is made, the nurse prepares the patient and family for home care. The nurse teaches the patient and family about the ventilator, suctioning, tracheostomy care, signs of pulmonary infection, cuff inflation and deflation, and assessment of vital signs. Teaching begins in the hospital and continues at home. Nursing responsibilities include evaluating the patient's and family's understanding of the information presented.

The nurse teaches the family cardiopulmonary resuscitation, including mouth-to-tracheostomy tube (instead of mouth-to-mouth) breathing. The nurse also explains how to handle a power failure, which usually involves converting the ventilator from an electrical power source to a battery power source. Conversion is automatic in most types of home ventilators and lasts

### Chart 25-14 • Criteria for Successful Home Ventilator Care

The decision to proceed with home ventilation therapy is usually based on the following parameters.

#### Patient Criteria

- The patient has a chronic underlying pulmonary or neuromuscular disorder.
- The patient's clinical pulmonary status is stable.
- The patient is willing to go home on mechanical ventilation.

#### Home Criteria

- The home environment is conducive to care of the patient.
- The electrical facilities are adequate to operate all equipment safely.
- The home environment is controlled, without drafts in cold weather and with proper ventilation in warm weather.
- Space is available for cleaning and storing ventilator equipment.

#### Family Criteria

- Family members are competent, dependable, and willing to spend the time required for proper training as primary caregivers.
- Family members understand the diagnosis and prognosis.
- Family has sufficient financial and supportive resources and can obtain professional support if necessary.

approximately 1 hour. The nurse instructs the family on the use of a manual self-inflation bag should it be necessary. Chart 25-15 lists some of the patient's and family's responsibilities.

**CONTINUING CARE.** A home care nurse monitors and evaluates how well the patient and family are adapting to providing care in the home. The nurse assesses the adequacy of the patient's ventilation and oxygenation as well as airway patency. The nurse addresses any unique adaptation problems the patient may have and listens to the patient's and family's anxieties and frustrations, offering support and encouragement where possible. The home care nurse helps identify and contact community resources that may assist in home management of the patient with mechanical ventilation.

The technical aspects of the ventilator are managed by vendor follow-up. A respiratory therapist usually is assigned to the patient and makes frequent home visits to evaluate the patient and perform a maintenance check of the ventilator.

Transportation services are identified in case the patient requires transportation in an emergency. These arrangements must be made before an emergency arises.

#### Evaluation

Expected patient outcomes may include the following:

1. Exhibits adequate gas exchange, as evidenced by normal breath sounds, acceptable arterial blood gas levels, and vital signs

CHART 25-15  HOME CARE CHECKLIST Ventilator Care

At the completion of the home care instruction, the patient or caregiver will be able to:	PATIENT	CAREGIVER
<ul style="list-style-type: none"> <li>State proper care of patient on ventilator                             <ul style="list-style-type: none"> <li>Observe physical signs such as color, secretions, breathing pattern, and state of consciousness.</li> <li>Perform physical care such as suctioning, postural drainage, and ambulation.</li> <li>Observe the tidal volume and pressure manometer regularly. Intervene when they are abnormal (ie, suction if airway pressure increases).</li> <li>Provide a communication method for the patient (eg, pad and pencil, electric larynx, talking tracheostomy tube, sign language).</li> <li>Monitor vital signs as directed.</li> <li>Use a predetermined signal to indicate when feeling short of breath or in distress.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li></li> <li></li> <li></li> <li></li> <li></li> <li>✓</li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>
<ul style="list-style-type: none"> <li>Care for and maintain equipment properly                             <ul style="list-style-type: none"> <li>Check the ventilator settings twice each day and whenever the patient is removed from the ventilator.</li> <li>Adjust the volume and pressure alarms if needed.</li> <li>Fill humidifier as needed and check its level three times a day.</li> <li>Empty water in tubing as needed.</li> <li>Use a clean humidifier when circuitry is changed.</li> <li>Keep exterior of ventilator clean and free of any objects.</li> <li>Change external circuitry once a week or more often as indicated.</li> <li>Report malfunction or strange noises immediately.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li></li> <li></li> <li>✓</li> <li></li> <li></li> <li></li> <li>✓</li> </ul>	<ul style="list-style-type: none"> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> <li>✓</li> </ul>

2. Demonstrates adequate ventilation with minimal mucus accumulation
3. Is free of injury or infection, as evidenced by normal temperature, white blood cell count, and clear sputum
4. Is mobile within limits of ability
  - a. Gets out of bed to chair, bears weight, or ambulates as soon as possible
  - b. Performs range-of-motion exercises every 6 to 8 hours
5. Communicates effectively through written messages, gestures, or other communication strategies
6. Copes effectively
  - a. Verbalizes fears and concerns about condition and equipment
  - b. Participates in decision making when possible
  - c. Uses stress reduction techniques when necessary
7. Absence of complications
  - a. Absence of cardiac compromise, as evidenced by stable vital signs and adequate urine output
  - b. Absence of pneumothorax, as evidenced by bilateral chest excursion, normal chest x-ray, and adequate oxygenation
  - c. Absence of pulmonary infection, as evidenced by normal temperature, clear pulmonary secretions, and negative sputum cultures

from the tube, and finally from oxygen. Weaning from mechanical ventilation is performed at the earliest possible time consistent with patient safety. The decision must be made from a physiologic rather than a mechanical viewpoint. A thorough understanding of the patient's clinical status is required in making this decision. Weaning is started when the patient is recovering from the acute stage of medical and surgical problems and when the cause of respiratory failure is sufficiently reversed. Chart 25-16 presents information about patient care during weaning from mechanical ventilation.

Successful weaning involves collaboration among the physician, respiratory therapist, and nurse. Each health care provider must understand the scope and function of other team members in relation to patient weaning to conserve the patient's strength, use resources efficiently, and maximize successful outcomes.

**Criteria for Weaning**

Careful assessment is required to determine whether the patient is ready to be removed from mechanical ventilation. If the patient is stable and showing signs of improvement or reversal of the disease or condition that caused the need for mechanical ventilation, weaning indices should be assessed (see Chart 25-16).

Stable vital signs and arterial blood gases are also important predictors of successful weaning. Once readiness has been determined, the nurse records baseline measurements of weaning indices to monitor progress.

**Weaning the Patient From the Ventilator**

**Respiratory weaning**, the process of withdrawing the patient from dependence on the ventilator, takes place in three stages: the patient is gradually removed from the ventilator, then

**Patient Preparation**

To maximize the chances of success of weaning, the nurse must consider the patient as a whole, taking into account factors that impair the delivery of oxygen and elimination

**Chart 25-16 • Care of the Patient Being Weaned From Mechanical Ventilation**

- Assess patient for weaning criteria:
  - a. Vital capacity: 10 to 15 mL/kg
  - b. Maximum inspiratory pressure (MIP) at least  $-20$  cm H<sub>2</sub>O
  - c. Tidal volume: 7 to 9 mL/kg
  - d. Minute ventilation: 6 L/min
  - e. Rapid/shallow breathing index: below 100 breaths/minute/L; PaO<sub>2</sub> >60 mm Hg with FiO<sub>2</sub> less than 40%
- Monitor activity level, assess dietary intake, and monitor results of laboratory tests of nutritional status. Reestablishing independent spontaneous ventilation can be physically exhausting. It is crucial that the patient have enough energy reserves to succeed.
- Assess the patient's and family's understanding of the weaning process and address any concerns about the process. Explain that the patient may feel short of breath initially and provide encouragement as needed. Reassure the patient that he or she will be attended closely and that if the weaning attempt is not successful, it can be tried again later.
- Implement the weaning method prescribed: A/C ventilation, IMV, SIMV, PSV, PAV, CPAP, or T-piece.
- Monitor vital signs, pulse oximetry, ECG, and respiratory pattern constantly for the first 20 to 30 minutes and every 5 minutes after that until weaning is complete. Monitoring the patient closely provides ongoing indications of success or failure.
- Maintain a patent airway; monitor arterial blood gas levels and pulmonary function tests. Suction the airway as needed.
- In collaboration with the physician, terminate the weaning process if adverse reactions occur. These include a heart rate increase of 20 beats/min, systolic blood pressure increase of 20 mm Hg, a decrease in oxygen saturation to less than 90%, respiratory rate less than 8 or greater than 20 breaths/min, ventricular dysrhythmias, fatigue, panic, cyanosis, erratic or labored breathing, paradoxical chest movement.
- If the weaning process continues, measure tidal volume and minute ventilation every 20 to 30 minutes; compare with the patient's desired values, which have been determined in collaboration with the physician.
- Assess for psychological dependence if the physiologic parameters indicate weaning is feasible and the patient still resists. Possible causes of psychological dependence include fear of dying and depression from chronic illness. It is important to address this issue before the next weaning attempt.

of carbon dioxide as well as those that increase oxygen demand (eg, sepsis, seizures, thyroid imbalances) or decrease the patient's overall strength (eg, inadequate nutrition, neuromuscular disease). Adequate psychological preparation is necessary before and during the weaning process.

### Methods of Weaning

Successful weaning depends on the combination of adequate patient preparation, available equipment, and an interdisciplinary approach to solve patient problems (see Chart 25-16). All usual modes of ventilation can be used for weaning.

When assist-control (A/C) ventilation is used, the control rate is decreased, so that the patient strengthens the respiratory muscles by triggering progressively more breaths. The nurse assesses the patient for signs of distress: rapid or shallow breathing, use of accessory muscles, reduced level of consciousness, increase in carbon dioxide levels, decrease in oxygen saturation, and tachycardia.

SIMV is indicated if the patient satisfies all the criteria for weaning but cannot sustain adequate spontaneous ventilation for long periods. As the patient's respiratory muscles become stronger, the rate is decreased until the patient is breathing spontaneously.

The PAV mode of partial ventilatory support allows the ventilator to generate pressure in proportion to the patient's efforts. With every breath, the ventilator synchronizes with the patient's ventilatory efforts. Nursing assessment includes careful monitoring of the patient's respiratory rate, arterial blood gases, tidal volume, minute ventilation, and breathing pattern.

CPAP allows the patient to breathe spontaneously while applying positive pressure throughout the respiratory cycle to keep the alveoli open and promote oxygenation. Providing CPAP during spontaneous breathing also offers the advantage of an alarm system and may reduce patient anxiety if the patient has been taught that the machine is keeping track of breathing. It also maintains lung volumes and improves the patient's oxygenation status. CPAP is often used in conjunction with PSV. Nurses should carefully assess for tachypnea, tachycardia, reduced tidal volumes, decreasing oxygen saturations, and increasing carbon dioxide levels.

When the patient can breathe spontaneously, weaning trials using a T-piece or tracheostomy mask (see Fig. 25-2) are normally conducted with the patient disconnected from the ventilator, receiving humidified oxygen only and performing all work of breathing. Because patients do not have to overcome the resistance of the ventilator, they may find this mode more comfortable, or they may become anxious as they breathe with no support from the ventilator. During T-piece trials, the nurse monitors the patient closely and provides encouragement. This method of weaning is usually used when the patient is awake and alert, is breathing without difficulty, has good gag and cough reflexes, and is hemodynamically stable. During the weaning process, the patient is maintained on the same or a higher oxygen concentration than when receiving mechanical ventilation. While the patient is using the T-piece, he or she is observed for signs and symptoms of hypoxia, increasing respiratory muscle fatigue, or systemic fatigue. These include rest-

lessness, increased respiratory rate (greater than 35 breaths/min), use of accessory muscles, tachycardia with premature ventricular contractions, and paradoxical chest movement (asynchronous breathing, chest contraction during inspiration and expansion during expiration). Fatigue or exhaustion is initially manifested by an increased respiratory rate associated with a gradual reduction in tidal volume; later there is a slowing of the respiratory rate.

If the patient appears to be tolerating the T-piece trial, a second set of arterial blood gas measurements is drawn 20 minutes after the patient has been on spontaneous ventilation at a constant  $\text{FiO}_2$  pressure support ventilation. (Alveolar–arterial equilibration takes 15 to 20 minutes to occur.)

Signs of exhaustion and hypoxia correlated with deterioration in the blood gas measurements indicate the need for ventilatory support. The patient is placed back on the ventilator each time signs of fatigue or deterioration develop.

If clinically stable, the patient usually can be extubated within 2 or 3 hours after weaning and allowed spontaneous ventilation by means of a mask with humidified oxygen. Patients who have had prolonged ventilatory assistance usually require more gradual weaning; it may take days or even weeks. They are weaned primarily during the day and placed back on the ventilator at night to rest.

Because patients respond in different manners to weaning methods, there is no definitive way to assess which method is best. Regardless of the weaning method being used, ongoing assessment of respiratory status is essential to monitor patient progress.

Successful weaning from the ventilator is supplemented by intensive pulmonary care. The following methods are used: oxygen therapy; arterial blood gas evaluation; pulse oximetry; bronchodilator therapy; CPT; adequate nutrition, hydration, and humidification; blood pressure measurement; and incentive spirometry. Daily spontaneous breathing trials may be used to evaluate the patient's ability to breathe without ventilatory support. There is some evidence that such trials are best performed if sedation is temporarily withdrawn for the trial (MacIntyre, 2007). A patient may still have borderline pulmonary function and need vigorous supportive therapy before his or her respiratory status returns to a level that supports activities of daily living.

### Weaning From the Tube

Weaning from the tube is considered when the patient can breathe spontaneously, maintain an adequate airway by effectively coughing up secretions, swallow, and move the jaw. If frequent suctioning is needed to clear secretions, tube weaning may be unsuccessful. Secretion clearance and aspiration risks are assessed to determine whether active pharyngeal and laryngeal reflexes are intact.

Once the patient can clear secretions adequately, a trial period of mouth breathing or nose breathing is conducted. This can be accomplished by several methods. The first method requires changing to a smaller size tube to increase

the resistance to airflow or plugging the tracheostomy tube (deflating the cuff first). The smaller tube is sometimes replaced by a cuffless tracheostomy tube, which allows the tube to be plugged at lengthening intervals to monitor patient progress. A second method involves changing to a fenestrated tube (a tube with an opening or window in its bend). This permits air to flow around and through the tube to the upper airway and enables talking. A third method involves switching to a smaller tracheostomy button (stoma button). A tracheostomy button is a plastic tube approximately 1 inch long that helps keep the windpipe open after the larger tracheostomy tube has been removed. Finally, when the patient demonstrates the ability to maintain a patent airway, the tube can be removed. An occlusive dressing is placed over the stoma, which heals in several days to weeks.

### Weaning From Oxygen

The patient who has been successfully weaned from the ventilator, cuff, and tube and has adequate respiratory function is then weaned from oxygen. The  $\text{FiO}_2$  is gradually reduced until the  $\text{PaO}_2$  is in the range of 70 to 100 mm Hg while the patient is breathing room air. If the  $\text{PaO}_2$  is less than 70 mm Hg on room air, supplemental oxygen is recommended. To be eligible for financial reimbursement from the Centers for Medicare and Medicaid Services for in-home oxygen, the patient must have a  $\text{PaO}_2$  of less than 60 mm Hg while awake and at rest.

### Nutrition

Success in weaning the long-term ventilator-dependent patient requires early and aggressive but judicious nutritional support. The respiratory muscles (diaphragm and especially intercostals) become weak or atrophied after just a few days of mechanical ventilation and may be catabolized for energy, especially if nutrition is inadequate. Compensation for inadequate nutrition must be undertaken with care; excessive intake can increase production of carbon dioxide and the demand for oxygen and lead to prolonged ventilator dependence and difficulty in weaning (O'Leary-Kelley, Puntillo, Barr, et al., 2005). Because the metabolism of fat produces less carbon dioxide than the metabolism of carbohydrates, a high-fat diet, in which 50% of daily kilocalories are from fat, may assist patients with respiratory failure, both during mechanical ventilation and while being weaned. The evidence on the value of a limited carbohydrate intake versus a carbohydrate-enriched diet is uncertain. Adequate protein intake is important in increasing respiratory muscle strength. Protein intake should be approximately 25% of total daily kilocalories, or 1.2 to 1.5 g/kg/day. Daily nutrition should be closely monitored.

Soon after the patient is admitted, a consultation with a dietitian or nutrition support team should be arranged to plan the best form of nutritional replacement. Adequate nutrition may decrease the duration of mechanical ventilation and prevent other complications, especially sepsis. Sepsis can occur if bacteria enter the bloodstream and release toxins that, in turn, cause vasodilation and

hypotension, fever, tachycardia, increased respiratory rate, and coma. Aggressive treatment of sepsis is essential to reverse this threat to survival and to promote weaning from the ventilator when the patient's condition improves.

## THE PATIENT UNDERGOING THORACIC SURGERY

Assessment and management are particularly important for the patient undergoing thoracic surgery. Frequently, patients undergoing such surgery also have obstructive pulmonary disease or other chronic disease. Preoperative preparation and careful postoperative management are crucial for successful patient outcomes because these patients may have a narrow range between their physical tolerance for certain activities and their limitations, which, if exceeded, can lead to distress. Various types of thoracic surgical procedures are performed to relieve disease conditions such as lung abscesses, lung cancer, cysts, benign tumors, and emphysema (Chart 25-17). An exploratory **thoracotomy** (creation of a surgical opening into the thoracic cavity) may be performed to diagnose lung or chest disease. A biopsy may be performed in this procedure with a small amount of lung tissue removed for analysis; the chest incision is then closed.

The objectives of preoperative care for the patient undergoing thoracic surgery are to ascertain the patient's functional reserve, to determine whether the patient is likely to survive and recover from the surgery, and to ensure that the patient is in optimal condition for surgery.

### Preoperative Management

#### Assessment and Diagnostic Findings

The nurse performs chest auscultation to assess breath sounds in all regions of the lungs (see Chapter 21). It is important to note whether breath sounds are normal, indicating a free flow of air in and out of the lungs. (In the patient with emphysema, the breath sounds may be markedly decreased or even absent on auscultation.) The nurse notes crackles and wheezes and assesses for hyperresonance and decreased diaphragmatic motion. Unilateral diminished breath sounds and rhonchi can be the result of occlusion of the bronchi by mucus plugs. The nurse assesses for retained secretions during auscultation by asking the patient to cough. It is important to note any signs of rhonchi or wheezing. The patient history and assessment should include the following questions:

- What signs and symptoms (cough, sputum expectorated [amount and color], hemoptysis, chest pain, dyspnea) are present?
- If there is a smoking history, how long has the patient smoked? Does the patient smoke currently? How many packs a day?
- What is the patient's cardiopulmonary tolerance while resting, eating, bathing, and walking?
- What is the patient's breathing pattern? How much exertion is required to produce dyspnea?
- Does the patient need to sleep in an upright position or with more than two pillows?
- What is the patient's general physiologic status (eg, general appearance, mental alertness, behavior, nutritional status)?
- What other medical conditions exist (eg, allergies, cardiac disorders, diabetes)?

A number of tests are performed to determine the patient's preoperative status and to assess the patient's physical assets and limitations. Many patients are seen by their surgeons in the office, and many tests and examinations are performed on an outpatient basis. The decision to perform any pulmonary resection is based on the patient's cardiovascular status and pulmonary reserve. Pulmonary function studies (especially lung volume and vital capacity) are performed to determine whether the planned resection will leave sufficient functioning lung tissue. Arterial blood gas values are assessed to provide a more complete picture of the functional capacity of the lung. Exercise tolerance tests are useful to determine whether the patient who is a candidate for pneumonectomy can tolerate removal of one of the lungs.

Preoperative studies are performed to provide a baseline for comparison during the postoperative period and to detect any unsuspected abnormalities. These studies may include a bronchoscopic examination (a lighted scope is inserted into the airways to examine the bronchi), chest x-ray, magnetic resonance imaging (MRI), electrocardiogram (ECG) for arteriosclerotic heart disease, conduction defects), nutritional assessment, determination of blood urea nitrogen and serum creatinine levels (to assess renal function), determination of glucose tolerance or blood glucose level (to check for diabetes), serum electrolytes and protein levels, blood volume determinations, and complete blood cell count.

#### Preoperative Nursing Management

##### Improving Airway Clearance

The underlying lung condition often is associated with increased respiratory secretions. Before surgery, the airway is cleared of secretions to reduce the possibility of postoperative atelectasis or infection. Chart 25-18 lists the risk factors for postoperative atelectasis and pneumonia. Strategies to reduce the risk for atelectasis and infection include humidification, postural drainage, and chest percussion after bronchodilators are administered, if prescribed. The nurse estimates the volume of sputum if the patient expectorates large amounts of secretions. Such measurements are carried out to determine whether and when the amount decreases. Antibiotics are administered as prescribed for infection, which can cause excessive secretions.

##### Teaching the Patient

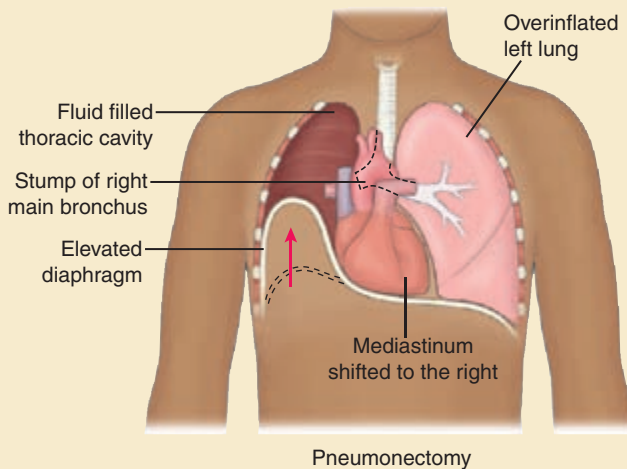
Increasingly, patients are admitted on the day of surgery, which does not provide much time for preoperative assessment or teaching. Nurses in all settings must take an active role in educating the patient and relieving anxiety. The

## Chart 25-17 • Thoracic Surgeries and Procedures

### Pneumonectomy

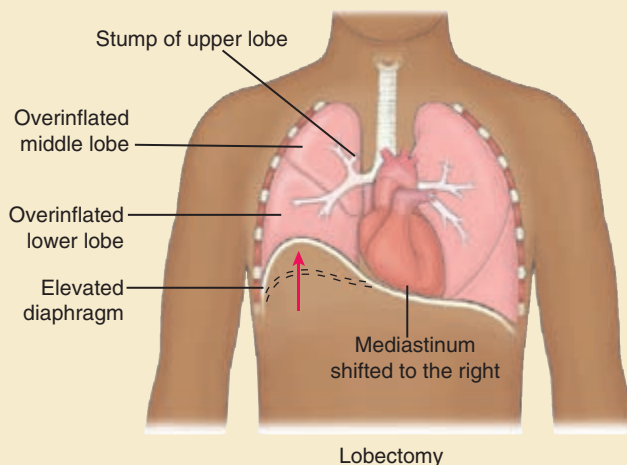
The removal of an entire lung (pneumonectomy) is performed chiefly for cancer when the lesion cannot be removed by a less extensive procedure. It also may be performed for lung abscesses, bronchiectasis, or extensive unilateral tuberculosis. The removal of the right lung is more dangerous than the removal of the left, because the right lung has a larger vascular bed and its removal imposes a greater physiologic burden.

A posterolateral or anterolateral thoracotomy incision is made, sometimes with resection of a rib. The pulmonary artery and the pulmonary veins are ligated and severed. The main bronchus is divided and the lung removed. The bronchial stump is stapled, and usually no drains are used because the accumulation of fluid in the empty hemithorax prevents mediastinal shift.



### Lobectomy

When the pathology is limited to one area of a lung, a lobectomy (removal of a lobe of a lung) is performed. Lobectomy, which is more common than pneumonectomy, may be carried out for bronchogenic carcinoma, giant emphysematous blebs or bullae, benign tumors, metastatic malignant tumors, bronchiectasis, and fungus infections.



The surgeon makes a thoracotomy incision: its exact location depends on the lobe to be resected. When the pleural space is entered, the involved lung collapses and the lobar vessels and the bronchus are ligated and divided. After the lobe is removed, the remaining lobes of the lung are re-expanded. Usually, two chest catheters are inserted for drainage. The upper tube is for air removal; the lower one is for fluid drainage. Sometimes, only one catheter is needed. The chest tube is connected to a chest drainage apparatus for several days.

### Segmentectomy (Segmental Resection)

Some lesions are located in only one segment of the lung. Bronchopulmonary segments are subdivisions of the lung that function as individual units. They are held together by delicate connective tissue. Disease processes may be limited to a single segment. Care is used to preserve as much healthy and functional lung tissue as possible, especially in patients who already have limited cardiopulmonary reserve. Single segments can be removed from any lobe; the right middle lobe, which has only two small segments, invariably is removed entirely. On the left side, corresponding to a middle lobe, is a "lingular" segment of the upper lobe. This can be removed as a single segment or by lingulectomy. This segment frequently is involved in bronchiectasis.

### Wedge Resection

A wedge resection of a small, well-circumscribed lesion may be performed without regard for the location of the intersegmental planes. The pleural cavity usually is drained because of the possibility of an air or blood leak. This procedure is performed for diagnostic lung biopsy and for the excision of small peripheral nodules.

### Bronchoplastic or Sleeve Resection

Bronchoplastic resection is a procedure in which only one lobar bronchus, together with a part of the right or left bronchus, is excised. The distal bronchus is reanastomosed to the proximal bronchus or trachea.

### Lung Volume Reduction

Lung volume reduction is a surgical procedure involving the removal of 20% to 30% of a patient's lung through a midsternal incision or video thoracoscopy. The diseased lung tissue is identified on a lung perfusion scan. This surgery leads to significant improvements in dyspnea, exercise capacity, quality of life, and survival of a subgroup of people with end-stage emphysema (Naunheim, 2004).

### Video Thoracoscopy

A video thoracoscopy is an endoscopic procedure that allows the surgeon to look into the thorax without making a large incision. The procedure is performed to obtain specimens of tissue for biopsy, to treat recurrent spontaneous pneumothorax, and to diagnose either pleural effusions or pleural masses. Thoracoscopy has also been found to be an effective diagnostic and therapeutic alternative for the treatment of mediastinal disorders (Cirino, Campos, Jatene, et al., 2000). Some advantages of video thoracoscopy are rapid diagnosis and treatment of some conditions, a decrease in postoperative complications, and a shortened hospital stay (see Chapter 21).

CHART  
25-18

### Risk Factors for Surgery-Related Atelectasis and Pneumonia

#### Preoperative Risk Factors

- Increased age
- Obesity
- Poor nutritional status
- Smoking history
- Abnormal pulmonary function tests
- Preexisting lung disease
- Emergency surgery
- History of aspiration
- Comorbid states
- Preexisting disability

#### Intraoperative Risk Factors

- Thoracic incision
- Prolonged anesthesia

#### Postoperative Risk Factors

- Immobilization
- Supine position
- Decreased level of consciousness
- Inadequate pain management
- Prolonged intubation/mechanical ventilation
- Presence of nasogastric tube
- Inadequate preoperative education

nurse informs the patient what to expect, from administration of anesthesia to thoracotomy and the likely use of chest tubes and a drainage system in the postoperative period. The patient is also informed about the usual postoperative administration of oxygen to facilitate breathing and the possible use of a ventilator. It is essential to explain the importance of frequent turning to promote drainage of lung secretions. Instruction in the use of incentive spirometry begins before surgery to familiarize the patient with its correct use. The nurse teaches diaphragmatic and pursed-lip breathing, and the patient should begin practicing these techniques (see Charts 25-3 and 25-4).

Because a coughing schedule is necessary in the postoperative period to promote the clearance or removal of secretions, the nurse instructs the patient in the technique of coughing and warns the patient that the coughing routine may be uncomfortable. The nurse teaches the patient to splint the incision with the hands, a pillow, or a folded towel (see Chart 25-5).

Another technique, “huffing,” may be helpful for the patient with diminished expiratory flow rates or for the patient who refuses to cough because of severe pain. Huffing is the expulsion of air through an open glottis. This type of forced expiration technique (FET) stimulates pulmonary expansion and assists in alveolar inflation. The nurse instructs the patient as follows:

- Take a deep diaphragmatic breath and exhale forcefully against your hand in a quick, distinct pant, or huff.
- Practice doing small huffs and progress to one strong huff during exhalation.

Patients should be informed preoperatively that blood and other fluids may be administered, oxygen will be ad-

ministered, and vital signs will be checked often for several hours after surgery. If a chest tube is needed, the patient should be informed that it will drain the fluid and air that normally accumulate after chest surgery. The patient and family are informed that the patient may be admitted to the intensive care unit for 1 to 2 days after surgery, that the patient may experience pain at the incision site, and that medication is available to relieve pain and discomfort.

#### Relieving Anxiety

The nurse listens to the patient to evaluate his or her feelings about the illness and proposed treatment. The nurse also determines the patient’s motivation to return to normal or baseline function. The patient may reveal significant concerns: fear of hemorrhage because of bloody sputum, fear of discomfort from a chronic cough and chest pain, fear of ventilator dependence, or fear of death because of dyspnea and the underlying disease (eg, tumor).

The nurse helps the patient to overcome these fears and to cope with the stress of surgery by correcting any misconceptions, supporting the patient’s decision to undergo surgery, reassuring the patient that the incision will “hold,” and dealing honestly with questions about pain and discomfort and the patient’s treatment. The management and control of pain begin before surgery, when the nurse informs the patient that many postoperative problems can be overcome by following certain routines related to deep breathing, coughing, turning, and moving. If patient-controlled analgesia (PCA) or epidural analgesia is to be used after surgery, the nurse instructs the patient in its use.

### Postoperative Management

After surgery, the vital signs are checked frequently. Oxygen is administered by a mechanical ventilator, nasal cannula, or mask for as long as necessary. A reduction in lung capacity requires a period of physiologic adjustment, and fluids may be given at a low hourly rate to prevent fluid overload and pulmonary edema. After the patient is conscious and the vital signs have stabilized, the head of the bed may be elevated 30 to 45 degrees. Careful positioning of the patient is important. After pneumonectomy, a patient is usually turned every hour from the back to the operative side and should not be completely turned to the unoperated side. This allows the fluid left in the space to consolidate and prevents the remaining lung and the heart from shifting (mediastinal shift) toward the operative side. The patient with a lobectomy may be turned to either side, and a patient with a segmental resection usually is not turned onto the operative side unless the surgeon prescribes this position.

Medication for pain is needed for several days after surgery; it is usually a combination of epidural analgesia, PCA, and scheduled or as-needed oral analgesics (Gottschalk, Cohen, Yang, et al., 2006). Because coughing can be painful, the patient should be taught to splint the chest. Exercises are resumed early in the postoperative period to facilitate lung ventilation. The nurse assesses for signs of complications, including cyanosis, dyspnea, and acute chest pain. These may indicate atelectasis and should be reported immediately.

Increased temperature or white blood cell count may indicate an infection, and pallor and increased pulse may indicate internal hemorrhage. Dressings are assessed for fresh bleeding.

## Mechanical Ventilation

Depending on the nature of the surgery, the patient's underlying condition, the intraoperative course, and the depth of anesthesia, the patient may require mechanical ventilation after surgery. The physician is responsible for determining the ventilator settings and modes, as well as determining the overall method and pace of weaning. It is important to assess the patient's tolerance and weaning progress. Early extubation from mechanical ventilation can lead to earlier removal of arterial lines.

## Chest Drainage

A crucial intervention for improving gas exchange and breathing in the postoperative period is the proper management of chest drainage and the **chest drainage system**. After thoracic surgery, chest tubes and a closed drainage system are used to re-expand the involved lung and to remove excess air, fluid, and blood. Chest drainage systems also are used in treatment of spontaneous pneumothorax and trauma resulting in pneumothorax. Table 25-3 describes and compares the main features of these systems, and Chart 25-19 explains the management of chest drainage systems. Chart 25-20 discusses actions that may prevent cardiopulmonary complications after thoracic surgery.

The normal breathing mechanism operates on the principle of negative pressure; that is, the pressure in the chest cavity normally is lower than the pressure of the atmosphere, causing air to move into the lungs during inspiration. Whenever the chest is opened, there is a loss of negative pressure, which results in collapse of the lung. The collec-

tion of air, fluid, or other substances in the chest can compromise cardiopulmonary function and can also cause the lung to collapse. Pathologic substances that collect in the pleural space include fibrin or clotted blood, liquids (serous fluids, blood, pus, chyle), and gases (air from the lung, tracheobronchial tree, or esophagus).

Chest tubes may be inserted to drain fluid or air from any of the three compartments of the thorax (the right and left pleural spaces and the mediastinum). The pleural space, located between the visceral and parietal pleura, normally contains 20 mL or less of fluid, which helps lubricate the visceral and parietal pleura. Surgical incision of the chest wall almost always causes some degree of pneumothorax (air accumulating in the pleural space) or hemothorax (buildup of serous fluid or blood in the pleural space). Air and fluid collect in the pleural space, restricting lung expansion and reducing gas exchange. Placement of a chest tube in the pleural space restores the negative intrathoracic pressure needed for lung re-expansion after surgery or trauma.

The mediastinal space is an extrapleural space that lies between the right and left thoracic cavities and contains the large blood vessels, heart, mainstem bronchus, and thymus gland. If fluid accumulates here, the heart can become compressed and stop beating, causing death. Mediastinal chest tubes can be inserted either anteriorly or posteriorly to the heart to drain blood after surgery.

There are two types of chest tubes: small-bore and large-bore catheters. Small-bore catheters (7 Fr to 12 Fr) have a one-way valve apparatus to prevent air from moving back into the chest. They can be inserted through a small skin incision. Large-bore catheters, which range in size up to 40 Fr, are usually connected to a chest drainage system to collect any pleural fluid and monitor for air leaks. After the

**Table 25-3 COMPARISON OF CHEST DRAINAGE SYSTEMS\***

Types of Chest Drainage Systems	Description	Comments
<b>Traditional Water Seal</b>		
Also referred to as wet suction	Has three chambers: a collection chamber, water seal chamber (middle chamber), and wet suction control chamber	Requires that sterile fluid be instilled into water seal and suction chambers Has positive- and negative-pressure release valves Intermittent bubbling indicates that the system is functioning properly Additional suction can be added by connecting system to a suction source
<b>Dry Suction Water Seal</b>		
Also referred to as dry suction	Has three chambers: a collection chamber, water seal chamber (middle chamber), and wet suction control chamber	Requires that sterile fluid be instilled in water seal chamber at 2-cm level No need to fill suction chamber with fluid Suction pressure is set with a regulator Has positive- and negative-pressure release valves Has an indicator to signify that the suction pressure is adequate Quieter than traditional water seal systems
<b>Dry Suction</b>		
Also referred to as one-way valve system	Has a one-way mechanical valve that allows air to leave the chest and prevents air from moving back into the chest	No need to fill suction chamber with fluid; thus, can be set up quickly in an emergency Works even if knocked over, making it ideal for patients who are ambulatory

\*If no fluid drainage is expected, a drainage collection device may not be needed.

CHART  
25-19

## Guidelines for Managing Chest Drainage Systems

### Equipment

- Chest tube insertion tray (contains chest tube, scalpel, gloves)
- Antiseptic solution
- Local anesthetic agent
- Chest drainage system
- Adhesive tape

### Implementation

#### Actions

1. If using a chest drainage system with a water seal, fill the water seal chamber with sterile water to the level specified by the manufacturer.
2. When using suction in chest drainage systems with a water seal, fill the suction control chamber with sterile water to the 20-cm level or as prescribed. In systems without a water seal, set the regulator dial at the appropriate suction level.
3. Attach the drainage catheter exiting the thoracic cavity to the tubing coming from the collection chamber. Tape securely with adhesive tape.
4. If suction is used, connect the suction control chamber tubing to the suction unit. If using a wet suction system, turn on the suction unit and increase pressure until slow but steady bubbling appears in the suction control chamber. If using a chest drainage system with a dry suction control chamber, turn the regulator dial to 20 cm H<sub>2</sub>O.

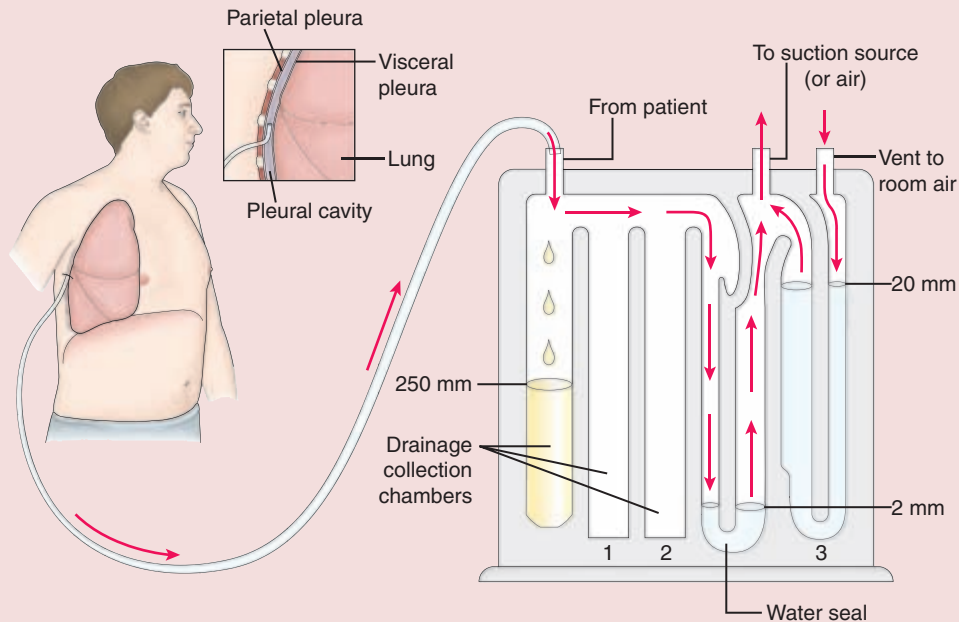
#### Rationale

Water seal drainage allows air and fluid to escape into a drainage chamber. The water acts as a seal and keeps the air from being drawn back into the pleural space. The water level regulator dial setting determines the degree of suction applied.

In chest drainage units, the system is closed. The only connection is the one to the patient's catheter.

With a wet suction system, the degree of suction is determined by the amount of water in the suction control chamber and is not dependent on the rate of bubbling or the pressure gauge setting on the suction unit.

With a dry suction control chamber, the regulator dial replaces the water.



Example of a disposable chest drainage system.

5. Mark the drainage from the collection chamber with tape on the outside of the drainage unit. Mark hourly/daily increments (date and time) at the drainage level.

This marking shows the amount of fluid loss and how fast fluid is collecting in the drainage chamber. It serves as a basis for determining the need for blood replacement, if the fluid is blood. Visibly bloody drainage will appear in the chamber in the immediate postoperative period but should gradually become serous. If the patient is bleeding as heavily as 100 mL every 15 minutes, check the drainage every few minutes. A reoperation or autotransfusion may be needed. The transfusion of blood collected in the drainage chamber must be reinfused within 4 to 6 hours. Usually, however, drainage decreases progressively in the first 24 hours.

*Continued*



## Guidelines for Managing Chest Drainage Systems (Continued)

### Actions

6. Ensure that the drainage tubing does not kink, loop, or interfere with the patient's movements.
7. Encourage the patient to assume a comfortable position with good body alignment. With the lateral position, make sure that the patient's body does not compress the tubing. The patient should be turned and repositioned every 1.5 to 2 hours. Provide adequate analgesia.
8. Assist the patient with range-of-motion exercises for the affected arm and shoulder several times daily. Provide adequate analgesia.
9. Gently "milk" the tubing in the direction of the drainage chamber as needed.
10. Make sure there is fluctuation ("tidaling") of the fluid level in the water seal chamber (in wet systems), or check the air leak indicator for leaks (in dry systems with a one-way valve). *Note:* Fluid fluctuations in the water seal chamber or air leak indicator area will stop when:
  - a. The lung has re-expanded
  - b. The tubing is obstructed by blood clots, fibrin, or kinks
  - c. A loop of tubing hangs below the rest of the tubing
  - d. Suction motor or wall suction is not working properly
11. With a dry system, assess for the presence of the indicator (bellows or float device) when setting the regulator dial to the desired level of suction.
12. Observe for air leaks in the drainage system; they are indicated by constant bubbling in the water seal chamber, or by the air leak indicator in dry systems with a one-way valve. Also assess the chest tube system for correctable external leaks. Notify the physician immediately of excessive bubbling in the water seal chamber not due to external leaks.
13. When turning down the dry suction, depress the manual high-negativity vent, and assess for a rise in the water level of the water seal chamber.
14. Observe and immediately report rapid and shallow breathing, cyanosis, pressure in the chest, subcutaneous emphysema, symptoms of hemorrhage, or significant changes in vital signs.
15. Encourage the patient to breathe deeply and cough at frequent intervals. Provide adequate analgesia. If needed, request an order for patient-controlled analgesia. Also teach the patient how to perform incentive spirometry.
16. If the patient is lying on a stretcher and must be transported to another area, place the drainage system below the chest level. If the tubing disconnects, cut off the contaminated tips of the chest tube and tubing, insert a sterile connector in the cut ends, and reattach to the drainage system. Do *not* clamp the chest tube during transport.
17. When assisting in the chest tube's removal, instruct the patient to perform a gentle Valsalva maneuver or to breathe quietly. The chest tube is then clamped and quickly removed. Simultaneously, a small bandage is applied and made airtight with petrolatum gauze covered by a 4 × 4-inch gauze pad and thoroughly covered and sealed with nonporous tape.

### Rationale

- Kinking, looping, or pressure on the drainage tubing can produce back-pressure, which may force fluid back into the pleural space or impede its drainage.
- Frequent position changes promote drainage, and good body alignment helps prevent postural deformities and contractions. Proper positioning also helps breathing and promotes better air exchange. Analgesics may be needed to promote comfort.
- Exercise helps to prevent ankylosis of the shoulder and to reduce postoperative pain and discomfort. Analgesics may be needed to relieve pain.
- "Milking" prevents the tubing from becoming obstructed by clots and fibrin. Constant attention to maintaining the patency of the tube facilitates prompt expansion of the lung and minimizes complications.
- Fluctuation of the water level in the water seal shows effective connection between the pleural cavity and the drainage chamber and indicates that the drainage system remains patent. Fluctuation is also a gauge of intrapleural pressure in systems with a water seal (wet and dry, but not with the one-way valve).
- An air leak indicator shows changes in intrathoracic pressure in dry systems with a one-way valve. Bubbles will appear if a leak is present. The air leak indicator takes the place of fluid fluctuations in the water seal chamber.
- The indicator shows that the vacuum is adequate to maintain the desired level of suction.
- Leaking and trapping of air in the pleural space can result in tension pneumothorax.
- A rise in the water level of the water seal chamber indicates high negative pressure in the system that could lead to increased intrathoracic pressure.
- Many clinical conditions can cause these signs and symptoms, including tension pneumothorax, mediastinal shift, hemorrhage, severe incisional pain, pulmonary embolus, and cardiac tamponade. Surgical intervention may be necessary.
- Deep breathing and coughing help to raise the intrapleural pressure, which promotes drainage of accumulated fluid in the pleural space. Deep breathing and coughing also promote removal of secretions from the tracheobronchial tree, which in turn promotes lung expansion and prevents atelectasis (alveolar collapse).
- The drainage apparatus must be kept at a level lower than the patient's chest to prevent fluid from flowing backward into the pleural space. Clamping can result in a tension pneumothorax.
- The chest tube is removed as directed when the lung is re-expanded (usually 24 hours to several days), depending on the cause of the pneumothorax. During tube removal, the chief priorities are preventing air from entering the pleural cavity as the tube is withdrawn and preventing infection.

**Chart 25-20 • Preventing Postoperative Cardiopulmonary Complications After Thoracic Surgery****Patient Management**

- Auscultate lung sounds and assess for rate, rhythm, and depth.
- Monitor oxygenation with pulse oximetry.
- Monitor electrocardiogram for rate and rhythm changes.
- Assess capillary refill, skin color, and status of the surgical dressing.
- Encourage and assist the patient to turn, cough, and take deep breaths.

**Chest Drainage Management**

- Verify that all connection tubes are patent and connected securely.
- Assess that the water seal is intact when using a wet suction system and assess the regulator dial in dry suction systems.

- Monitor characteristics of drainage including color, amount, and consistency. Assess for significant increases or decreases in drainage output.
- Note fluctuations in the water seal chamber for wet suction systems and the air leak indicator for dry suction systems.
- Keep system below the patient's chest level.
- Assess suction control chamber for bubbling in wet suction systems.
- Keep suction at prescribed level.
- Maintain appropriate fluid in water seal for wet suction systems.
- Keep air vent open when suction is off.

chest tube is positioned, it is sutured to the skin and connected to a drainage apparatus (Fig. 25-10) to remove the residual air and fluid from the pleural or mediastinal space. This results in the re-expansion of remaining lung tissue.

**Chest Drainage Systems**

Chest drainage systems have a suction source, a collection chamber for pleural drainage, and a mechanism to prevent air from re-entering the chest with inhalation. Various types of chest drainage systems are available for use in removal of air and fluid from the pleural space and re-expansion of the lungs. Chest drainage systems come with either wet (water seal) or dry suction control. In wet suction systems, the amount of suction is determined by the amount of water instilled in the suction chamber. The amount of bubbling in the suction chamber indicates how strong the suction is. Wet systems use a water seal to prevent air from moving back into the chest on inspiration. Dry systems use a one-way valve and may have a suction control dial in place of the water. Both systems can operate by gravity drainage, without a suction source.

**NURSING ALERT**

When the wall vacuum is turned off, the drainage system must be open to the atmosphere so that intrapleural air can escape from the system. This can be done by detaching the tubing from the suction port to provide a vent.

**Water Seal Systems**

The traditional water seal system (or wet suction) for chest drainage has three chambers: a collection chamber, a water seal chamber, and a wet suction control chamber. The collection chamber acts as a reservoir for fluid draining from the chest tube. It is graduated to permit easy measurement of drainage. Suction may be added to create negative pressure and promote drainage of fluid and removal of air. The suction control chamber regulates the amount of negative pressure applied to the chest. The amount of suction is determined by the water level. It is usually set at 20 cm H<sub>2</sub>O; adding more fluid re-

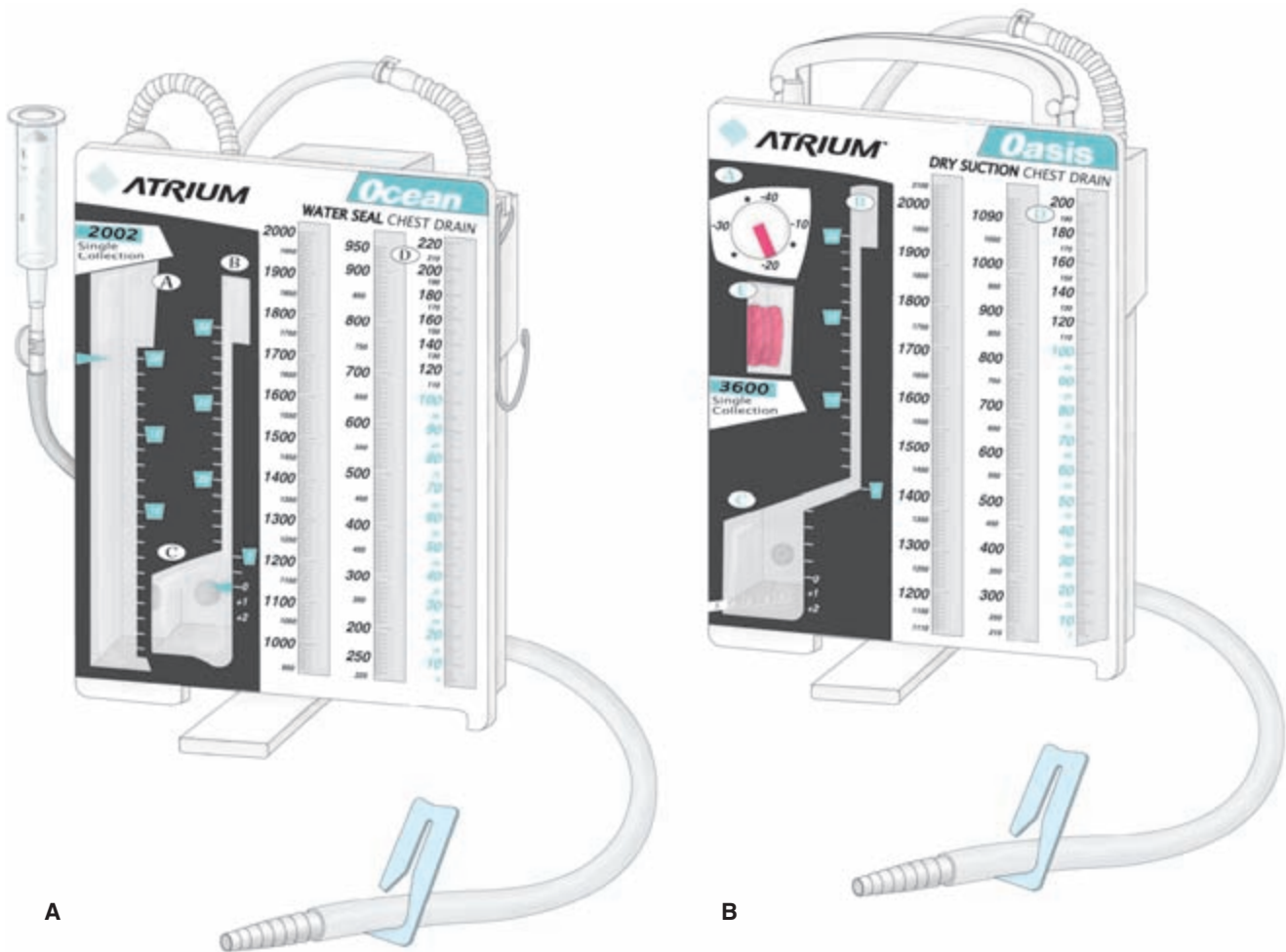
sults in more suction. After the suction is turned on, bubbling appears in the suction chamber. A positive-pressure valve is located at the top of the suction chamber that automatically opens with increases in positive pressure within the system. Air is automatically released through a positive-pressure relief valve if the suction tubing is inadvertently clamped or kinked.

The water seal chamber has a one-way valve or water seal that prevents air from moving back into the chest when the patient inhales. There is an increase in the water level with inspiration and a return to the baseline level during exhalation; this is referred to as tidaling. Intermittent bubbling in the water seal chamber is normal, but continuous bubbling can indicate an air leak. Bubbling and tidaling do not occur when the tube is placed in the mediastinal space; however, fluid may pulsate with the patient's heartbeat. If the chest tube is connected to gravity drainage only, suction is not used. The pressure is equal to the water seal only. Two-chamber chest drainage systems (water seal chamber and collection chamber) are available for use with patients who need only gravity drainage.

The water level in the water seal chamber reflects the negative pressure present in the intrathoracic cavity. A rise in the water level indicates negative pressure in the pleural or mediastinal space. Excessive negative pressure can cause trauma to tissue. Most chest drainage systems have an automatic means to prevent excessive negative pressure. By pressing and holding a manual high-negativity vent (usually located on the top of the chest drainage system) until the water level in the water seal chamber returns to the 2-cm mark, excessive negative pressure is avoided, preventing damage to tissue.

**NURSING ALERT**

If the chest tube and drainage system become disconnected, air can enter the pleural space, producing a pneumothorax. To prevent pneumothorax if the chest tube is inadvertently disconnected from the drainage system, a temporary water seal can be established by immersing the chest tube's open end in a bottle of sterile water.



**Figure 25-10** Chest drainage systems. **A**, The Atrium Ocean is an example of a water seal chest drain system composed of a drainage chamber and water seal chamber. The suction control is determined by the height of the water column in that chamber (usually 20 cm). (A, suction control chamber; B, water seal chamber; C, air leak zone; D, collection chamber.) **B**, The Atrium Oasis is an example of a dry suction water seal system that uses a mechanical regulator for vacuum control, a water seal chamber, and a drainage chamber. (A, dry suction regulator; B, water seal chamber; C, air leak monitor; D, collection chamber; E, suction monitor bellows.) Art redrawn with permission from Atrium Medical Corporation, Hudson, NH.

### Dry Suction Water Seal Systems

Dry suction water seal systems, also referred to as dry suction, have a collection chamber for drainage, a water seal chamber, and a dry suction control chamber. The water seal chamber is filled with water to the 2-cm level. Bubbling in this area can indicate an air leak. The dry suction control chamber contains a regulator dial that conveniently regulates vacuum to the chest drain. Water is not needed for suction in these systems. Without the bubbling in the suction chamber, the machine is quieter. However, if the container is knocked over, the water seal may be lost.

Once the tube is connected to the suction source, the regulator dial allows the desired level of suction to be set; the suction is increased until an indicator appears. The indicator has the same function as the bubbling in the traditional water seal system; that is, it indicates that the vacuum is adequate to maintain the desired level of suction. Some drainage systems use a bellows (a chamber that can

be expanded or contracted) or an orange-colored float device as an indicator of when the suction control regulator is set.

When the water in the water seal rises above the 2-cm level, intrathoracic pressure increases. Dry suction water seal systems have a manual high-negativity vent located on top of the drain. The manual high-negativity vent is pressed until the indicator appears (either a float device or bellows), and the water level in the water seal returns to the desired level, indicating that the intrathoracic pressure is decreased.

### **NURSING ALERT**

The manual vent should not be used to lower the water level in the water seal when the patient is on gravity drainage (no suction) because intrathoracic pressure is equal to the pressure in the water seal.

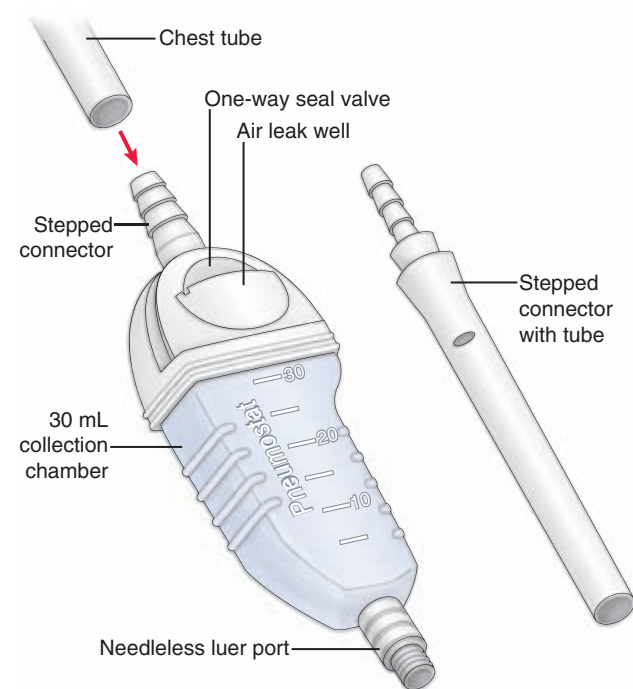
### Dry Suction Systems With a One-Way Valve

A third type of chest drainage system is dry suction with a one-way mechanical valve. This system has a collection chamber, a one-way mechanical valve, and a dry suction control chamber. The valve permits air and fluid to leave the chest but prevents their movement back into the pleural space. This model lacks a water seal chamber and therefore can be set up quickly in emergency situations, and the dry control drain still works even if it is knocked over. This makes the dry suction systems useful for the patient who is ambulating or being transported. However, without the water seal chamber, there is no way to tell by inspection whether the pressure in the chest has changed, even though an air leak indicator is present so that the system can be checked. If an air leak is suspected, 30 mL of water is injected into the air leak indicator or the container is tipped so that fluid enters the air leak detection chamber. Bubbles will appear if a leak is present.

If the chest tube has been inserted to re-expand a lung after pneumothorax, or if very little fluid drainage is expected, a one-way valve (Heimlich valve) may be connected to the chest tube. This valve may be attached to a collection bag (Fig. 25-11) or covered with a sterile dressing if no drainage is expected.

### Postoperative Nursing Management

Postoperative nursing care of the patient who has undergone thoracic surgery addresses close monitoring of the patient's respiratory and cardiovascular status, interventions to prevent complications, and the psychological reactions that often occur in response to this major surgical procedure and the fears that it often engenders in patients and their families.



**Figure 25-11** One-way (Heimlich) valve, a disposable, single-use chest drainage system with 30 mL collection volume. Used when minimal volume of chest drainage is expected.

### Monitoring Respiratory and Cardiovascular Status

The nurse monitors the heart rate and rhythm by auscultation and ECG because episodes of major dysrhythmias are common after thoracic and cardiac surgery. In the immediate postoperative period, an arterial line may be maintained to allow frequent monitoring of arterial blood gases, serum electrolytes, hemoglobin and hematocrit values, and arterial pressure. Central venous pressure may be monitored to detect early signs of fluid volume disturbances; however, central venous pressure monitoring devices are being used less than in the past. Early extubation from mechanical ventilation can also lead to earlier removal of arterial lines. Another important component of postoperative assessment is to note the results of the preoperative evaluation of the patient's lung reserve by pulmonary function testing. A preoperative FEV<sub>1</sub> (the volume of air that the patient can forcibly exhale in 1 second) of more than 2 L or more than 70% of predicted value indicates a good lung reserve. Patients who have a postoperative FEV<sub>1</sub> of less than 40% of predicted value have decreased tidal volume, which places them at risk for respiratory failure, other morbidity, and death.

### Improving Gas Exchange and Breathing

Gas exchange is determined by evaluating oxygenation and ventilation. In the immediate postoperative period, this is achieved by measuring vital signs (blood pressure, pulse, and respirations) at least every 15 minutes for the first 1 to 2 hours, and then less frequently as the patient's condition stabilizes. Pulse oximetry is used for continuous monitoring of the adequacy of oxygenation. Arterial blood gas measurements are obtained early in the postoperative period to establish a baseline to assess the adequacy of oxygenation and ventilation and the possible retention of carbon dioxide. The frequency with which postoperative arterial blood gases are measured depends on whether the patient is mechanically ventilated and whether he or she exhibits signs of respiratory distress; these measurements can help determine appropriate therapy. It also is common practice for patients to have an arterial line in place to obtain blood for blood gas measurements and to monitor blood pressure closely. Hemodynamic monitoring may be used to assess hemodynamic stability.

Breathing techniques, such as diaphragmatic and pursed-lip breathing, taught prior to surgery should be performed by the patient every 2 hours to expand the alveoli and prevent atelectasis. Sustained maximal inspiration therapy or incentive spirometry promotes lung inflation, improves the cough mechanism, and allows early assessment of acute pulmonary changes. (See Charts 25-3 and 25-4 for more information.)

If the patient is oriented and blood pressure is stabilized, the head of the bed is elevated 30 to 40 degrees during the immediate postoperative period. This position facilitates ventilation, promotes chest drainage from the lower chest tube, and helps residual air to rise in the upper portion of the pleural space, where it can be removed through the upper chest tube.

The nurse consults with the surgeon about patient positioning to determine the best side-lying position. In general, the patient should be positioned from back to side

frequently and moved from a flat to a semiupright position as soon as tolerated. Most commonly, the patient is instructed to lie on the operative side. However, the patient with unilateral lung pathology may not be able to turn well onto that side because of pain. In addition, positioning the patient with the “good lung” (the nonoperated lung) down allows a better match of ventilation and perfusion and therefore may actually improve oxygenation. The patient’s position is changed from flat to semiupright as soon as possible because remaining in one position tends to promote the retention of secretions in the dependent portion of the lungs, and the upright position increases diaphragmatic excursion, enhancing lung expansion. After a pneumonectomy, the operated side should be dependent so that fluid in the pleural space remains below the level of the bronchial stump and the other lung can fully expand.

### Improving Airway Clearance

Retained secretions are a threat to the patient after thoracotomy surgery. Trauma to the tracheobronchial tree during surgery, diminished lung ventilation, and diminished cough reflex all result in the accumulation of excessive secretions. If the secretions are retained, airway obstruction occurs. This, in turn, causes the air in the alveoli distal to the obstruction to become absorbed and the affected portion of the lung to collapse. Atelectasis, pneumonia, and respiratory failure may result.

To maintain a patent airway, secretions are suctioned from the tracheobronchial tree before the endotracheal tube is discontinued. Secretions continue to be removed by suctioning until the patient can cough up secretions effectively. Nasotracheal suctioning may be needed to stimulate a deep cough and aspirate secretions that the patient cannot clear by coughing. However, it should be used only after other methods to raise secretions have been unsuccessful (Chart 25-21).

The patient is encouraged to cough effectively to maintain a patent airway; ineffective coughing results in exhaustion and retention of secretions (see Chart 25-5). To be effective, the cough must be low-pitched, deep, and controlled. Because it is difficult to cough in a supine position, the patient is helped to a sitting position on the edge of the bed, with the feet resting on a chair. The patient should cough at least every hour during the first 24 hours and when necessary thereafter. If audible crackles are present, it may be necessary to use chest percussion with the cough routine until the lungs are clear. Aerosol therapy is helpful in humidifying and mobilizing secretions so that they can easily be cleared with coughing. To minimize incisional pain during coughing, the nurse supports the incision or encourages the patient to do so (Fig. 25-12). If a patient is identified as being at high risk for postoperative pulmonary complications, then CPT is started immediately (perhaps even before surgery). The techniques of postural drainage, vibration, and percussion help loosen and mobilize the secretions so that they can be coughed up or suctioned.

Following the use of these measures, the nurse listens to both lungs, anteriorly and posteriorly, to determine whether there are any changes in breath sounds. Diminished breath sounds may indicate collapsed or hypoventilated alveoli.

### Chart 25-21 • Performing Nasotracheal Suction

- Explain procedure to the patient.
- Medicate patient for pain if necessary.
- Place the patient in a sitting or semi-Fowler’s position. Make sure the patient’s head is not flexed forward. Remove excess pillows if necessary.
- Oxygenate the patient several minutes before initiating the suctioning procedure. Have oxygen source ready nearby during procedure.
- Put on sterile gloves.
- Lubricate catheter with water-soluble gel.
- Gently pass catheter through the patient’s nose to the pharynx. If it is difficult to pass the catheter, and repeated suctioning is expected, a soft rubber nasal trumpet may be placed nasopharyngeally to provide easier catheter passage. Check the position of the tip of the catheter by asking the patient to open the mouth to inspect it; the tip of the catheter should be in the lower pharynx.
- Instruct the patient to take a deep breath or stick out the tongue. This action opens the epiglottis and promotes downward movement of the catheter.
- Advance the catheter into the trachea only during inspiration. Listen for cough or for passage of air through the catheter.
- Attach the catheter to suction apparatus. Apply intermittent suction while slowly withdrawing the catheter. Do not let suction exceed 120 mm Hg.
- Do not suction for longer than 10 to 15 seconds, as dysrhythmias, bradycardia, or cardiac arrest may occur in patients with borderline oxygenation.
- If additional suctioning is needed, withdraw the catheter to the back of the pharynx. Reassure patient and oxygenate for several minutes before resuming suctioning.

### Relieving Pain and Discomfort

Pain after a thoracotomy may be severe, depending on the type of incision and the patient’s reaction and ability to cope with pain. Pain can impair the patient’s ability to breathe deeply and cough. Immediately after the surgical procedure and before the incision is closed, the surgeon may perform a nerve block with a long-acting local anesthetic such as bupivacaine (Marcaine, Sensorcaine). Bupivacaine is titrated to relieve postoperative pain while allowing the patient to cooperate in deep breathing, coughing, and mobilization. An epidural catheter may be placed for continuous or PCA using a combination of a long-acting local anesthetic and an opioid, or a continuous epidural infusion may be combined with IV PCA using an opioid (Gottschalk, et al., 2006). Opioid analgesic agents such as morphine are commonly used in PCA, which allows the patient to control the frequency and total dosage. Preset limits on the pump avoid overdosage. With proper instruction, PCA is well tolerated and allows earlier mobilization and cooperation with the treatment regimen. (See Chapter 13 for a more extensive discussion of PCA and pain management.)

It is important to avoid depressing the respiratory system with excessive analgesia: the patient should not be so sedated as to be unable to cough. Inadequate treatment of



A. Nurse's hands should support the chest incision anteriorly and posteriorly. The patient is instructed to take several deep breaths, inhale, and then cough forcibly.



B. With one hand, the nurse exerts downward pressure on the shoulder of the affected side while firmly supporting the area beneath the wound. The patient is instructed to take several deep breaths, inhale, and then cough forcibly.



C. The nurse can wrap a towel or sheet around the patient's chest and hold the ends together, pulling slightly as the patient coughs, and releasing during deep breaths.

D. The patient can be taught to hold a pillow firmly against the incision while coughing. This can be done while lying down or sitting in an up-right position.



**Figure 25-12** Techniques for supporting incision while a patient recovering from thoracic surgery coughs.

pain, however, may also lead to hypoventilation and decreased coughing.

### **NURSING ALERT**

It is important not to confuse the restlessness of hypoxia with the restlessness caused by pain. Dyspnea, restlessness, increasing respiratory rate, increasing blood pressure, and tachycardia are warning signs of impending respiratory insufficiency. Pulse oximetry is used to monitor oxygenation and to differentiate causes of restlessness.

Lidocaine (Xylocaine) and prilocaine (Citanest) are local anesthetic agents that may be used to treat pain at the site of the chest tube insertion. These medications are administered as topical transdermal analgesics that penetrate the skin; they have also been found to be effective when used together. EMLA cream, which is a mixture of the two medications, may be effective in treating pain from chest tube removal. However, many physicians prefer not to use analgesia when removing chest tubes because the pain, although severe, is of short duration (usually less than a few minutes) and the analgesia might interfere with respiratory effort.

### **Promoting Mobility and Shoulder Exercises**

Because large shoulder girdle muscles are transected during a thoracotomy, the arm and shoulder must be mobilized by full range of motion of the shoulder. As soon as physiologically possible, usually within 8 to 12 hours, the patient is helped to get out of bed. Although this may be painful initially, the earlier the patient moves, the sooner the pain will subside. In addition to getting out of bed, the patient begins arm and

shoulder exercises to restore movement and prevent painful stiffening of the affected arm and shoulder (Chart 25-22). Regular doses of acetaminophen can help relieve shoulder pain (Gottschalk, et al., 2006).

### **Maintaining Fluid Volume and Nutrition**

During the surgical procedure or immediately after, the patient may receive a transfusion of blood products, followed by a continuous IV infusion. Because a reduction in lung capacity often occurs after thoracic surgery, a period of physiologic adjustment is needed. Fluids should be administered at a low hourly rate and titrated (as prescribed) to prevent overloading the vascular system and precipitating pulmonary edema. The nurse performs careful respiratory and cardiovascular assessments and monitors intake and output, vital signs, and jugular vein distention. The nurse also monitors the infusion site for signs of infiltration, including swelling, tenderness, and redness.

Patients undergoing thoracotomy may have poor nutritional status before surgery because of dyspnea, sputum production, and poor appetite. Therefore, it is especially important that adequate nutrition be provided. A liquid diet is provided as soon as bowel sounds return, and the patient is progressed to a full diet as soon as possible. Small, frequent meals are better tolerated and are crucial to the recovery and maintenance of lung function.

### **Monitoring and Managing Potential Complications**

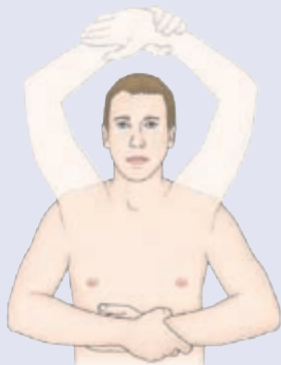
Complications after thoracic surgery are always a possibility and must be identified and managed early. In addition, the nurse monitors the patient at regular intervals for signs of respiratory distress or developing respiratory failure,

CHART  
25-22

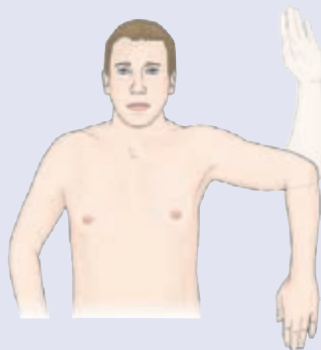
## PATIENT EDUCATION

*Performing Arm and Shoulder Exercises*

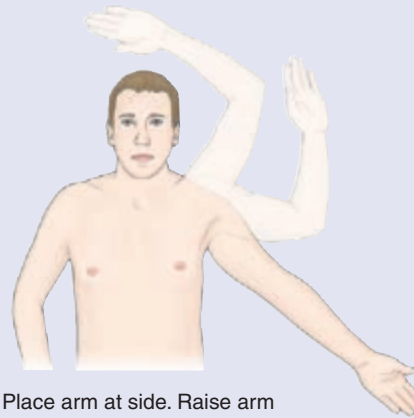
Arm and shoulder exercises are performed after thoracic surgery to restore movement, prevent painful stiffening of the shoulder, and improve muscle power.



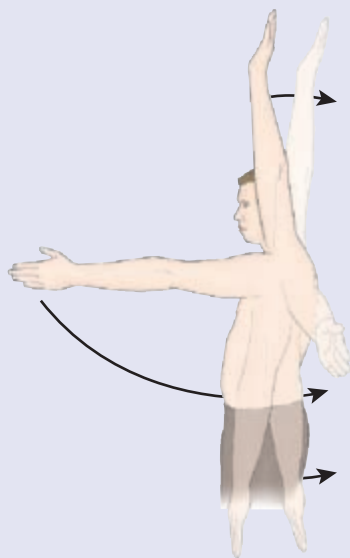
Hold hand of the affected side with the other hand, palms facing in. Raise the arms forward, upward, and then overhead, while taking a deep breath. Exhale while lowering the arms. Repeat five times.



Raise arm sideward, upward, and downward in a waving motion



Place arm at side. Raise arm sideward, upward, and then overhead. Repeat five times. These exercises can also be performed while lying in bed.



Extend the arm up and back, out to the side and back, down at the side, and back.



Place hands in small of back. Push elbows as far back as possible.



Sit erect in an armchair; place the hands on arms of the chair. Press down on hands, consciously pulling the abdomen in and stretching up from the waist. Inhale while raising the body until elbows are extended completely. Hold this position a moment, and begin exhaling while lowering the body slowly to the original position.

dysrhythmias, bronchopleural fistula, hemorrhage and shock, atelectasis, and incisional or pulmonary infection.

Respiratory distress is treated by identifying and eliminating its cause while providing supplemental oxygen. If the patient progresses to respiratory failure, intubation and mechanical ventilation are necessary.

Dysrhythmias are often related to the effects of hypoxia or the surgical procedure. They are treated with antiarrhyth-

mic medication and supportive therapy (see Chapter 27). Pulmonary infections or effusion, often preceded by atelectasis, may occur a few days into the postoperative course.

Pneumothorax may occur after thoracic surgery if there is an air leak from the surgical site to the pleural cavity or from the pleural cavity to the environment. Failure of the chest drainage system prevents return of negative pressure in the pleural cavity and results in pneumothorax. In the

CHART  
25-23

### HOME CARE CHECKLIST

#### The Patient With a Thoracotomy

At the completion of the home care instruction, the patient or caregiver will be able to:	PATIENT	CAREGIVER
• Use local heat and oral analgesia to relieve intercostal pain.	✓	✓
• Alternate walking and other activities with frequent rest periods, expecting weakness and fatigue for the first 3 weeks.	✓	✓
• Perform breathing exercises several times daily for the first few weeks at home.	✓	
• Avoid lifting more than 20 pounds until complete healing has taken place; the chest muscles and incision may be weaker than normal for 3 to 6 months after surgery.	✓	
• Walk at a moderate pace, gradually and persistently extending walking time and distance.	✓	
• Immediately stop any activity that causes undue fatigue, increased shortness of breath, or chest pain.	✓	
• Avoid bronchial irritants (smoke, fumes, air pollution, aerosol sprays).	✓	✓
• Avoid others with known colds or lung infections.	✓	✓
• Obtain an annual influenza vaccine and discuss vaccination against pneumonia with the physician.	✓	
• Report for follow-up care by the surgeon or clinic as necessary.	✓	✓
• Stop smoking, if applicable, and avoid exposure to secondhand smoke.	✓	✓

postoperative patient, pneumothorax is often accompanied by hemothorax. The nurse maintains the chest drainage system and monitors the patient for signs and symptoms of pneumothorax: increasing shortness of breath, tachycardia, increased respiratory rate, and increasing respiratory distress.

Bronchopleural fistula is a serious but rare complication that prevents the return of negative intrathoracic pressure and lung re-expansion. Depending on its severity, it is treated with closed chest drainage, mechanical ventilation, and possibly talc pleurodesis (described in Chapter 23).

Hemorrhage and shock are managed by treating the underlying cause, whether by reoperation or by administration of blood products or fluids. Pulmonary edema from overinfusion of IV fluids is a significant danger. Early symptoms are dyspnea, crackles, bubbling sounds in the chest, tachycardia, and pink, frothy sputum. This constitutes an emergency and must be reported and treated immediately.

### Promoting Home and Community-Based Care

#### Teaching Patients Self-Care

The nurse instructs the patient and family about postoperative care that will be continued at home. The nurse explains signs and symptoms that should be reported to the physician. These include the following:

- Change in respiratory status: increasing shortness of breath, fever, increased restlessness or other changes in mental or cognitive status, increased respiratory rate, change in respiratory pattern, change in amount or color of sputum
- Bleeding or other drainage from the surgical incision or chest tube exit sites
- Increased chest pain

In addition, respiratory care and other treatment modalities (oxygen, incentive spirometry, CPT, and oral, inhaled, or IV medications) may be continued at

home. Therefore, the nurse needs to instruct the patient and family in their correct and safe use.

The nurse emphasizes the importance of progressively increased activity. The nurse instructs the patient to ambulate within limits and explains that return of strength is likely to be very gradual. Another important aspect of patient teaching addresses shoulder exercises. The patient is instructed to do these exercises five times daily. Additional patient teaching is described in Chart 25-23.

#### Continuing Care

Depending on the patient's physical status and the availability of family assistance, a home care referral may be indicated. The home care nurse assesses the patient's recovery from surgery, with special attention to respiratory status, the surgical incision, chest drainage, pain control, ambulation, and nutritional status. The patient's use of respiratory modalities is assessed to ensure that they are being used correctly and safely. In addition, the nurse assesses the patient's adherence to the postoperative treatment plan and identifies acute or late postoperative complications.

The recovery process may take longer than the patient had expected, and providing support to the patient is an important task for the home care nurse. Because of shorter hospital stays, follow-up appointments with the physician are essential. The nurse teaches the patient about the importance of keeping follow-up appointments and completing laboratory tests as prescribed to assist the physician in evaluating recovery. The home care nurse provides continuous encouragement and education to the patient and family during the process. As recovery progresses, the nurse also reminds the patient and family about the importance of participating in health promotion activities and recommended health screening.

For a detailed plan of nursing care for the patient who has had a thoracotomy, see Chart 25-24.



CHART  
25-24

## PLAN OF NURSING CARE

### Care of the Patient After Thoracotomy

**NURSING DIAGNOSIS:** Impaired gas exchange related to lung impairment and surgery  
**GOAL:** Improvement of gas exchange and breathing

#### Nursing Interventions

1. Monitor pulmonary status as directed and as needed:
  - a. Auscultate breath sounds.
  - b. Check rate, depth, and pattern of respirations.
  - c. Assess blood gases for signs of hypoxemia or CO<sub>2</sub> retention.
  - d. Evaluate patient's color for cyanosis.
2. Monitor and record blood pressure, apical pulse, and temperature every 2–4 hours, central venous pressure (if indicated) every 2 hours.
3. Monitor continuous electrocardiogram for pattern and dysrhythmias.
4. Elevate head of bed 30–40 degrees when patient is oriented and hemodynamic status is stable.
5. Encourage deep-breathing exercises (see section on Breathing Retraining) and effective use of incentive spirometer (sustained maximal inspiration).
6. Encourage and promote an effective cough routine to be performed every 1–2 hours during first 24 hours.
7. Assess and monitor the chest drainage system\*
  - a. Assess for leaks and patency as needed (See Chart 25–19).
  - b. Monitor amount and character of drainage and document every 2 hours. Notify physician if drainage is 150 mL/h or greater.

#### Rationale

1. Changes in pulmonary status indicate improvement or onset of complications.
2. Aid in evaluating effect of surgery on cardiac status.
3. Dysrhythmias (especially atrial fibrillation and atrial flutter) are more frequently seen after thoracic surgery. A patient with total pneumonectomy is especially prone to cardiac irregularity.
4. Maximum lung excursion is achieved when patient is as close to upright as possible.
5. Helps to achieve maximal lung inflation and to open closed airways.
6. Coughing is necessary to remove retained secretions.
7. System is used to eliminate any residual air or fluid after thoracotomy.

#### Expected Outcomes

- Lungs are clear on auscultation
- Respiratory rate is within acceptable range with no episodes of dyspnea
- Vital signs are stable
- Dysrhythmias are not present or are under control
- Demonstrates deep, controlled, effective breathing to allow maximal lung expansion
- Uses incentive spirometer every 2 hours while awake
- Demonstrates deep, effective coughing technique
- Lungs are expanded to capacity (evidenced by chest x-ray)

**NURSING DIAGNOSIS:** Ineffective airway clearance related to lung impairment, anesthesia, and pain  
**GOAL:** Improvement of airway clearance and achievement of a patent airway

#### Nursing Interventions

1. Maintain an open airway.
2. Perform endotracheal suctioning until patient can raise secretions effectively.
3. Assess and medicate for pain. Encourage deep-breathing and coughing exercises. Help splint incision during coughing.

#### Rationale

1. Provides for adequate ventilation and gas exchange.
2. Endotracheal secretions are present in excessive amounts in postthoracotomy patients due to trauma to the tracheo-bronchial tree during surgery, diminished lung ventilation, and cough reflex.
3. Helps to achieve maximal lung inflation and to open closed airways. Coughing is painful; incision needs to be supported.

#### Expected Outcomes

- Airway is patent
- Coughs effectively
- Splints incision while coughing
- Sputum is clear or colorless
- Lungs are clear on auscultation

\*A patient with a pneumonectomy usually does not have water seal chest drainage because it is desirable that the pleural space fill with an effusion, which eventually obliterates this space. Some surgeons do use a modified water seal system.


 CHART  
25-24

**PLAN OF NURSING CARE**
**Care of the Patient After Thoracotomy (Continued)**

Nursing Interventions	Rationale	Expected Outcomes
<ol style="list-style-type: none"> <li>4. Monitor amount, viscosity, color, and odor of sputum. Notify physician if sputum is excessive or contains bright-red blood.</li> <li>5. Administer humidification and mini-nebulizer therapy as prescribed.</li> <li>6. Perform postural drainage, percussion, and vibration as prescribed. Do not percuss or vibrate directly over operative site.</li> <li>7. Auscultate both sides of chest to determine changes in breath sounds.</li> </ol>	<ol style="list-style-type: none"> <li>4. Changes in sputum suggest presence of infection or change in pulmonary status. Colorless sputum is not unusual; opacification or coloring of sputum may indicate dehydration or infection.</li> <li>5. Secretions must be moistened and thinned if they are to be raised from the chest with the least amount of effort.</li> <li>6. Chest physiotherapy uses gravity to help remove secretions from the lung.</li> <li>7. Indications for tracheal suctioning are determined by chest auscultation.</li> </ol>	
<b>NURSING DIAGNOSIS:</b> Acute pain related to incision, drainage tubes, and the surgical procedure <b>GOAL:</b> Relief of pain and discomfort		
Nursing Interventions	Rationale	Expected Outcomes
<ol style="list-style-type: none"> <li>1. Evaluate location, character, quality, and severity of pain. Administer analgesic medication as prescribed and as needed. Observe for respiratory effect of opioid. Is patient too somnolent to cough? Are respirations depressed?</li> <li>2. Maintain care postoperatively in positioning the patient:             <ol style="list-style-type: none"> <li>a. Place patient in semi-Fowler's position.</li> <li>b. Patients with limited respiratory reserve may not be able to turn on unoperated side.</li> <li>c. Assist or turn patient every 2 hours.</li> </ol> </li> <li>3. Assess incision area every 8 hours for redness, heat, induration, swelling, separation, and drainage.</li> <li>4. Request order for patient-controlled analgesia pump if appropriate for patient.</li> </ol>	<ol style="list-style-type: none"> <li>1. Pain limits chest excursions and thereby decreases ventilation.</li> <li>2. The patient who is comfortable and free of pain will be less likely to splint the chest while breathing. A semi-Fowler's position permits residual air in the pleural space to rise to upper portion of pleural space and be removed via the upper chest catheter.</li> <li>3. These signs indicate possible infection.</li> <li>4. Allowing patient control over frequency and dose improves comfort and compliance with treatment regimen.</li> </ol>	<ul style="list-style-type: none"> <li>• Asks for pain medication, but verbalizes that he or she expects some discomfort while deep breathing and coughing</li> <li>• Verbalizes that he or she is comfortable and not in acute distress</li> <li>• No signs of incisional infection evident</li> </ul>
<b>NURSING DIAGNOSIS:</b> Anxiety related to outcomes of surgery, pain, technology <b>GOAL:</b> Reduction of anxiety to a manageable level		
Nursing Interventions	Rationale	Expected Outcomes
<ol style="list-style-type: none"> <li>1. Explain all procedures in understandable language.</li> <li>2. Assess for pain and medicate, especially before potentially painful procedures.</li> <li>3. Silence all <i>unnecessary</i> alarms on technology (monitors, ventilators).</li> </ol>	<ol style="list-style-type: none"> <li>1. Explaining what can be expected in understandable terms decreases anxiety and increases cooperation.</li> <li>2. Premedication before painful procedures or activities improves comfort and minimizes undue anxiety.</li> <li>3. <i>Unnecessary</i> alarms increase the risk of sensory overload and may increase anxiety. <i>Essential</i> alarms must be turned on at all times.</li> </ol>	<ul style="list-style-type: none"> <li>• States that anxiety is at a manageable level</li> <li>• Participates with health care team in treatment regimen</li> <li>• Uses appropriate coping skills (verbalization, pain relief strategies, use of support systems such as family, clergy)</li> <li>• Demonstrates basic understanding of technology used in care</li> </ul>

Continued

CHART  
25-24

## PLAN OF NURSING CARE

## Care of the Patient After Thoracotomy (Continued)

<p><b>Nursing Interventions</b></p> <ol style="list-style-type: none"> <li>4. Encourage and support patient while increasing activity level.</li> <li>5. Mobilize resources (family, clergy, social worker) to help patient cope with outcomes of surgery (diagnosis, change in functional abilities).</li> </ol>	<p><b>Rationale</b></p> <ol style="list-style-type: none"> <li>4. Positive reinforcement improves patient motivation and independence.</li> <li>5. A multidisciplinary approach promotes the patient's strengths and coping mechanisms.</li> </ol>	<p><b>Expected Outcomes</b></p>
<p><b>NURSING DIAGNOSIS:</b> Impaired physical mobility of the upper extremities related to thoracic surgery  <b>GOAL:</b> Increased mobility of the affected shoulder and arm</p>		
<p><b>Nursing Interventions</b></p> <ol style="list-style-type: none"> <li>1. Assist patient with normal range of motion and function of shoulder and trunk:             <ol style="list-style-type: none"> <li>a. Teach breathing exercises to mobilize thorax.</li> <li>b. Encourage skeletal exercises to promote abduction and mobilization of shoulder (see Chart 25-22).</li> <li>c. Assist out of bed to chair as soon as pulmonary and circulatory systems are stable (usually by evening of surgery).</li> </ol> </li> <li>2. Encourage progressive activities according to level of fatigue.</li> </ol>	<p><b>Rationale</b></p> <ol style="list-style-type: none"> <li>1. Necessary to regain normal mobility of arm and shoulder and to speed recovery and minimize discomfort.</li> <li>2. Increases patient's use of affected shoulder and arm.</li> </ol>	<p><b>Expected Outcomes</b></p> <ul style="list-style-type: none"> <li>• Demonstrates arm and shoulder exercises and verbalizes intent to perform them on discharge</li> <li>• Regains previous range of motion in shoulder and arm</li> </ul>
<p><b>NURSING DIAGNOSIS:</b> Risk for imbalanced fluid volume related to the surgical procedure  <b>GOAL:</b> Maintenance of adequate fluid volume</p>		
<p><b>Nursing Interventions</b></p> <ol style="list-style-type: none"> <li>1. Monitor and record hourly intake and output. Urine output should be at least 30 mL/h after surgery.</li> <li>2. Administer blood component therapy and parenteral fluids and/or diuretics as prescribed to restore and maintain fluid volume.</li> </ol>	<p><b>Rationale</b></p> <ol style="list-style-type: none"> <li>1. Fluid management may be altered before, during, and after surgery, and patient's response to and need for fluid management must be assessed.</li> <li>2. Pulmonary edema due to transfusion or fluid overload is an ever-present threat; after pneumonectomy, the pulmonary vascular system has been greatly reduced.</li> </ol>	<p><b>Expected Outcomes</b></p> <ul style="list-style-type: none"> <li>• Patient is adequately hydrated, as evidenced by:             <ul style="list-style-type: none"> <li>• Urine output greater than 30 mL/h</li> <li>• Vital signs stable, heart rate, and central venous pressure approaching normal</li> </ul> </li> <li>• No excessive peripheral edema</li> </ul>
<p><b>NURSING DIAGNOSIS:</b> Deficient knowledge of home care procedures  <b>GOAL:</b> Increased ability to carry out care procedures at home</p>		
<p><b>Nursing Interventions</b></p> <ol style="list-style-type: none"> <li>1. Encourage patient to practice arm and shoulder exercises five times daily at home.</li> <li>2. Instruct patient to practice assuming a functionally erect position in front of a full-length mirror.</li> <li>3. Instruct patient about home care (see chart 25-3).</li> </ol>	<p><b>Rationale</b></p> <ol style="list-style-type: none"> <li>1. Exercise accelerates recovery of muscle function and reduces long-term pain and discomfort.</li> <li>2. Practice will help restore normal posture.</li> <li>3. Knowing what to expect facilitates recovery.</li> </ol>	<p><b>Expected Outcomes</b></p> <ul style="list-style-type: none"> <li>• Demonstrates arm and shoulder exercises</li> <li>• Verbalizes need to try to assume an erect posture</li> <li>• Verbalizes the importance of relieving discomfort, alternating walking and rest, performing breathing exercises, avoiding heavy lifting, avoiding undue fatigue, avoiding bronchial irritants, preventing colds or lung infections, getting influenza vaccine, keeping follow-up visits, and stopping smoking</li> </ul>

## CRITICAL THINKING EXERCISES

**1** A 20-year-old woman who was admitted to your unit because of sudden onset of severe chest pain is diagnosed with spontaneous pneumothorax. A physician will insert a chest tube with a Heimlich valve shortly. What do your patient and her family need to know about the procedure? What supplies do you think you will need in the room for the chest tube insertion? What assessments will be necessary immediately after chest tube insertion? In 1 hour?

**2** A 72-year-old man who has COPD from working as a coal miner has pneumonia in his right lower and middle lobes. To help mobilize and drain the secretions, CPT is prescribed. The patient only wants to sit in bed because it is easier for him to breathe when in the semi-Fowler's position. What positions are the most important for successful CPT? What can you do to aid him during the treatments?

**3** Oxygen therapy is required for the following patients: a 59-year-old patient who has just been diagnosed with severe COPD and will need lifelong supplemental oxygen; a 21-year-old patient who was rescued from a house fire and needs short-term oxygen therapy because of exposure to smoke; and a 65-year-old patient with terminal metastatic cancer. Compare and contrast the similarities and differences in the oxygen therapy necessary for each patient, and discuss teaching and safety precautions indicated for each patient and his or her family. Describe the patient teaching that will be required for the patients who will be discharged from the hospital with a prescription for oxygen therapy.

**4** **EBP** Following an episode of flu, a 50-year-old woman developed respiratory failure and was intubated. Three weeks later, because of complications that prevented extubation, a tracheostomy was performed. She has been relying on the ventilator for more than 2 months and is now strong enough to begin weaning. However, whenever the respiratory technician adjusts the ventilator settings, she becomes extremely anxious and starts hyperventilating. How will you explain the weaning process to her? What other antianxiety measures may be helpful? Develop an evidence-based practice weaning plan for this patient.

**5** Your patient has just returned from the operating room after thoracic surgery. She has an endotracheal tube, two chest tubes, two IV lines, an epidural catheter, and an indwelling urinary catheter in place. The surgeon's orders include ventilator settings, a cardiac monitor, "stat" complete blood cell (CBC) count on arrival to the intensive care unit, and arterial blood gases in 1 hour. What are your immediate priorities for assessment for this patient? What observations need to be reported to the surgeon immediately? What other nursing interventions are warranted immediately? In 8 hours? At 24 hours and 48 hours postoperatively?



The Smeltzer suite offers these additional resources to enhance learning and facilitate understanding of this chapter:

- thePoint on line resource, [thepoint.lww.com/Smeltzer12E](http://thepoint.lww.com/Smeltzer12E)
- Student CD-ROM included with the book
- *Study Guide to Accompany Brunner & Suddarth's Textbook of Medical-Surgical Nursing*

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## RESOURCES

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- American Lung Association, [www.lungusa.org](http://www.lungusa.org)
- American Thoracic Society, [www.thoracic.org](http://www.thoracic.org)
- National Heart, Lung, and Blood Institute/National Institutes of Health, [www.nhlbi.nih.gov/index.htm](http://www.nhlbi.nih.gov/index.htm)
- National Lung Health Education Program, [www.nlhep.org](http://www.nlhep.org) (has easy-to-read teaching resources for patients)