## CHAPTER 8

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## The Airway

### KEY TERMS

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<th>Term</th>
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<tr>
<td><strong>Airway</strong></td>
<td>The respiratory system structures through which air passes.</td>
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<td><strong>Alveoli</strong></td>
<td>The air sacs in the lungs where gas exchange takes place.</td>
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<td><strong>Bag-valve-mask (BVM)</strong></td>
<td>A common ventilation device consisting of a self-inflating bag, a one-way valve, a mask, and an oxygen reservoir.</td>
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<td><strong>Bronchi</strong></td>
<td>The two major branches of the trachea into each lung.</td>
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<td><strong>Cricoid ring</strong></td>
<td>A firm cartilage ring just inferior to the lower portion of the larynx.</td>
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<td><strong>Cyanotic</strong></td>
<td>Bluish discoloration of mucous membranes and skin caused by hypoperfusion of tissues.</td>
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<td><strong>Diaphragm</strong></td>
<td>The large, dome-shaped muscle that separates the thoracic cavity from the abdominal cavity, used in breathing.</td>
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<td><strong>Epiglottis</strong></td>
<td>The flaplike structure that prevents food and liquid from entering the trachea during swallowing.</td>
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<td><strong>Gag reflex</strong></td>
<td>A reflex that causes the patient to retch when the back of the throat is stimulated; this reflex helps unresponsive patients protect their airways.</td>
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<tr>
<td><strong>Glottis</strong></td>
<td>The passageway into the trachea from the pharynx.</td>
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<tr>
<td><strong>Intercostal muscles</strong></td>
<td>Muscles located between the ribs that move with breathing.</td>
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<tr>
<td><strong>Jaw thrust</strong></td>
<td>A method of opening the airway by displacing the jaw forward; used instead of the head-tilt chin-lift in patients with suspected spinal injury.</td>
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<td><strong>Laryngectomy</strong></td>
<td>A surgical procedure in which the larynx is removed.</td>
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<td><strong>Larynx</strong></td>
<td>The voice box, or vocal cords, consisting of bands of cartilage that vibrate when the person speaks.</td>
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<tr>
<td><strong>Nasal cannula</strong></td>
<td>A device for delivering oxygen via tubing that has holes that blow oxygen directly into the patient's nostrils.</td>
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<tr>
<td><strong>Nasopharyngeal airway</strong></td>
<td>A flexible tube of rubber or plastic that is inserted into the patient's nostril to provide an air passage.</td>
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<tr>
<td><strong>Nasopharynx</strong></td>
<td>The part of the pharynx behind the nose.</td>
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<tr>
<td><strong>Nonrebreather mask</strong></td>
<td>A high-flow device for delivering oxygen to the patient.</td>
</tr>
<tr>
<td><strong>Oropharyngeal airway</strong></td>
<td>A curved piece of plastic that goes into the patient's mouth and lifts the tongue out of the oropharynx.</td>
</tr>
<tr>
<td><strong>Oropharynx</strong></td>
<td>The part of the pharynx behind the mouth.</td>
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<tr>
<td><strong>Pharynx</strong></td>
<td>The part of the airway behind the nose and mouth that is divided into two regions: the nasopharynx and the oropharynx.</td>
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<tr>
<td><strong>Suction devices</strong></td>
<td>Devices used to suction secretions and fluids from the mouth and oropharynx of unresponsive patients.</td>
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<tr>
<td><strong>Trachea</strong></td>
<td>The windpipe.</td>
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<td><strong>Tracheal stoma</strong></td>
<td>A permanent artificial opening in the trachea.</td>
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THE RESPIRATORY SYSTEM

The respiratory system includes all body structures through which air passes, including the nose, mouth, pharynx, trachea, bronchi, and lungs. Collectively, these tubes and passageways are known as the airway. Because the body requires a continuous supply of oxygen and removal of carbon dioxide, anything that blocks or obstructs the airway is a serious threat to life. As an EMT, you will use your most critical skills to ensure that the patient’s airway remains clear and open.

RESPIRATORY ANATOMY

Familiarity with the anatomy of the airway helps you understand airway management (Fig. 8-1). The airway begins with the mouth and nose and continues into the pharynx. The pharynx is divided into two regions: the nasopharynx and the oropharynx. The area just behind the nose is the nasopharynx, and the oropharynx lies just inferior to (below) the nasopharynx and is commonly called the back of the throat.

The passageway into the trachea, or windpipe, is called the glottis. The epiglottis is a flaplike structure located just superior to (above) the glottis. This flap of tissue prevents food and liquid from entering the trachea during swallowing.

The larynx, or voice box, lies just inferior to the glottic opening. The larynx forms the prominence commonly called the Adam’s apple. The larynx is also known as the thyroid cartilage. Inferior to the larynx is the cricoid ring, which is the first of the tracheal rings. The cricoid ring is an important landmark because it is the only tracheal ring that is a complete circle of firm cartilage.

As the trachea descends from the cricoid ring, it divides into the left and right bronchi. Each bronchus subdivides into smaller and smaller branches, ending at the alveoli, where gas exchange takes place (Fig. 8-2).

The main muscles of respiration are the diaphragm and the intercostal muscles. The diaphragm is the large, dome-shaped muscle that separates the thoracic and abdominal cavities. The intercostal muscles between the ribs cause the ribs to flare outward and upward when they contract, increasing the size of the thoracic cavity.

When the diaphragm contracts it flattens, moving downward. The contraction of the diaphragm and intercostal muscles increases the size of the chest and creates a negative pressure, pulling air into the lungs through the mouth and nose. Inhalation is therefore an active process controlled by muscle contraction and negative thoracic pressure. During exhalation, the diaphragm and intercostal muscles relax. The diaphragm moves upward, and the ribs move downward and inward. This movement decreases the size of the chest, moving air out through the mouth and nose. Ordinarily, exhalation is a passive process that occurs when the muscles relax. In cases of respiratory distress, the abdominal and intercostal muscles may be used to force exhalation.

RESPIRATORY PHYSIOLOGY

The process of exchanging oxygen and carbon dioxide is essential for life. Any interruption of respiration can be fatal within minutes. This gas exchange occurs at two sites: the alveolar/capillary exchange and the capillary/cellular exchange.

Air entering the lungs is rich in oxygen and low in carbon dioxide. The blood pumped to the lungs from the right side of the heart is low in oxygen and high in carbon dioxide. This causes the oxygen from the alveoli to enter the bloodstream, and carbon dioxide to move out of the blood into the alveoli, where it will be exhaled from the lungs.

The process is reversed at the capillary/cellular level. Blood in the arteries entering the capillaries is high in oxygen and low in carbon dioxide. The blood in the capillaries releases oxygen to the cells, and the cells
Figure 8-1  Anatomy of the respiratory system.
give up their carbon dioxide to the blood in the capillaries where it is transported to the lungs to be exhaled.

**Adequate Breathing**
To meet the oxygen demands of the body, a person must breathe at an adequate rate and depth. The number of breaths in 1 minute is called the *respiratory rate*. Box 8-1 lists the normal ranges of respiratory rates. The amount of air that a person inhales and exhales in one breath is called the *tidal volume*. The tidal volume for an average-sized adult man is approximately 500 mL.

Normal breathing is regular, relaxed, and quiet. Patients feel they are getting enough air, and the chest expands equally on both sides. Breath sounds are present and equal bilaterally (on the right and left sides). There is no visible effort associated with breathing.

**Inadequate Breathing**
In almost all cases, respiratory difficulty is a true emergency. Rapid recognition of inadequate breathing is one of the most important skills to master as an EMT. Often, the first clue that indicates inadequate breathing is a change in respiratory rate—either too fast or too slow. It is possible, however, for the patient’s respiratory rate to be normal while the tidal volume is below normal. Either situation (abnormal rate or below-normal tidal volume) results in inadequate breathing.

The easiest way to be sure that a patient has an adequate tidal volume is to observe the chest rising and falling with each ventilation. If the chest is only moving slightly, the tidal volume is inadequate.

Any patient complaining of difficulty breathing or shortness of breath is displaying symptoms of respiratory distress. Box 8-2 lists the major signs and symptoms of inadequate breathing.

**Considerations for Infants and Children**
Because the airway structures in infants and children are smaller than in adults, the airway is more easily obstructed. The tongue takes up proportionally more space in infants’ and children’s mouths (Fig. 8-3). The large tongue can easily fall against the back of the

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**Box 8-1**

**Normal Respiratory Rates**
- Adult: 12–20 per minute
- Children: 15–30 per minute
- Infants: 25–50 per minute

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*Figure 8-2* In the lungs, capillaries surround the alveoli.

*Figure 8-3* In infants and children the airway is more easily obstructed, and the tongue takes up proportionally more space in the mouth.
throat and block the airway if the patient is in the supine position.

Because the trachea in infants and children is very narrow, it can become easily obstructed by even a small amount of fluid or swelling. The infant’s trachea is so soft and flexible that it can be kinked by positioning the head incorrectly, especially by hyperextension of the neck or tilting the head back too far. The cricoid ring is pliable and less-developed than in adults.

The chest wall of infants and children is also very pliable. Because the intercostal muscles are weaker, children use the diaphragm more than the rib cage for inspiration. An important sign of inadequate respiration in infants and children is the visible use of the muscles in the chest and neck to assist breathing and nasal flaring.

**OXYGEN**

For normal body functioning, a constant supply of oxygen is required by every cell in the body. During normal respiration, we can get enough oxygen for body functioning from breathing room air. In illness or injury, however, the amount of oxygen in the blood may decrease as a result of respiratory difficulty, cardiac failure, blood loss, or chest trauma. The body may also require more oxygen in times of stress. In these situations, the patient requires supplemental oxygen to decrease the possibility of permanent damage.

**OXYGEN SOURCES**

The oxygen used in most EMS systems is stored in high-pressure tanks. Tanks come in several common sizes (Fig. 8-4; Table 8-1). Oxygen tanks are usually filled to about 2000 pounds of pressure per square inch. Because this great pressure could explode if a tank were damaged, always handle oxygen tanks carefully. The most delicate parts of the tanks are the

### Table 8-1

<table>
<thead>
<tr>
<th>CYLINDER</th>
<th>CAPACITY (L)</th>
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<tr>
<td>D</td>
<td>350</td>
</tr>
<tr>
<td>E</td>
<td>625</td>
</tr>
<tr>
<td>M</td>
<td>3000</td>
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<tr>
<td>G</td>
<td>5300</td>
</tr>
<tr>
<td>H</td>
<td>6900</td>
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The oxygen used in most EMS systems is stored in high-pressure tanks. Tanks come in several common sizes (Fig. 8-4; Table 8-1). Oxygen tanks are usually filled to about 2000 pounds of pressure per square inch. Because this great pressure could explode if a tank were damaged, always handle oxygen tanks carefully. The most delicate parts of the tanks are the

**Figure 8-4** Common sizes of oxygen tanks. The D tank is small, the E tank medium, and the M tank is large.

**REVIEW QUESTIONS**

**THE RESPIRATORY SYSTEM**

1. What happens when the diaphragm contracts?
2. Exhalation is normally a(n) (active/passive) process.
3. What is the most common symptom of acute respiratory distress?
4. Describe the differences in the proportion of the tongue to the mouth in an infant compared to an adult.

**BOX 8-2**

**Signs and Symptoms of Inadequate Breathing**

- Difficulty breathing, shortness of breath
- Too fast or too slow rate
- Irregular rhythm
- Diminished or absent breath sounds
- Unequal or inadequate chest expansion
- Increased effort of breathing
- Inadequate tidal volume, shallow breathing
- Cyanotic, pale, or cool and clammy skin
- Use of accessory muscles, retractions above the clavicles and between the ribs, nasal flaring, and seesaw breathing in infants and children
- Noisy respirations
- Patients sitting straight up or leaning slightly forward (tripod position)
- Changes in level of consciousness
Nonrebreather masks. This mask is the preferred prehospital method of delivering high concentrations of oxygen to the patient. This high-flow device can deliver up to 90% oxygen when the flow rate is set at 15 L/min. The nonrebreather mask stores oxygen in a reservoir bag. Inflate this bag with oxygen before you place the mask on the patient, and be sure that it does not collapse completely while the patient is breathing (Fig. 8-6).

Nonrebreather masks come in a variety of sizes. The proper mask should fit from the bridge of the patient’s nose to just below the bottom lip. Regardless of the mask size, the flow rate should be set at 15 L/min.

In the past, EMTs were instructed to withhold high-flow oxygen administration in certain patients. The standard has changed, however, for prehospital settings. Any adult, child, or infant who is in respiratory distress should receive high-concentration oxygen.

Some patients become very apprehensive when a mask is placed on their face. Usually, if you explain that they are receiving high concentrations of oxygen and that this will help them breathe more easily, they will calm down. Some patients are more comfortable if they hold the mask on their face, instead of having the strap around their head. Having a parent hold the

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**EQUIPMENT FOR OXYGEN DELIVERY**

**Oxygen Regulators**

To deliver the oxygen to the patient at the correct pressure and flow rate, a regulator is used (Fig. 8-5). The regulator attaches to the valve of the tank to control the flow of oxygen. Just as with a water faucet, you control the flow rate by adjusting the regulator. Technique 8-1 describes how to attach the regulator to the tank.

Some regulators have humidifiers that moisten the oxygen before it reaches the patient. Humidified oxygen is used more often in long-term oxygen therapy and generally is not used by EMTs.

**Oxygen Delivery Devices**

Once the flow of oxygen is regulated to the desired rate, described as liters per minute or L/min, it is delivered to the patient by a delivery device. Many types of oxygen delivery devices are available, but only two are generally used by EMTs in prehospital care: nonrebreather masks and nasal cannulas. If you work in a setting where another type of mask is used, be sure to learn about it.

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**Figure 8-5** Three different kinds of oxygen flow regulators.

**Figure 8-6** Inflate the nonrebreather bag with oxygen before you place the mask on the patient.
mask close to a child’s mouth and nose may help calm a child. If the patient will not tolerate an oxygen mask, you may need to use a nasal cannula.

**Nasal cannulas.** Nasal cannulas are a low-concentration alternative to delivering oxygen by mask (Fig. 8-7). The cannula is simply a piece of tubing that has holes that blow oxygen directly into the patient’s nostrils. Nasal cannulas are often used for long-term oxygen therapy in a medical facility or at home. With a nasal cannula, you should set the flow rate up to 6 L/min.

In prehospital settings, nasal cannulas should be used only for patients who are still uncomfortable with the mask after you have reassured them that they are getting plenty of oxygen. The nasal cannula is a low-flow device and is a poor alternative to the nonrebreather mask in patients requiring high concentrations of oxygen. However, it is better than nothing if the patient absolutely will not tolerate the mask.

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**TECHNIQUE 8-1**

**Attaching the Regulator to the Oxygen Tank**

1. Remove the protective seal from the valve on the tank.
2. Attached to the seal is a washer that provides an air-tight seal between the regulator and the tank. Be sure not to lose it.
3. Quickly open and close the valve to blow any dirt or contamination out of the tank opening. Be sure that the valve is facing away from you or anyone else.
4. Place the washer over the inlet port on the regulator.

Continued
5. Line up the regulator inlet port and pins with the tank opening and holes in the tank valve. The pins are designed so that only the correct regulator fits the tank. Be sure that the flow meter is turned off.

6. Tighten the screw by hand.

7. Open the tank valve to test that you have an air-tight seal. If oxygen is leaking, tighten the screw until the leak stops.

8. Adjust the flow meter to the desired setting. When finished, turn off the flow meter and close the tank valve. Release the pressure from the regulator by momentarily opening the flow meter.

**Review Questions**

**Oxygen**

1. What is the purpose of an oxygen regulator?
2. What flow rate should you use for administering oxygen via a nonrebreather mask?
3. When should you use a nasal cannula to deliver oxygen?
OPENING THE AIRWAY

MANUAL POSITIONING

Unresponsive patients lose muscular control of the jaw. If the patient is in the supine position, the jaw falls posteriorly, the base of the tongue can contact the back of the throat, and the epiglottis may block the glottic opening (Fig. 8-8). These three events close the airway and make it impossible to move air from the mouth and nose to the lungs.

The most common method of opening the airway is the head-tilt chin-lift technique. Tilting the head back and lifting the chin pulls the base of the tongue out of the oropharynx and lifts the epiglottis away from the glottis (Fig. 8-9). This simple technique requires no equipment and should be performed immediately whenever you are treating an unresponsive patient with no suspected trauma. To avoid placing pressure on the soft tissue under the chin, tilt the head by using two fingers under the bony surface of the chin.

Figure 8-8 Unresponsive patients may lose muscular control of the jaw. This may cause the tongue to contact the back of the throat, obstructing the airway.

Figure 8-9 When you tilt the head back and lift the chin, the base of the tongue and the epiglottis are lifted out of the airway.
AIRWAY ADJUNCTS

Oropharyngeal airways and nasopharyngeal airways are devices that help open and maintain the airway. One of these two devices should be used when patients are unable to control their airway.

Oropharyngeal Airway

The oropharyngeal airway (Fig. 8-11) is a curved piece of plastic that goes into the patient’s mouth and assists in lifting the tongue out of the oropharynx (Fig. 8-12). It is also called an oral airway or an OP airway. The gag reflex causes the patient to retch when the back of the throat is stimulated. This reflex helps prevent foreign bodies from entering the airway. Unresponsive patients who lose the gag reflex are at very high risk for airway obstructions and aspiration of material into the lungs. The oral airway should be used anytime the patient is unresponsive and has no gag reflex. If the oral airway is used in a patient who has a gag reflex, the patient may gag or vomit. This can seriously threaten the airway. Technique 8-2 describes the...
1. Put on gloves. Select the properly sized airway, which should measure from the corner of the patient’s mouth to the earlobe or angle of the jaw. Position yourself at the patient’s side.

2. Open the patient’s mouth by lifting the jaw and tongue. Insert the airway upside down (with the tip facing the roof of the patient’s mouth).

3. Advance the airway gently until you feel resistance.

4. Turn the airway 180º.

5. The flange should rest on the patient’s teeth.

6. Ventilate the patient as needed.
steps for inserting an oral airway in an adult. Technique 8-3 describes the steps for inserting an oral airway in a child or infant. Technique 8-3 may also be used for adults.

Nasopharyngeal Airway
The nasopharyngeal airway is a flexible tube of rubber or plastic (Fig. 8-13). It is inserted into the patient’s nostril to provide an air passage (Fig. 8-14). The nasopharyngeal airway is commonly called a nasal airway or NP airway. The nasopharyngeal airway is less likely to stimulate vomiting and is a valuable adjunct in patients who are responsive but need assistance in maintaining their airway. Nasopharyngeal airways may be the easiest airway adjunct to use if the patient is actively seizing. Technique 8-4 describes the steps for inserting a nasopharyngeal airway in a patient of any age.

If you meet resistance, do not force the airway. Remove it from that nostril, lubricate it, and try the other side. Even a well-lubricated nasopharyngeal airway may be uncomfortable for the patient and may elicit a painful response. Keep in mind that the nasal airway may become clogged by mucus, blood, or vomit. If this occurs, you should suction the airway to restore patency.

SUCTION
Fluid such as blood, vomit, mucus, or saliva in the airway can obstruct the free passage of air into and out of the lungs. This material can also be inhaled into the lungs with resulting damage to lung tissue. Anytime liquid is in the airway, it must be immediately removed. One method of removing foreign materials is to roll the patient onto his or her side and allow the fluids to drain from the mouth. Foreign material can also be removed by suction. Some suction units are capable of removing small solid objects (e.g., broken teeth, gum, or pieces of food), in addition to fluids, from the airway.
CHAPTER 8: The Airway

1. Put on gloves. Select the properly sized airway by measuring from the tip of the patient's nose to the earlobe. Also consider the diameter of the patient's nostril when choosing a nasal airway.

2. Lubricate the airway with a water-soluble lubricant.

3. Insert the airway into the patient's nostril with the bevel toward the base of the nostril or the nasal septum. Most nasal airways are designed to be inserted into the right nostril.

4. Advance the airway gently until the flange comes to rest at the patient's nostril. Ventilate the patient as needed.
Suction devices are important emergency equipment. Almost all ambulances have a built-in suction unit, usually mounted near the patient’s head. This suction unit is generally powered by the ambulance’s battery (Fig. 8-15).

Because it is important to have suction immediately available whenever you are treating a patient, you should have a suction device within reach. A portable suction unit is a small lightweight suction unit that can be removed from the ambulance. Most portable suction devices have rechargeable battery systems (Fig. 8-16). Some hand-operated suction units have become very popular because of their lightweight, compact design and their reliability, low cost, and size. Suction units are one of the most important pieces of equipment and should always be close at hand.

Most suction units generate negative pressure using a vacuum pump. A length of tubing empties into a collection canister. With most devices, a suction catheter is attached to the end of this tubing before it is placed into the patient’s mouth. Most suction catheters have a hole you must cover with your finger during suctioning. If the material that you are suctioning is so thick that it clogs the suction catheter, use the tubing without a catheter attached. If there is a large volume of material that needs to be cleared from the airway, roll the patient onto his or her side and continue to suction.

When you suction fluid or other material from the patient’s mouth, you are also removing oxygen from the patient. You must limit suctioning to 10 to 15 seconds to allow the patient to receive adequate oxygenation. Administer high-flow oxygen before and after suctioning.

Suction catheters are either rigid or soft (Fig. 8-17). The rigid catheters are also called hard, tonsil tip, tonsil sucker, or Yankauer catheters. These hard plastic catheters are easy to control while suctioning. They are used to suction the mouth and oropharynx of unresponsive patients. The tip of the rigid catheter should always remain visible when you insert it into the mouth. Never insert the catheter so far that you lose sight of the tip.

The rigid catheter can be used in infants and children. In these patients, however, stimulation of the back of the throat can cause changes in the heart rate. If you use a rigid suction catheter, avoid touching the back of the throat to decrease the chances of slowing the heart rhythm.
Soft suction catheters are also commonly called French catheters because of the way they are sized. These long, flexible pieces of plastic are used to suction the nasal passages or in other situations where the rigid catheter cannot be used. Soft catheters often become clogged because of the small diameter of the tubing. Just as with the rigid catheter, these catheters should not be inserted further than the base of the tongue.

A bulb syringe can be used to suction infants. This simple device is effective for suctioning the nose and mouth of a newborn and can be used to suction an infant up to approximately 3 to 4 months of age. This device is useful to clear obstructions from the nasal passages because newborns and infants are not able to breathe voluntarily through their mouths. The bulb syringe is compressed before placing it in the baby’s mouth or nose. Once the bulb syringe is in the mouth or nose, release the bulb and allow the fluids to fill the syringe. Withdraw the syringe and release the contents of the syringe onto a towel. Do not place the syringe far enough into the mouth to touch the back of the throat.

Principle 8-1 lists the key principles for suctioning all patients. Technique 8-5 describes one technique for suctioning an adult.

In some patients, blood, vomit, or secretions may enter the airway as rapidly as you can suction. In this case, do not continuously suction without oxygenating the patient. Suction for 10 seconds and then stop to ventilate. Provide artificial ventilation for 2 minutes and suction in 15-second intervals. This is a difficult situation, and you should contact medical direction for advice.
1. Inspect the portable and on-board suction units at the beginning of each shift to ensure that they are working and cleaned properly. If the unit has a pressure gauge, check the pump to be sure that it can generate a 300 mm Hg vacuum. Battery-operated units should be fully charged at all times and ready for use. Put on gloves, mask, and eye protection. Turn on the power. **You will hear the motor start and you should check to be sure that the suction is working by placing your thumb over the end of the suction tubing.**

2. Select and attach a catheter to the end of the suction tubing.

3. **Measure the distance from the corner of the patient’s mouth to the earlobe and place your fingers at this mark on the catheter.** Insert the catheter into the mouth without suction. This makes it easier to control the tip of the catheter during insertion. You can either keep your finger off of the hole in the catheter or turn the unit off until after you place the catheter into the patient’s mouth. If there are copious amounts of fluid in the mouth, suction immediately upon placing the catheter into the patient’s mouth.

4. Insert the catheter until your fingertips reach the patient’s lips. This prevents inserting the catheter too far.
Previous sections in this chapter have described how to maintain the patient’s airway by positioning the head, neck, and jaw and how to keep the airway clear of obstructions by suctioning. These airway management skills help keep the passageways open but do not deliver oxygen to the lungs. Patients who are breathing inadequately, or not at all, must be artificially ventilated in order to stay alive.

There are four preferred ways that you can assist patients who are not breathing on their own. Not all are equally effective. These four techniques of artificial ventilation are listed in decreasing order of preference:

1. Mouth-to-mask
2. Two-person bag-valve-mask
3. Flow-restricted, oxygen-powered ventilation device
4. One-person bag-valve-mask

Mouth-to-mouth ventilation is not included in this list of preferred methods, even though you may have learned this skill while learning CPR. Because of the direct physical contact with the patient and lack of body substance isolation precaution with this procedure, mouth-to-mouth ventilation is not a preferred EMT skill. You should stay skilled with the mouth-to-mouth technique in case you need to ventilate a family member or friend when you are not working as an EMT and do not have a mask available.

The first step in performing mouth-to-mouth ventilation is to open the airway. This is usually accomplished by the head-tilt chin-lift method. Then take a deep breath, pinch the patient’s nostrils closed, and make an airtight seal with your mouth over the patient’s lips. Exhale enough breath to make the patient’s chest rise, delivering the breath slowly and evenly over 2 seconds. Continue ventilations at a rate of one breath every 5 seconds for an adult or every 3 seconds for a child. Ventilate infants by sealing your mouth over both the infant’s mouth and nose, giving one breath every 3 seconds. Principle 8-2 lists the key principles of artificial ventilation.

MOUTH-TO-MASK WITH SUPPLEMENTAL OXYGEN TECHNIQUE

Mouth-to-mask ventilation is the preferred method of ventilating a nonbreathing patient. It is a simple technique, and because two hands are free to create a tight mask seal, it provides excellent ventilatory volumes. The percentage of delivered oxygen when using a mouth-to-mask technique with and without supple-
mental oxygen is much lower than with bag-valve-mask devices connected to an oxygen source. Mouth-to-mask ventilation is described in Technique 8-6.

**TWO-PERSON BAG-VALVE-MASK TECHNIQUE**

The bag-valve-mask (BVM) is a ventilation device commonly used in medicine. The BVM consists of a self-inflating bag, a one-way valve, a mask, and an oxygen reservoir (Fig. 8-18). The adult bag has a volume of approximately 1600 mL, and is squeezed to ventilate the patient. The BVM typically delivers less volume than mouth-to-mask technique. Ventilating with a BVM will allow you to deliver high concentrations of oxygen to the patient if the reservoir is in place and oxygen is attached flowing at 15 L/min.

The BVM is most effective when used with two EMTs. When properly performed, two-person BVM ventilation can deliver 90–100% oxygen to a nonbreathing patient when attached to an oxygen source. The procedure is described in Technique 8-7.

A few years ago, a number of BVMs were manufactured with pressure pop-off valves designed to

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**TECHNIQUE 8-6**

**Mouth-to-Mask Ventilation with Supplemental Oxygen**

1. Follow body substance isolation precautions. **Connect the one-way valve to the mask, if it is not already attached.** Attach oxygen tubing to the mask and set the flow rate at 15 to 30 L/min. Open the airway by tilting the head back (if no trauma is suspected) and lifting the jaw, and inserting an oral or nasal airway. From a position at the top of the patient’s head, place the mask on the patient.

2. Seal the mask to the patient’s face with your thumbs and index fingers. Take a normal breath, seal your lips over the ventilation port, and exhale slowly and constantly for 1.5 to 2 seconds. Stop ventilating when the patient’s chest rises. Allow the patient to passively exhale between breaths. Ventilate the adult patient once every 5 seconds and infants and children once every 3 seconds.

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*Figure 8-18* The bag-valve-mask device consists of a self-inflating bag, a one-way valve, a mask, and an oxygen reservoir.
prevent overinflation during ventilating. Research showed that these pop-off valves sometimes resulted in inadequate ventilation. Bag-valve-masks used in emergency situations should not have pop-off valves. Box 8-3 lists the features of BVMs.

**FLOW-RESTRICTED, OXYGEN-POWERED VENTILATION DEVICE**

The flow-restricted, oxygen-powered ventilation device (Fig. 8-19) is an alternative to bag-valve-mask ventilation. This device provides 100% oxygen at a peak flow rate of 40 L/min. The valve is designed to prevent overpressurization of the lungs by an inspiratory pressure relief valve that opens when the pressure exceeds 60 cm of water. Most valves have an audible

**TECHNIQUE 8-7**

**Two-Person Bag-Valve-Mask Procedure**

1. The first EMT manually opens the patient’s airway from the patient’s side. The second EMT assembles and prepares the BVM (including attaching to oxygen) from a position at the top of the patient’s head. The first EMT then inserts the properly sized oral or nasal airway (if tolerated).

2. The first EMT holds the bag portion of the BMV with both hands. The second EMT seals the mask by placing the apex of the mask over the bridge of the patient’s nose and then lowers the mask over the patient’s mouth and upper chin. The second EMT’s thumbs are positioned over the top half of the mask and the index and middle fingers over the bottom half. If the mask has a large round cuff surrounding a ventilation port, the port is centered over the mouth. The first EMT squeezes the bag slowly and steadily to deliver the breath over 1.5 to 2 seconds until the chest rises. The second EMT maintains the airway by using the ring and little fingers to bring the jaw up to the mask and evaluates the chest rise. The first EMT continues to ventilate the patient at least once every 5 seconds for adults or every 3 seconds for infants and children. The second EMT maintains the mask seal and open airway and continually monitors the chest rise.
alarm that sounds when the relief valve is activated. The flow-restricted, oxygen-powered ventilation device should never be used on infants or children because it may cause lung tissue damage and cause air to enter the stomach.

The flow-restricted, oxygen-powered ventilation devices used by EMTs operate in all environmental conditions. The trigger is positioned so that you can maintain the mask seal and airway while ventilating the patient. The main advantage of this technique is that it can be used by one EMT. The flow-restricted, oxygen-powered ventilation device is preferred over the BVM if only one EMT is available to ventilate the patient. The procedure is described in Technique 8-8.

**ONE-PERSON BAG-VALVE-MASK TECHNIQUE**

Ventilation with a BVM appears to be a simple skill when practiced on manikins, but on real patients it is very difficult for one EMT to maintain an open airway, seal the mask, and squeeze the bag. This technique becomes even more difficult if the patient has any anatomical variations, such as a very large nose, small or receding chin, or excessive facial hair. One-person BVM ventilation should be used only as a last resort when none of the other techniques of ventilation is possible or when there is only one EMT available to...
perform ventilation. The procedure is described in Technique 8-9.

**TECHNIQUE 8-9**

One-Person Bag-Valve-Mask Ventilation Procedure

Manually open the patient’s airway from a position at the top of the patient’s head. Insert the properly sized oral or nasal airway. Attach oxygen tubing to the oxygen port, and attach the mask to the BVM. Seal the mask by placing the apex of the mask over the bridge of the patient’s nose, and then lower the mask over the mouth and upper chin. Make a “C” with your index finger and thumb around the ventilation port. Maintain the airway by using the middle, ring, and little fingers under the jaw to maintain the chin lift. Squeeze the bag with your other hand slowly and steadily to deliver the breath in 1.5 to 2 seconds until the chest rises. Allow the patient to passively exhale. Evaluate the chest rise and continue to ventilate the patient at least once every 5 seconds for adults or once every 3 seconds for infants and children.

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One-person BVM ventilation requires a tremendous amount of practice and experience to perform properly.

**CONSIDERATIONS FOR TRAUMA PATIENTS**

Unresponsive trauma patients present a considerable challenge in airway management. In addition to bleeding into the airway and the possibility of facial trauma, spinal injuries require special care. All of the techniques of ventilation have to be modified so that the head is not tilted, compromising cervical spine alignment. These modifications are described in Technique 8-10.

**ASSESSING THE ADEQUACY OF ARTIFICIAL VENTILATION**

Whenever you ventilate a patient, it is very important to assess the adequacy of the artificial breathing. Regardless of the technique, you must continually evaluate the effectiveness of the ventilation. Everyone on the crew, not only the EMT ventilating the patient, should continually evaluate artificial ventilation. Box 8-4 lists the signs of adequate ventilation. Box 8-5 lists the signs of inadequate ventilation.

Chest rise is the best indicator that ventilations are being delivered effectively. There are a number of causes of inadequate chest rise. Use the four-step approach described in Box 8-6 for correcting poor chest rise while ventilating a patient.

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**REVIEW QUESTIONS**

**ARTIFICIAL VENTILATION**

1. Why is a two-person BVM ventilation technique preferred to a one-person BVM ventilation technique?
2. How does the airway become obstructed if an unresponsive person lies supine?
3. How should you insert an oral airway into a pediatric patient?
4. What is the maximum length of time you can suction a patient continuously?
5. When ventilating an adult, the inspiratory time should be __________ seconds.
### BOX 8-4

**Signs of Adequate Ventilation**
- The chest rises and falls with each artificial ventilation.
- The patient is being ventilated at least 12 times per minute for adults, or 20 times per minute for children and infants.
- The heart rate returns to normal.
- The skin color improves.

### BOX 8-5

**Signs of Inadequate Ventilation**
- The chest fails to rise and fall with each ventilation.
- The rate is either too fast or too slow.
- There is gastric distention.
- The heart rate does not return to normal.
- Cyanosis is present or worsens.

### BOX 8-6

**Correcting Poor Chest Rise During Ventilation**

<table>
<thead>
<tr>
<th>Step</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reposition the jaw</td>
<td>An improperly opened airway is the most common cause of poor chest rise.</td>
</tr>
<tr>
<td>Check the mask seal</td>
<td>Poor mask seal is the next most common cause of poor chest rise; you can generally hear air leaking through the sides of the mask.</td>
</tr>
<tr>
<td>Use an alternative technique</td>
<td>Some patients are ventilated more effectively with one technique than another.</td>
</tr>
<tr>
<td>Check for an obstruction</td>
<td>Foreign body airway obstructions may cause poor ventilation. You may need to perform the Heimlich maneuver or suction the patient.</td>
</tr>
</tbody>
</table>

### TECHNIQUE 8-10

**Modifying Ventilation Techniques for Trauma Patients**

Position yourself at the top of the patient's head. A second EMT can stabilize the patient's head and neck, or you can use your knees to prevent head movement. Maintain a mask seal with the thumbs and index fingers on top of the mask, and the middle, ring, and little fingers under the chin. This allows a jaw thrust to be performed at the same time, helping to maintain an open airway. Do not push down on the chin, because this may occlude the airway. Another EMT should ventilate the patient with the bag-valve-mask, as a much better seal with the mask can be achieved by using two hands rather than one. Ventilate once every 5 seconds for adults or once every 3 seconds for infants and children without tilting the head back. Allow for passive exhalation after each breath. Evaluate the chest rise and fall on every breath.
SPECIAL SITUATIONS IN AIRWAY MANAGEMENT

PATIENTS WITH LARYNGECTOMIES

A laryngectomy is a surgical procedure in which the voice box is removed, usually because of throat cancer. After a laryngectomy, the patient may have a tracheal stoma, which is a permanent artificial opening into the trachea (Fig. 8-20). In some cases, the patient has a tube that fits into the stoma. Tubes can be obstructed with mucus. If this tube becomes obstructed, use suction to remove the occlusion.

If a patient with a tracheal stoma must be ventilated, you can usually ventilate with a mask directly through the stoma. Use a small mask to get a seal on the neck. Because you are inflating below the level of the tongue and epiglottis, the head and neck do not need to be positioned.

In some cases, patients have a partial laryngectomy, in which there is still an air passage from the trachea to the mouth and nose. If air escapes from the mouth and nose when you ventilate a patient with a stoma, close the patient’s mouth and pinch the nose shut. If ventilating through the tracheal stoma proves to be difficult, try to suction the hole. If ventilation is still difficult, you should seal the tracheal stoma with a gloved hand, provide proper head tilt, and ventilate through the mouth and nose.

VENTILATING INFANTS AND CHILDREN

Respiratory emergencies are quite common in children, and you need to be able to artificially ventilate pediatric patients. Because the airway is more pliable, you must pay particular attention to head position. Infants should be ventilated with the head in the neutral position. Children may need to have their heads slightly extended. Avoid hyperextension or flexion of the head in any child or infant, which may close the airway. Ventilate infants and children once every 3 seconds and be prepared to suction to help clear the small airways.

Ventilate the patient every 3 seconds with just enough pressure to make the chest rise. Excessive pressure will cause gastric distention, which severely compromises the effectiveness of ventilation and increases the possibility of vomiting. Do not use pop-off valves because they can lead to unrecognized hyperventilation. Use an oral or nasal airway if other methods fail to provide an adequate airway.

FACIAL INJURIES

Facial trauma can pose considerable difficulty for managing the airway and ventilating trauma patients (Fig. 8-21). The head and face have a rich blood supply, and blunt injuries to the face cause significant bleeding and swelling.

Be prepared to use suction and positioning (jaw thrust without head tilt) to keep the airway clear of blood and vomit. Use an oral or nasal airway to help maximize the airway without tilting the head. Be cautious when using a nasal airway in patients with facial trauma. If there is significant injury to the bones of the skull, it is possible to insert the airway directly into the cranial cavity.

If you cannot open the airway in a trauma patient and all else has failed, you must tilt the head back to ventilate the patient. Although moving the neck may cause spinal cord injury, if you do not open the airway, the patient will die.
OBSTRUCTIONS
The American Heart Association and American Red Cross courses in CPR cover procedures for dealing with a foreign body airway obstruction, including abdominal thrusts, finger sweeps, and ventilation attempts. A combination of back blows and chest thrusts are used in infants. If three cycles of attempts to clear a foreign body airway obstruction fail to open the airway, you should transport the patient immediately, while continuing the cycle en route to the hospital.

DENTAL APPLIANCES
Dentures and partial dentures can create a problem for managing the airway. If at all possible, attempt to keep dentures in place when ventilating a patient. They add form and structure to the mouth and make it easier to get a mask seal.

If dentures become dislodged, they can create an airway obstruction. If this happens, you should remove them immediately.

OXYGEN
High-concentration oxygen should be given to all patients with signs or symptoms of inadequate breathing. Oxygen is stored in high-pressure tanks and controlled by regulators. In prehospital care, oxygen is delivered to the patient using either a nonrebreather mask or a nasal cannula. The mask is the preferred method of providing oxygen because it delivers much higher concentrations of oxygen. The nasal cannula should be used only if the patient will not tolerate the mask.

OPENING THE AIRWAY
Ensuring an open airway is one of the most important jobs of an EMT. Many circumstances can prevent the free passage of air from the mouth to the lungs. In an unresponsive patient, the base of the tongue can create an airway obstruction. Foreign bodies such as teeth, gum, and dentures can also create airway problems. Fluid (blood, saliva, vomit, etc.) should be suctioned from the airway immediately. The head-tilt chin-lift technique is the simplest airway skill and should be performed immediately on any unresponsive, non-trauma patient. Nasal and oral airway devices are very useful in helping maintain the airway.

ARTIFICIAL VENTILATION
Once the airway has been opened, the next priority in patient management is ventilation. EMT-Basics use four methods for providing artificial ventilation. Mouth-to-mask ventilations are the preferred method of ventilating a patient. In this technique, one EMT seals the mask to the patient’s face with both hands and exhales into the mask until the chest rises. The next option is the two-person BVM technique in which one EMT uses both hands to seal the mask to the patient’s face and open the airway while a second EMT squeezes the bag with both hands. The next option for ventilation uses the flow-restricted, oxygen-powered ventilation device. One EMT uses both hands to seal the mask and open the airway, and ventilation is given until the chest rises. The last option for ventilating a patient is the one-person BVM technique. Because one EMT must seal the mask, open the airway, and squeeze the bag, this technique is the least preferred method of artificial ventilation.

When ventilating a trauma patient, take care to open the airway using the jaw thrust and ventilate the patient without moving the head or neck. Everyone on the crew is responsible for continuously assessing the adequacy of ventilation. The four-step procedure to use when the chest does not rise is to reposition the airway, check the mask seal, use an alternative technique, and check for obstruction.

Situations in Airway Management
1. The artificial opening in the neck created when a patient has a laryngectomy is called a __________.
2. Ventilate children with the head in the __________ position.
3. What should you do with loose dentures in a patient requiring artificial ventilation?

CHAPTER SUMMARY

THE RESPIRATORY SYSTEM
The respiratory system maintains the delicate balance of oxygen and carbon dioxide in the body. The airway consists of the passageways from the lips and nostrils to the lungs. Airway structures include the nose, nasopharynx, mouth, oropharynx, epiglottis, glottis, larynx, cricoid ring, trachea, bronchi, and alveoli. Air is moved in and out of the lungs by the contraction and relaxation of the diaphragm and intercostal muscles. Normal breathing is relaxed and regular. The airway of the pediatric patient is easily obstructed. Great care must be taken to maintain this vital passageway of life in all patients.
Check your knowledge. The National Registry of EMTs and many state EMS agencies use the objectives below to develop EMT-Basic certification examinations. Can you meet them?

**Cognitive**

1. Name and label the major structures of the respiratory system on a diagram.
2. List the signs of adequate breathing.
3. List the signs of inadequate breathing.
4. Describe the steps in performing the head-tilt chin-lift.
5. Relate mechanism of injury to opening the airway.
6. Describe the steps in performing the jaw thrust.
7. State the importance of having a suction unit ready for immediate use when providing emergency care.
8. Describe the techniques of suctioning.
9. Describe how to artificially ventilate a patient with a pocket mask.
10. Describe the steps in performing the skill of artificially ventilating a patient with a BVM while using the jaw thrust.
11. List the parts of a BVM system.
12. Describe the steps in performing the skill of artificially ventilating a patient with a BVM for one and two rescuers.
13. Describe the signs of adequate artificial ventilation using the BVM.
14. Describe the signs of inadequate artificial ventilation using the BVM.
15. Describe the steps in artificially ventilating a patient with a flow restricted, oxygen-powered ventilation device.
16. List the steps in performing the actions taken when providing mouth-to-mouth and mouth-to-stoma artificial ventilation.
17. Describe how to measure and insert an oropharyngeal (oral) airway.
18. Describe how to measure and insert a nasopharyngeal (nasal) airway.
19. Define the components of an oxygen delivery system.
20. Identify a nonrebreather face mask and state the oxygen flow requirements needed for its use.
21. Describe the indications for using a nasal cannula versus a nonrebreather face mask.
22. Identify a nasal cannula and state the flow requirements needed for its use.

**Affective**

1. Explain the rationale for basic life support artificial ventilation and airway protective skills taking priority over most other basic life support skills.
2. Explain the rationale for providing adequate oxygenation through high inspired oxygen concentrations to patients who, in the past, may have received low concentrations.

**Psychomotor**

1. Demonstrate the steps in performing the head-tilt chin-lift.
2. Demonstrate the steps in performing the jaw thrust.
3. Demonstrate the techniques of suctioning.
4. Demonstrate the steps in providing mouth-to-mouth artificial ventilation with body substance isolation (barrier shields).
5. Demonstrate how to use a pocket mask to artificially ventilate a patient.
6. Demonstrate the assembly of a BVM unit.
7. Demonstrate the steps in performing the skill of artificially ventilating a patient with a BVM for one and two rescuers.
8. Demonstrate the steps in performing the skill of artificially ventilating a patient with a BVM while using the jaw thrust.
10. Demonstrate how to artificially ventilate a patient with a stoma.
11. Demonstrate how to insert an oropharyngeal (oral) airway.
12. Demonstrate how to insert a nasopharyngeal (nasal) airway.
13. Demonstrate the correct operation of oxygen tanks and regulators.
14. Demonstrate the use of a nonrebreather face mask and state the oxygen flow requirements needed for its use.
15. Demonstrate the use of a nasal cannula and state the flow requirements needed for its use.
16. Demonstrate how to artificially ventilate the infant and child patient.
17. Demonstrate oxygen administration for the infant and child patient.
SPECIAL SITUATIONS IN AIRWAY MANAGEMENT

Special situations present challenges when managing the airway and ventilating certain patients. Patients with stomas can generally be ventilated directly through the stoma. The airways of infants and children are easily compromised by head position, swelling, or fluid. Facial injuries can cause considerable bleeding and swelling. Foreign body airway obstructions should be managed by abdominal thrusts, finger sweeps, and ventilation attempts. If they remain in place, dental appliances should be kept in place during artificial ventilation.

DIVISION 2: Airway

Review Questions Answer Key

ANSWERS TO REVIEW QUESTIONS BOX 8-1
1. The diaphragm flattens when it contracts, increasing the size of the chest cavity causing inhalation.
2. Passive
3. Respiratory rate is too fast or too slow.
4. Proportionally, the tongue of an infant takes up more space in the mouth, causing the airways to be more easily blocked.

ANSWERS TO REVIEW QUESTIONS BOX 8-2
1. To control the flow of oxygen
2. 15 L/min
3. When a patient cannot tolerate a mask

ANSWERS TO REVIEW QUESTIONS BOX 8-3
1. In two-person BVM ventilations, two hands can be used to create a mask seal, increasing the tidal volume.
2. The jaw relaxes, allowing the tongue to contact the back of the throat and the epiglottis to block the glottic opening.
3. Use a tongue depressor to press the tongue forward and out of the way, and the insert the airway with the tip facing the floor of the mouth.
4. 10 to 15 seconds
5. 2

ANSWERS TO REVIEW QUESTIONS BOX 8-4
1. Stoma
2. Neutral
3. Remove the dentures if they are loose in the mouth.