9 Respiration and Artificial Ventilation

STANDARD
Airway Management, Respiration, and Artificial Ventilation (Respiration, Artificial Ventilation)

COMPETENCY
Applies knowledge (fundamental depth, foundational breadth) of general anatomy and physiology to patient assessment and management in order to assure a patent airway, adequate mechanical ventilation, and respiration for patients of all ages.

CORE CONCEPTS
- Physiology and pathophysiology of the respiratory system
- How to recognize adequate and inadequate breathing
- Principles and techniques of positive pressure ventilation
- Principles and techniques of oxygen administration

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Oxygen Delivery Devices
See a video on different types of oxygen delivery devices. Who knew there were so many choices? Learn the flow rates and oxygen delivery amounts associated with each device as well as the pros and cons of these devices.

King Airway Insertion
Watch this video to learn how to insert a King airway and what you should do directly after insertion of this device.

OBJECTIVES

After reading this chapter you should be able to:

9.1 Define key terms introduced in this chapter.

9.2 Explain the physiological relationship between assessing and maintaining an open airway, assessing and ensuring adequate ventilation, and assessing and maintaining adequate circulation. (p. 198–201)

9.3 Describe the mechanics of ventilation. (pp. 198–199)

9.4 Explain mechanisms that control the depth and rate of ventilation. (pp. 198–199)

9.5 Explain the relationships between tidal volume, respiratory rate, minute volume, dead air space, and alveolar ventilation. (pp. 198–199)

9.6 Describe the physiology of external and internal respiration. (p. 199)

9.7 Recognize patients at risk for failure of the cardiopulmonary system. (pp. 199–201)

9.8 Differentiate between adequate breathing, inadequate breathing (respiratory failure), and respiratory arrest. (pp. 201–202)

9.9 Use information from the scene size-up and patient assessment to anticipate hypoxia. (pp. 205–207)

9.10 Given a variety of scenarios, differentiate between patients who require artificial ventilation and those who do not. (pp. 202–209, 218)

9.11 Identify patients who require administration of supplemental oxygen. (pp. 202–207, 218)

9.12 Discuss the potential negative effects of positive pressure ventilation, and how to minimize complications from positive pressure ventilation. (p. 208)

9.13 Demonstrate the following techniques of artificial respiration for pediatric (as applicable) and adult medical and trauma patients:
- **a.** Mouth-to-mask (pp. 210–212)
- **b.** Two-rescuer bag-valve mask (BVM) (pp. 214–215)
- **c.** One-rescuer BVM (pp. 215–216)
- **d.** Flow-restricted, oxygen-powered ventilation device (pp. 216–218)
- **e.** Automatic transport ventilator (as permitted by local protocol) (pp. 218–219)

9.14 Assess the adequacy of artificial ventilations. (pp. 208–219)

9.15 Demonstrate the application of cricoid pressure. (p. 215)

9.16 Modify artificial ventilation and oxygen techniques for patients with stomas. (pp. 215–216)

9.17 Discuss considerations for selecting the best device for delivering oxygen for a variety of patient scenarios. (pp. 219–233)

9.18 Demonstrate administration of oxygen by:
- **a.** Nonrebreather mask (pp. 229–230)
- **b.** Nasal cannula (p. 230)

9.19 Describe the purpose and use of partial rebreather masks, Venturi masks, and tracheostomy masks. (pp. 231–233)

9.20 Demonstrate safe transport, storage, and use of oxygen. (pp. 225–227)

9.21 Describe the purpose of each part of an oxygen delivery system. (pp. 219–224)

9.22 Describe the use of humidified oxygen. (pp. 223–224)

KEY TERMS

alveolar ventilation, *p. 199*
artificial ventilation, *p. 208*
cellular respiration, *p. 199*
cricoid pressure, *p. 215*
cyanosis, *p. 206*
diffusion, *p. 199*
hypoxia, *p. 201*
positive pressure ventilation, *p. 208*
pulmonary respiration, *p. 199*
respiration, *p. 201*
respiratory arrest, *p. 202*
respiratory distress, *p. 201*
respiratory failure, *p. 201*
stoma, *p. 215*
ventilation, *p. 198*

By securing the airway, you provide an open pathway for air to move into and out of the body, as we discussed in Chapter 8, "Airway Management." However, a patent airway does not guarantee that the air will move, and it certainly does not guarantee that air will move in adequate volumes to support life. To ensure this, the EMT must assess breathing, or the "B" of the ABCs.

Recall that breathing accomplishes two essential functions: It brings oxygen into the body and it eliminates carbon dioxide. Although your body will tolerate the buildup of carbon dioxide longer than it will tolerate a lack of oxygen, both of these functions are absolutely necessary to support life.

Proper airway management must always be paired with the assessment of adequate breathing to ensure that both of these critical functions are occurring. If you determine that the patient's breathing is not meeting the body's needs, then you must take immediate corrective action. A thorough primary assessment focuses on a rapid evaluation of both airway *and* breathing and identifies immediate life threats associated with the airway and the respiratory system.

In this chapter, you will learn the skills necessary to correct inadequate breathing. However, it is just as important to learn the decision-making process that will tell you when to employ those skills. You must learn not just "how to" but, equally important, "when to" assist a patient with breathing.

PHYSIOLOGY AND PATHOPHYSIOLOGY

CORE CONCEPT

Physiology and pathophysiology of the respiratory system

Mechanics of Breathing

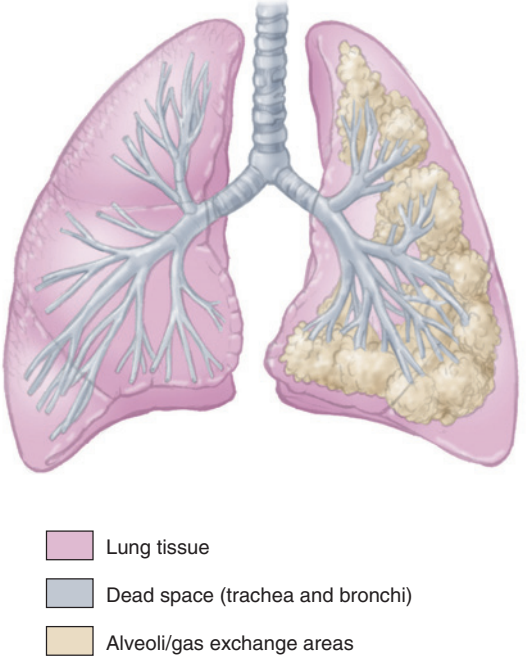
ventilation
breathing in and out (inhalation and exhalation), or artificial provision of breaths.

Air is moved into and out of the chest in a process called ***ventilation***. To move air, the diaphragm and the muscles of the chest are contracted and relaxed to change the pressure within the chest cavity. This changing pressure inflates and deflates the lungs. *Inhalation* is an active process. The muscles of the chest, including the intercostal muscles between the ribs, expand at the same time the diaphragm contracts in a downward motion. These movements increase the size of the chest cavity and create a negative pressure. This negative pressure pulls air in through the glottic opening and inflates the lungs. Conversely, *exhalation* is a passive process. That is, it occurs when the previously discussed muscles relax. As the size of the chest decreases, it creates a positive pressure and pushes air out. Because it is passive, exhalation typically takes slightly longer than inhalation.

As we discussed in Chapter 6, "Principles of Pathophysiology," the amount of air moved in one breath (one cycle of inhalation and exhalation) is called *tidal volume*. A normal tidal volume is typically 5–7 mL per kg of body weight. The amount of air moved into and out of the lungs per minute is called *minute volume*. Minute volume is calculated by multiplying the tidal volume and the respiratory rate (MV = TV × RR).

Recall that ventilation (inhalation and exhalation) is ultimately designed to move air to and from the alveoli for gas exchange. However, as noted in Chapter 6, "Principles of Pathophysiology," not all the air we breathe reaches the alveoli. For example, a 100-kg adult has an average tidal volume of roughly 500 mL. Of that 500 mL, only about 350 mL reaches the alveoli. The remainder occupies the trachea, bronchioles, and other parts of the airway, the area known as *dead air space* (Figure 9-1). The alveoli are the only place where oxygen and

FIGURE 9-1 Dead air space: areas of the airway outside the alveoli.



carbon dioxide are exchanged with the bloodstream; therefore, the air in the dead space contributes nothing to oxygenating the body. The term ***alveolar ventilation*** refers to how much air actually reaches the alveoli.

alveolar ventilation
the amount of air that reaches the alveoli.

Of course, alveolar ventilation depends very much on tidal volume. Consider the following example:

> An asthma patient has a normal tidal volume of 500 mL. Today, however, because his asthma attack has constricted his bronchiole tubes, he can move only 300 mL of tidal volume. If the air in the dead space remains constant at 150 mL, then only 150 mL of air reaches his alveoli per breath.

- Normal tidal volume: 500 mL × 16 breaths per minute = 8,000 mL
- Normal alveolar ventilation: 350 mL (500–150 dead space air) ×16 bpm = 5,600 mL
- Asthma attack tidal volume: 300 mL × 16 bpm = 4,800 mL
- Asthma attack alveolar ventilation: 150 mL (300–150 dead air space) × 16 bpm = 2,400 mL

Remember that alveolar ventilation can be altered through changes in rate as well as by changes in volume. A person breathing too slowly will have a decreased minute volume, so the amount of air reaching the alveoli per minute is decreased, just as it would be decreased by a reduction in tidal volume.

- Normal minute volume: 500 mL × 16 breaths per minute = 8,000 mL
- Slowed minute volume: 500 mL × 8 breaths per minute = 4,000 mL

Occasionally, very fast respiratory rates may decrease minute volume as well, not primarily because of rate but because the faster rate can affect the tidal volume. Fast breathing can, at times, limit the amount of time the lungs have to fill and therefore decrease tidal volume. Even though increasing the rate should increase minute volumes, exceptionally fast breathing will actually reduce minute volume and alveolar ventilation.

Physiology of Respiration

Inhaled air fills the alveoli. The pulmonary capillaries bring circulating blood to the outside of these tiny air sacs, where the thin walls of the alveoli and the thin walls of the capillaries allow oxygen from the air in the alveoli to move into the blood to circulate throughout the body. The thin walls of the capillaries and alveoli also allow carbon dioxide to move from the blood into the alveoli to be expelled during exhalation.

The movement of gases from an area of high concentration to an area of low concentration is called ***diffusion***. The diffusion of oxygen and carbon dioxide that takes place between the *alveoli* and circulating blood is called ***pulmonary respiration***. Carbon dioxide is offloaded from the blood into alveoli, while oxygen from the air in the alveoli is loaded onto the hemoglobin of the blood and transported to the cells. At the cells, through a similar but reversed process of diffusion, oxygen passes from the blood, across cell membranes, and into the cells, while carbon dioxide from the cells passes into the blood. The diffusion of oxygen and carbon dioxide that takes place between the *cells* and circulating blood is called ***cellular respiration*** (Figure 9-2).

diffusion
a process by which molecules move from an area of high concentration to an area of low concentration.

pulmonary respiration
the exchange of oxygen and carbon dioxide between the alveoli and circulating blood in the pulmonary capillaries.

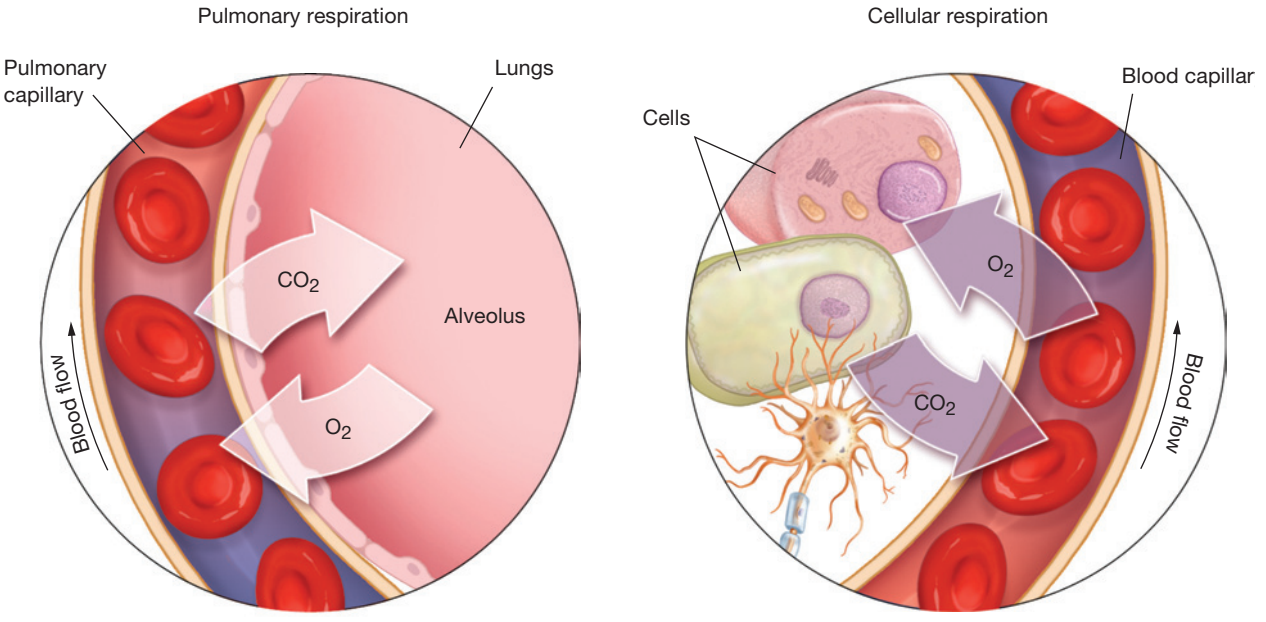
cellular respiration
the exchange of oxygen and carbon dioxide between cells and circulating blood.

Remember: For this entire process to be working, the respiratory system must be appropriately matched up with a functioning cardiovascular system. The respiratory system must be moving air in and out of the alveoli and the circulatory system must be transporting adequate amounts of blood between the cells and the alveoli. These two systems working in concert are often referred to as the *cardiopulmonary system* and also referred to as a ventilation-perfusion (V/Q) match, as was discussed in Chapter 6, "Principles of Pathophysiology." When either of these systems fails, the process of respiration is defeated.

Pathophysiology of the Cardiopulmonary System

Before proceeding, take a few minutes to review the concepts of pathophysiology of the cardiopulmonary system that were discussed in detail in Chapter 6.

FIGURE 9-2 The processes of pulmonary and cellular respiration.



Consider the following mechanical failures of the cardiopulmonary system that may occur:

- **Mechanics of breathing disrupted.** If the chest cannot create the necessary pressure changes, air cannot be moved in and out of the lungs. Breathing can be disrupted by a variety of causes, such as:
  - *A patient stabbed in the chest.* When the diaphragm moves downward, air is pulled into the chest cavity through the stab wound in addition to the normal drawing in of air through the glottic opening. Because of the air rushing into the chest through the stab wound, a negative pressure cannot be created to efficiently pull air into the lungs through the normal airway passages.
  - *A patient loses nervous control of respiration.* A patient may lose the ability to transmit messages through nerve tissue to innervate the muscles of respiration. This can occur in diseases like muscular dystrophy and multiple sclerosis.
  - *A patient sustains painful chest wall injuries.* Pain and physical damage can both limit chest wall movement.
  - *A patient has airway problems such as bronchoconstriction.* If air cannot move, breathing cannot occur. Some diseases like asthma and chronic obstructive pulmonary disease (COPD) can cause bronchial tubes to decrease in diameter and limit the amount of air that can flow through them.
- **Gas exchange interrupted.** Sometimes the ability to diffuse oxygen and carbon dioxide is impaired. Consider the following examples:
  - *Low oxygen levels in the outside air such as in confined space rescue situations.* Here there simply is not enough oxygen in the air breathed in.
  - *Diffusion problems.* Some diseases like congestive heart failure and COPD can limit the ability of alveoli to exchange oxygen and carbon dioxide. Here oxygenated air and blood reach the alveoli, but the alveoli themselves are not working.
- **Circulation issues.** There can be problems that prevent the blood from carrying enough oxygen to the body's cells, such as:
  - *Not enough blood.* If a person has lost a significant amount of blood, not enough blood can be circulated to the alveoli. If blood is not present at the interface with the alveoli, oxygen and carbon dioxide cannot be exchanged.
  - *Hemoglobin problems.* Occasionally respiration can be impaired if there is not enough hemoglobin, the oxygen-binding protein in the blood. For example, anemia is a disease that causes low amounts of hemoglobin in the blood. In other situations,

as with a patient whose body pH becomes very acidotic, sufficient hemoglobin may be present but may have a difficulty in holding oxygen. When hemoglobin fails, oxygen cannot be transported.

RESPIRATION

respiration (RES-pir-AY-shun)
the diffusion of oxygen and carbon dioxide between the alveoli and the blood (pulmonary respiration) and between the blood and the cells (cellular respiration). Also used to mean, simply, breathing.

As just discussed, *ventilation* is the term properly applied to the process of inhaling and exhaling, or breathing, whereas ***respiration*** refers to the exchange of gases between the alveoli and the blood (external respiration) and between the blood and the cells (internal respiration). However, in common speech, and in an overall sense, *respiration* means, simply, breathing in all its aspects.

Adequate and Inadequate Breathing

CORE CONCEPT
How to recognize adequate and inadequate breathing

hypoxia (hi-POK-se-uh)
an insufficiency of oxygen in the body's tissues.

The brain and body cells need a steady supply of oxygen to accomplish the tasks of everyday living. Low levels of oxygen, or ***hypoxia***, will disrupt normal function. Although it is also important for carbon dioxide to be removed, the body will tolerate high levels of carbon dioxide (*hypercapnia*) for longer periods of time than it will tolerate hypoxia. As we evaluate breathing in a patient, we will assess severity based on how well the patient's cardiopulmonary system is accomplishing the goals of oxygenation and removal of carbon dioxide.

When the cardiopulmonary system fails, the body makes adjustments to compensate for hypoxia and/or a buildup of carbon dioxide. These adjustments are somewhat predictable and can help us recognize the severity of the patient's problem.

In most people, the urge to breathe is caused by the buildup of carbon dioxide. Special sensors in the cardiovascular system, called chemoreceptors, detect increasing levels of carbon dioxide as well as low levels of oxygen. When these sensors detect significant changes, especially a build-up of carbon dioxide, the respiratory system is stimulated to breathe more rapidly.

When a person's cardiopulmonary system cannot keep up with the body's current demands, carbon dioxide levels increase and hypoxia occurs. The body typically responds with an increased respiratory rate to attempt to move more air. At this point, it is common for the patient to complain of the sensation of shortness of breath. The body will also typically respond by engaging the sympathetic (or "fight-or-flight") nervous system. The sympathetic nervous system will increase heart rate in an attempt to move more blood (and transport more oxygen and carbon dioxide) and will constrict blood vessels, which also aids in the movement of blood.

In some cases, the adjustments the body makes will keep up with added demands. For example, a patient will have a challenge, such as an asthma attack, and the patient's body will be compensating for that challenge. Increased respiratory rate, increased heart rate, and perhaps even position changes may be enough to meet the challenge and, at least minimally, the body's needs. The outward signs of these changes (vital signs, appearance, position) will indicate that the patient's system is working extra hard to meet his needs. If these changes are effective, there will be signs that oxygen and carbon dioxide are being adequately exchanged. These signs include normal mental status, relatively normal skin color, and a pulse oximetry reading (measurement of blood oxygen saturation) that is within normal limits. These patients are classified as having ***respiratory distress***. That is, they have a challenge, but the compensatory mechanisms the body is providing are meeting their increased demands. They are, in fact, compensating.

respiratory distress
increased work of breathing; a sensation of shortness of breath.

Unfortunately, some challenges are just too great for the body's compensatory mechanisms to overcome. Additionally, most of the mechanisms of compensation, such as increased respiratory muscle use, come at a cost of increased oxygen demand. If the very nature of the problem is that there was not enough oxygen to begin with, the demand for oxygen will quickly overtake the limited supply. In these cases, compensation fails and the body's metabolic needs are not met. Hypoxia becomes profound, carbon dioxide builds to dangerous levels, and the muscles used for increased respiration begin to tire. This condition represents *inadequate breathing* and is called ***respiratory failure*** (Figure 9-3).

respiratory failure
the reduction of breathing to the point where oxygen intake is not sufficient to support life.

FIGURE 9-3 Respiratory distress usually involves accessory muscle use and increased work of breathing. Severe or prolonged respiratory distress can proceed to respiratory failure and inadequate ventilation when the body can no longer work so hard to breathe. In this case you will see a reduced level of responsiveness or an appearance of tiring, shallow ventilations, and other signs of inadequate breathing. *(© Dan Limmer)*

respiratory arrest
when breathing completely stops.

Respiratory failure is especially important to recognize, because it is often the precursor to the complete stoppage of breathing (***respiratory arrest***).

As an EMT, you will use your primary assessment to evaluate patients and rapidly classify their respiratory status. In essence, you will be making the decision as to whether their breathing is adequate or inadequate.

Inadequate Breathing

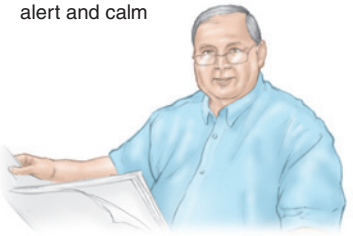
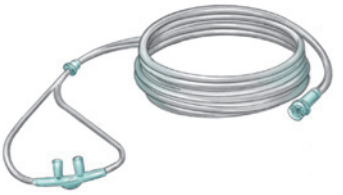
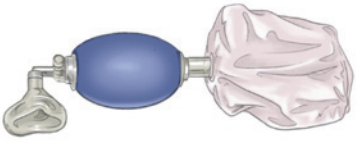
When you note that a patient's breathing is absent, you will provide artificial ventilation. However, there is a time before respiration completely ceases when, although the patient may show some signs of breathing, these breathing efforts are not enough to support life. That is, if the patient continues to breathe in this manner, he will eventually develop respiratory arrest and die. This is deemed inadequate breathing. In inadequate breathing, either the *rate of breathing* or the *depth of breathing* (or both) falls outside of normal ranges.

Recognizing inadequate breathing requires both keen assessment skills and prompt action (Table 9-1). Identifying this condition and providing ventilation to an inadequately breathing patient may actually keep him alive and breathing in a case where he would have stopped breathing and died without your intervention (Figure 9-4).

Table 9-1 Respiratory Conditions with Appropriate Interventions

CONDITION	SIGNS	EMT INTERVENTION	
ADEQUATE BREATHING Patient is breathing adequately but needs supplemental oxygen due to a medical or traumatic condition.	• Rate and depth of breathing are adequate. • No abnormal breath sounds. • Air moves freely in and out of the chest. • Skin color normal.	Oxygen by *nonrebreather mask* or *nasal cannula*.	
INADEQUATE BREATHING (RESPIRATORY FAILURE) Patient is moving some air in and out but it is slow or shallow and not enough to live.	• Patient has some breathing but not enough to live. • Rate and/or depth outside of normal limits. • Shallow ventilations. • Diminished or absent breath sounds. • Noises such as crowing, stridor, snoring, gurgling, or gasping. • Blue (cyanotic) or gray skin color. • Decreased minute volume.	Assisted ventilations (air forced into the lungs under pressure) with a *pocket face mask, bag-valve mask,* or *FROPVD.* See chapter text about adjusting rates for rapid or slow breathing. **NOTE:** *A nonrebreather mask requires adequate breathing to pull oxygen into the lungs. It DOES NOT provide ventilation to a patient who is not breathing or who is breathing inadequately.*	
PATIENT IS NOT BREATHING AT ALL (RESPIRATORY ARREST)	• No chest rise. • No evidence of air being moved from the mouth or nose. • No breath sounds.	Artificial ventilations with a *pocket facemask, bag-valve mask, FROPVD,* or *ATV* at 10–12/minute for an adult and 20/minute for an infant or child. **NOTE:** *DO NOT use oxygen-powered ventilation devices on infants or children.*	

FIGURE 9-4 Along the continuum from normal, adequate breathing to no breathing at all, there are milestones where an EMT should apply a nonrebreather mask or switch to positive pressure ventilation with a pocket face mask, BVM, or FROPVD for assisting the patient's own ventilations or providing artificial ventilation. It is essential to recognize the need for assisted ventilations, even before severe respiratory distress develops.

PATIENT'S CONDITION	WHEN AND HOW TO INTERVENE
Adequate breathing: Speaks full sentences; alert and calm 	**Nonrebreather mask or nasal cannula** 
Increasing respiratory distress: Visibly short of breath; Speaking 3–4 word sentences; Increasing anxiety 	**Nonrebreather mask** 
Severe respiratory distress: Speaking only 1–2 word sentences; Very diaphoretic (sweaty); Severe anxiety 	**Assisted ventilations** Pocket face mask (PFM), bag-valve mask (BVM), or flow-restricted, oxygen-powered ventilation device (FROPVD) Assist the patient's own ventilations, adjusting the rate for rapid or slow breathing 
Continues to deteriorate: Sleepy with head-bobbing; Becomes unarousable 	
Respiratory arrest: No breathing 	**Artificial ventilation** Pocket face mask (PFM), bag-valve mask (BVM), or flow-restricted, oxygen-powered ventilation device (FROPVD) Assisted ventilations at 12/minute for an adult or 20/minute for a child or infant

Key decision-making point:

Recognize inadequate breathing before respiratory arrest develops.

Assist ventilations before they stop altogether!

Inside/Outside

RESPIRATORY DISTRESS TO RESPIRATORY FAILURE

Respiratory failure occurs when the mechanisms of respiratory compensation can no longer keep up with a respiratory challenge. To illustrate this process, let's review the progression of a patient having an asthma attack.

Patients with asthma have episodic attacks where their bronchiole tubes spasm and constrict. This leads to decreased air flow and decreased tidal volume. As minute volume and alveolar ventilation decrease, the body senses increased levels of carbon dioxide and slight hypoxia. The brain responds with an increased stimulus to breathe and activation of the sympathetic nervous system.

Inside the body, the respiratory system compensates. Respiratory rate and depth are increased in an attempt to increase alveolar ventilation. The heart pumps faster and harder in an attempt to move oxygen and carbon dioxide more quickly. Blood vessels constrict as the "fight-or-flight" response engages.

Outside the body, the patient may notice a sensation of shortness of breath. He may complain that he "can't catch my breath." You may notice an increased respiratory rate and an increased work of breathing. It may simply look like it is hard for the patient to breathe. You may hear wheezes, which are the sounds of the bronchoconstriction. You may also note the patient has slightly pale skin. However, since the patient's compensatory mechanisms are working, you should not see blue skin. His mental status is also normal, since adequate levels of oxygen are being supplied to the brain. At this point you would classify this patient as being in *respiratory distress*. He has a challenge, but his needs are being met by compensatory mechanisms inside the body.

Unfortunately, the asthma attack continues. Inside the body, the patient's bronchiole tubes get narrower as they begin to swell in response to the attack. Tidal volume and alveolar ventilation decrease even more, and the brain now lacks sufficient oxygen. Carbon dioxide also has been building up and is beginning to interfere with normal function. As you reassess this patient, you notice he is beginning to get anxious, maybe even a bit combative, as hypoxia increases and affects his brain. You notice it is harder to hear air moving when you listen to his chest. His wheezes have become "tighter." His fingernails are now turning blue, and you notice a similar discoloration in his lips and around his eyes. *Respiratory failure* has begun. Compensation can no longer keep up with his needs.

As the attack continues, tidal volume and alveolar ventilation decrease even further. Hypoxia is now profound. The patient's body has become acidotic from the retention of too much carbon dioxide and from anaerobic metabolism (metabolism without enough oxygen present), and he is growing tired. For a prolonged period now, the muscles in his chest have been working extra hard. These respiratory muscles demand oxygen that the patient's respiratory system cannot deliver. As a result, the respiratory muscles fatigue.

On the outside, the patient's mental status now is obviously severely impaired. He has become drowsy; in fact, he can barely stay awake. His respiratory rate has slowed, and you note he is breathing irregularly. His color is ashen with a definite bluish discoloration. He is now in profound respiratory failure. *Respiratory arrest* is imminent.

PATIENT ASSESSMENT

Assessing Breathing

As you assess breathing during the primary assessment, you should answer two important questions. The first question is, "Is the patient breathing?" You can determine this simply by their response to a simple hello. If he is unconscious, you may need to revert to BLS procedures and perform a "look-listen-feel" assessment. If he is not breathing, you must take immediate action to breathe for him. The second question you must answer is, "If he is breathing, is it adequate?" Is the effort he is putting forth enough to support his needs? If the answer is no, then you must intervene.

Signs of Adequate Breathing

To determine signs of adequate breathing, you should:

- *Look* for adequate and equal expansion of both sides of the chest when the patient inhales. If he has an obviously serious respiratory problem, expose and visually inspect the chest.
- *Listen* for air entering and leaving the nose, mouth, and chest. The breath sounds (when auscultated, or listened to with a stethoscope) should be present and equal on both sides of the chest. The sounds from the mouth and nose should be typically free of gurgling, gasping, crowing, wheezing, snoring, and stridor (harsh, high-pitched sound during inhalation).
- *Feel* for air moving out of the nose or mouth.
- Check for typical skin coloration. There should be no blue or gray colorations.
- Note the rate, rhythm, quality, and depth of breathing typical for a person at rest (Table 9–2).

Table 9-2 Adequate Breathing	
NORMAL RATES	**QUALITY**
Adult—12–20 per minute	Breath sounds—present and equal
Child—15–30 per minute	Chest expansion—adequate and equal
Infant—25–50 per minute	Minimum effort
RHYTHM	**DEPTH**
Regular	Adequate

Signs of Inadequate Breathing

Signs of inadequate breathing include the following:

- Chest movements are absent, minimal, or uneven.
- Movement associated with breathing is limited to the abdomen (abdominal breathing).
- No air can be felt or heard at the nose or mouth, or the amount of air exchanged is below normal.
- Breath sounds are diminished or absent.
- Noises such as wheezing, crowing, stridor, snoring, gurgling, or gasping are heard during breathing.
- Rate of breathing is too rapid or too slow.
- Breathing is very shallow, very deep, or appears labored.
- The patient's skin, lips, tongue, ear lobes, or nail beds are blue or gray. This condition is called ***cyanosis***, and the patient is said to be cyanotic.
- Inspirations are prolonged (indicating a possible upper airway obstruction) or expirations are prolonged (indicating a possible lower airway obstruction).
- Patient is unable to speak, or the patient cannot speak full sentences because of shortness of breath.
- In children, there may be retractions (a pulling in of the muscles) above the clavicles and between and below the ribs.
- Nasal flaring (widening of the nostrils of the nose with respirations) may be present, especially in infants and children.

cyanosis (SIGH-uh-NO-sis)
a blue or gray color resulting from lack of oxygen in the body.

Respiratory Evaluation

NORMAL BREATHING *(Adequate Breathing)*	**RESPIRATORY DISTRESS** *(Adequate Breathing)*	**RESPIRATORY FAILURE** *(Inadequate Breathing)*	**RESPIRATORY ARREST** *(Inadequate Breathing)*
Quiet, no unusual sounds	May have unusual sounds such as wheezing, stridor, or coughing	Same as distress; beware absent sounds	No sounds of breathing
Normal rate of breathing	Typically elevated rate of breathing; not excessively fast, though Adequate minute volume	Often too fast or too slow Sometimes irregular or slowing Inadequate minute volume	None
Normal skin color	Sometimes normal or pale due to vasoconstriction	Pale or blue; sometimes mottled (blotchy)	Pale or blue
Normal mental status	Normal, sometimes agitated or anxious	Altered mental status	Typically unconscious or rapidly becoming unconscious

Occasionally, respiratory arrest will be difficult to determine. Recall the steps of basic CPR. Look at the chest for rise and fall. Listen for the sounds of breathing. Feel for air movement. Although gasping breaths may occasionally be present, they should never be confused for normal breathing.

Hypoxia

As already noted, hypoxia is an insufficiency in the supply of oxygen to the body's tissues. There are several major causes of hypoxia. Consider the following scenarios:

- **A patient is trapped in a fire.** The air that the patient breathes contains smoke and reduced amounts of oxygen. Since the patient cannot breathe in enough oxygen, hypoxia develops.
- **A patient has emphysema.** This lung disease decreases the efficiency of the transfer of oxygen between the atmosphere and the body. Since the lungs cannot function properly, hypoxia develops.
- **A patient overdoses on a drug that has a depressing effect on the respiratory system.** The patient's respirations are only 5 per minute. In this case, the victim is not breathing frequently enough to support the body's oxygen needs. Hypoxia develops.
- **A patient has a heart attack.** The lungs function properly by taking atmospheric air and turning it over to the blood for distribution. The damaged heart, however, cannot pump the blood throughout the body, and hypoxia develops.

There are many causes of hypoxia in addition to the examples named, including stroke, shock, and others. The most important thing to know is how to recognize signs of hypoxia so that it may be treated. Hypoxia may be indicated by cyanosis (blue or gray color to the skin). Additionally, when the brain suffers hypoxia, the patient's mental status may deteriorate. Restlessness or confusion may result.

As an EMT, your concern will be preventing hypoxia from developing or becoming worse and, when possible, reducing the level of hypoxia. This is done with the administration of oxygen.

PATIENT CARE

Inadequate Breathing

When the patient's signs indicate inadequate breathing or no breathing (respiratory failure or respiratory arrest), a life-threatening condition exists and prompt action must be taken. In the previous chapter we discussed the procedures for opening, clearing, and securing the airway. In some patients with respiratory failure you may need to first address airway issues. Review Chapter 8, "Airway Management," for more information. The additional procedures to treat life-threatening respiratory problems are:

- Providing artificial ventilation to the nonbreathing patient and the patient with inadequate breathing
- Providing supplemental oxygen to the breathing patient

These procedures are discussed next and on the following pages.

Decision Points:

When do I intervene?

It can sometimes be difficult to determine when a patient needs your intervention. Often patients in respiratory failure will be breathing and conscious. It is important, however, to identify not just the presence of breathing but the adequacy of breathing. Even though the patient may still be breathing, if he is displaying the signs of inadequate breathing, he absolutely needs your intervention. Keep in mind that what the patient is doing on his own is not meeting his needs. If left unchecked, his condition will progress to respiratory arrest. In general, it is better to be too aggressive than not aggressive enough. If the patient will allow you to intervene with a bag-valve mask, it generally means he needs it.

CORE CONCEPT
Principles and techniques of positive pressure ventilation

POSITIVE PRESSURE VENTILATION

artificial ventilation
forcing air or oxygen into the lungs when a patient has stopped breathing or has inadequate breathing. Also called *positive pressure ventilation.*

positive pressure ventilation
See artificial ventilation.

If you determine that the patient is not breathing or that his breathing is inadequate, you will need to provide artificial ventilation. *Ventilation* is the breathing of air or oxygen. ***Artificial ventilation***, also called ***positive pressure ventilation***, is forcing air or oxygen into the lungs when a patient has stopped breathing or has inadequate breathing.

It is important to remember that when we use positive pressure, we use a force that is exactly the opposite of the force the body normally uses to draw air into the lungs. Under normal circumstances, the respiratory system creates a negative pressure within the chest cavity to pull in air. With artificial ventilations, we use positive pressure from outside to push air in. This change has some negative side effects you must be conscious of and will need to limit by using proper technique.

The negative side effects of positive pressure ventilation are:

- **Decreasing cardiac output/dropping blood pressure.** Normally, the heart uses the negative pressure of ventilation to assist the filling of its chambers with blood. When we use positive pressure to ventilate, we eliminate that negative pressure and filling assistance. Although the heart can typically compensate, the risk of causing a drop in blood pressure exists, especially when excessive positive pressures are used to ventilate. This risk from positive pressure can be minimized by using just enough volume to raise the chest.
- **Gastric distention.** Gastric distention is the filling of the stomach with air that occurs when air is pushed through the esophagus during positive pressure ventilation. The esophagus, which leads to the stomach, is a larger opening than the trachea, which leads to the lungs, and the esophagus does not have a protective "cap" like the epiglottis that covers the trachea. Consequently, air is frequently diverted through the esophagus when we attempt to push air through the trachea. Side effects of gastric distention include vomiting and restriction of the movement of the diaphragm. Gastric distention can be minimized by using airway adjuncts when ventilating and also by establishing proper head position and airway opening techniques. Later in this chapter we will discuss cricoid pressure, a technique that can also help minimize gastric distention.
- **Hyperventilation.** When we take over ventilations for a patient, it is important to pay attention to rate. There are any number of distractions and stressors that cause EMTs to ventilate too quickly, and you should know that there are negative consequences of this action. Hyperventilation causes too much carbon dioxide to be blown off. This causes a vasoconstriction (narrowing of the blood vessels) in the body and can limit blood flow to the brain. Always concentrate on maintaining proper ventilation rates while providing artificial ventilation.

Techniques of Artificial Ventilation

Various techniques are available to the EMT that can be used to provide artificial ventilation:

- Mouth-to-mask (preferably with high-concentration supplemental oxygen at 15 liters per minute)
- Two-rescuer bag-valve mask (BVM) (preferably with high-concentration supplemental oxygen at 15 liters per minute)
- Flow-restricted, oxygen-powered ventilation device
- One-rescuer bag-valve mask (preferably with high-concentration supplemental oxygen at 15 liters per minute)

NOTE: *Do not ventilate a patient who is vomiting or who has vomitus in his airway. Positive pressure ventilation will force the vomitus into the patient's lungs. Make sure the patient is not actively vomiting and suction any vomitus from the airway before ventilating.*

No matter what method you use to ventilate the patient, you must ensure that the patient is being adequately ventilated. To determine the signs of *adequate* artificial ventilation, you should:

- Watch the chest rise and fall with each ventilation.
- Ensure that the rate of ventilation is sufficient—approximately 10–12 per minute in adults, 20 per minute in children, and a minimum of 20 per minute in infants.

FIGURE 9-5 Examples of barrier devices.

Inadequate artificial ventilation occurs when:

- The chest does not rise and fall with ventilations.
- The rate of ventilation is too fast or too slow.

Techniques used for artificial ventilation should also ensure adequate protection of the rescuer from the patient's body fluids, including saliva, blood, and vomit. For this reason, mouth-to-mouth ventilation is not recommended unless there is no alternative method of artificial ventilation available. A number of compact barrier devices are available for personal use (Figure 9-5).

NOTE: *The skill of assisting a patient's ventilations is difficult to master as it requires careful watching for the chest rise and coordinating delivery of the pocket-mask or BVM ventilation.*

As noted earlier, ventilation will also be required on a patient who is breathing but doing so inadequately. This may be due to a very rapid but shallow rate or a very slow rate. In any case, keep in mind that it may be intimidating to ventilate (use a pocket face mask or bag-valve mask on) a patient who is breathing and may even be aware of what you are doing. Follow these guidelines for ventilation of a breathing patient:

For a patient with rapid ventilations:

- Carefully assess the adequacy of respirations.
- Explain the procedure to the patient. Calm reassurance and a simple explanation such as, "I'm going to help you breathe," are essential for the awake patient.
- Place the mask (pocket face mask or BVM) over the patient's mouth and nose.
- After sealing the mask on the patient's face, squeeze the bag with the patient's inhalation. Watch as the patient's chest begins to rise and deliver the ventilation with the start of the patient's own inhalation. The goal will be to increase the volume of the breaths you deliver. Over the next several breaths, adjust the rate so you are ventilating fewer times per minute but with greater volume per breath (increasing the minute volume).

For a patient with slow ventilations:

- Carefully assess the adequacy of respirations.
- Explain the procedure to the patient. Again, calm reassurance and a simple explanation such as, "I'm going to help you breathe," are essential in the awake patient.
- Place the mask (pocket face mask or BVM) over the patient's mouth and nose.
- After sealing the mask on the patient's face, squeeze the bag every time the patient begins to inhale. If the rate is very slow, add ventilations in between the patient's own to obtain a rate of approximately 12 per minute with adequate minute volume.

CPAP/BiPAP

A new and very effective prehospital modality of therapy for treating patients with inadequate breathing and respiratory distress is *noninvasive positive pressure ventilation (NPPV)* in the form of *CPAP* (continuous positive airway pressure) and *BiPAP* (biphasic continuous

positive airway pressure). NPPV assists the ventilations of a breathing patient by assuring that each breath the patient takes maintains adequate pressure within the respiratory tract, improving alveolar ventilation and gas exchange (thus preventing hypoxia and carbon dioxide accumulation). NPPV can be used only by patients who are still breathing on their own. It will be extensively discussed in Chapter 19, "Respiratory Emergencies."

Mouth-to-Mask Ventilation

pocket face mask
a device, usually with a one-way valve, to aid in artificial ventilation. A rescuer breathes through the valve when the mask is placed over the patient's face. It also acts as a barrier to prevent contact with a patient's breath or body fluids. It can be used with supplemental oxygen when fitted with an oxygen inlet.

Mouth-to-mask ventilation is performed using a ***pocket face mask***. The pocket face mask is made of soft, collapsible material and can be carried in your pocket, jacket, or purse (Figure 9-6). Many EMTs purchase their own pocket face masks for workplace or auto first aid kits.

Face masks have important infection control features. Your ventilations (breaths) are delivered through a valve in the mask so that you do not have direct contact with the patient's mouth. Most pocket masks have one-way valves that allow your ventilations to enter but prevent the patient's exhaled air from coming back through the valve and into contact with you (Figure 9-7).

Some pocket masks have oxygen inlets. When high-concentration oxygen is attached to the inlet, it delivers an oxygen concentration of approximately 50 percent. This is significantly better than the 16 percent oxygen concentration (in exhaled air) delivered by mouth-to-mask ventilations without supplemental oxygen.

Most pocket face masks are made of a clear plastic. This is important because you must be able to observe the patient's mouth and nose for vomiting or secretions that need to be suctioned. You also need to observe the color of the lips, an indicator of the patient's respiratory status. Some pocket face masks have a strap that goes around the patient's head. This is helpful during one-rescuer CPR, since it will hold the mask on the patient's face while you are performing chest compressions. However, it does not replace the need for proper hand placement on the mask.

To provide mouth-to-mask ventilation (Table 9-3), follow these steps:

1. Position yourself at the patient's head and open the airway. It may be necessary to clear the airway of obstructions. If appropriate, insert an oropharyngeal airway to help keep the patient's airway open (as described later in this chapter).

FIGURE 9-6 Pocket face mask.

FIGURE 9-7 Use only a pocket mask with a one-way valve.

Table 9-3 Use of the Pocket Face Mask

PATIENT	USE OF THE POCKET FACE MASK
Patient *without* suspected spine injury—EMT at top of patient's head 	• Position yourself directly above (at the top of) the patient's head. • Apply the mask to the patient. Use the bridge of the patient's nose as a guide for correct position. • Place your thumbs over the top of the mask, your index fingers over the bottom of the mask, and the rest of your fingers under the patient's jaw. • Lift the jaw to the mask as you tilt the patient's head backward and place the remaining fingers under the angle of the jaw. • While lifting the jaw, squeeze the mask with your thumbs to achieve a seal between the mask and the patient's face. • Give breaths into the one-way valve of the mask. Watch for the chest to rise.
Patient *without* suspected spine injury—Alternative: EMT beside patient's head 	• Position yourself beside the patient's head. • Apply the mask to the patient. Use the bridge of the nose as a guide for correct position. • Seal the mask by placing your index finger and thumb of the hand closer to the top of the patient's head along the top border of the mask. • Place the thumb of the hand closer to the patient's feet on the lower margin of the mask. Place the remaining fingers of this hand along the bony margin of the jaw. • Lift the jaw while performing a head-tilt, chin-lift maneuver. • Compress the outer margins of the mask against the face to obtain a seal. • Give breaths into the one-way valve on the mask. Watch for the chest to rise.
Patient *with* suspected spine injury—EMT at top of patient's head 	• Position yourself directly above (at the top of) the patient's head. • Apply the mask to the patient. Use the bridge of the patient's nose as a guide for correct position. • Place the thumb sides of your hands along the mask to hold it firmly on the face. • Use your remaining fingers to lift the angle of the jaw. ***Do not tilt the head backward.*** • While lifting the jaw, squeeze the mask with your thumbs and fingers to achieve a seal. • Give breaths into the one-way valve on the mask. Watch for the chest to rise. **NOTE:** *Factors such as hand size, patient size, or dentures not in place may necessitate modifications in hand position and technique to achieve the necessary tight seal.*

2. Connect oxygen to the inlet on the mask and run at 15 liters per minute. If oxygen is not immediately available, do not delay mouth-to-mask ventilations.
3. Position the mask on the patient's face so that the apex (top of the triangle) is over the bridge of the nose and the base is between the lower lip and prominence of the chin. (Center the ventilation port over the patient's mouth.)
4. Hold the mask firmly in place while maintaining head tilt. Use one of these positions or some variation—with the aim of achieving a tight seal:
   - Thumbs over the top of the mask, index fingers over the bottom of the mask, and remaining fingers under the patient's jaw (Table 9-3, top)
   - Thumbs along the side of the mask and remaining fingers under the patient's jaw (Table 9-3, bottom)
5. Take a breath and exhale into the mask port or one-way valve at the top of the mask port. Each ventilation should be delivered over 1 second in adults, infants, and children and be of just enough volume to make the chest rise. Full expansion of the chest is undesirable; the ventilation should cease as soon as you notice the chest moving.
6. Remove your mouth from the port and allow for passive exhalation. Continue as you would for mouth-to-mouth ventilations or CPR.

When properly used, and if the rescuer has an adequate expiratory capacity, the pocket face mask may deliver higher volumes of air to the patient than the bag-valve-mask device.

Bag-Valve Mask

bag-valve mask (BVM) a handheld device with a face mask and self-refilling bag that can be squeezed to provide artificial ventilations to a patient. It can deliver air from the atmosphere or oxygen from a supplemental oxygen supply system.

The ***bag-valve mask (BVM)*** (also called bag mask or bag-mask device) is a handheld ventilation device. It may also be referred to as a bag-valve-mask unit, system, device, resuscitator, or simply BVM. The bag-valve-mask unit can be used to ventilate a nonbreathing patient and is also helpful to assist ventilations in the patient whose own respiratory attempts are not enough to support life, such as a patient in respiratory failure or drug overdose. The BVM also provides an infection-control barrier between you and your patient. The use of the bag-valve mask in the field is often referred to as "bagging" the patient (Table 9-4).

Bag-valve-mask units come in sizes for adults, children, and infants (Figure 9-8). Many different types of bag-valve-mask systems are available; however, all have the same basic parts. The bag must be a self-refilling shell that is easily cleaned and sterilized. (Some bag-

FIGURE 9-8 Adult, child, and infant bag-valve-mask units.

Table 9-4 Use of the Bag-Valve Mask

PATIENT	USE OF THE BAG-VALVE MASK
Patient *without* suspected spine injury 	• Open the airway and insert appropriately sized oral or nasal airway (if no gag reflex). • Position your thumbs over the top of the mask, with index fingers over the bottom of the mask. • Place the mask over the patient's face. Position the mask over the patient's nose and lower to the chin. (Large, round-style masks are centered first on the mouth.) • Use your middle, ring, and little fingers to bring the jaw up to the mask. • Connect the bag to the mask and have an assistant squeeze the bag until the chest rises. • If the chest does not rise and fall, reevaluate the head position and mask seal. • If unable to ventilate, use another device (e.g., pocket face mask or FROPVD).
Patient *with* suspected spine injury 	• Open the airway with a jaw thrust and insert an appropriate size airway if no gag reflex exists. • Have an assistant manually immobilize the head and neck. Immobilization of the head between your knees may be acceptable if no assistance is available. • Place the thumb sides of your hands along the mask to hold it firmly on the face. • Place the mask on the patient's face as previously described. • Use your little and ring fingers to bring the jaw up to the mask without tilting the head or neck. • Have an assistant squeeze the bag with two hands until the chest rises. • Continually evaluate ventilations.

valve-mask units are designed for single use and are then disposed of.) The system must have a non-jam valve that allows an oxygen inlet flow of 15 liters per minute. The valve should be nonrebreathing (preventing the patient from rebreathing his own exhalations) and not subject to freezing in cold temperatures. Most systems have a standard 15/22 respiratory fitting to ensure a proper fit with other respiratory equipment, face masks, and endotracheal tubes.

The mechanical workings of a bag-valve-mask device are simple. Oxygen, flowing at 15 liters per minute, is attached to the BVM and enters the reservoir. When the bag is squeezed, the air inlet to the bag is closed, and the oxygen is delivered to the patient.

When the squeeze of the bag is released, a passive expiration by the patient will occur. While the patient exhales, oxygen enters the reservoir to be delivered to the patient the next time the bag is squeezed. BVM systems without a reservoir deliver approximately 50 percent oxygen. In contrast, systems with an oxygen reservoir provide nearly 100 percent oxygen. The bag itself will hold anywhere from 1,000 to 1,600 mL of air. This means that the bag-valve-mask system must be used properly and efficiently.

The most difficult part of delivering BVM artificial ventilations is obtaining an adequate mask seal so that air does not leak out around the edges of the mask. It is difficult to maintain the seal with one hand while squeezing the bag with the other, and one-rescuer bag-valve-mask operation is often unsuccessful or inadequate for this reason. Therefore, it is strongly recommended by the American Heart Association that BVM artificial ventilation be performed by two rescuers. In two-rescuer BVM ventilation, one rescuer is assigned to squeeze the bag while the other rescuer uses two hands to maintain a mask seal.

FIGURE 9-9 Delivering two-rescuer BVM ventilation when no trauma is suspected in the patient.

FIGURE 9-10 Delivering two-rescuer BVM ventilation while providing manual stabilization of the head and neck when trauma is suspected in the patient.

NOTE: *Many older bag-valve masks have "pop-off" valves, designed to open after certain pressures are obtained. Studies have shown that pop-off valves may prevent adequate ventilations. BVM systems with pop-off valves should be replaced. A BVM system should also have a clear face mask so that you can observe the lips for cyanosis and monitor the airway in case suctioning is needed.*

The two-rescuer technique can also be modified so that the jaw-thrust maneuver can be used during BVM ventilations. This technique is to be used when performing BVM ventilation on a patient with a suspected head, neck, or spine injury. Proficiency in this technique requires frequent mannequin practice. There are different ways to perform BVM ventilation when trauma (injury) is not suspected (Figure 9-9) and when trauma is suspected (Figure 9-10).

Two-Rescuer BVM Ventilation—No Trauma Suspected When two rescuers perform bag-valve ventilation on a patient in whom *no* trauma is suspected, follow these steps:

1. Open the patient's airway *using the head-tilt, chin-lift maneuver*. Suction and insert an airway adjunct as necessary.
2. Select the correct bag-valve mask size (adult, child, or infant).
3. Kneel at the patient's head. Position thumbs over the top half of the mask, index fingers over the bottom half.
4. Place the apex, or top, of the triangular mask over the bridge of the patient's nose. Then lower the mask over the mouth and upper chin. If the mask has a large, round cuff surrounding a ventilation port, center the port over the patient's mouth.
5. Use your middle, ring, and little fingers to bring the patient's jaw up to the mask. *Maintain the head-tilt, chin-lift maneuver*.
6. The second rescuer should connect the bag to the mask, if not already done. While you maintain the mask seal, the second rescuer should squeeze the bag with two hands until the patient's chest rises. The second rescuer should squeeze the bag *once every 5 seconds for an adult, once every 3 seconds for a child or infant*.
7. The second rescuer should release pressure on the bag and let the patient exhale passively. While this occurs, the bag is refilling from the oxygen source.

Two-Rescuer BVM Ventilation—Trauma Suspected When two rescuers perform bag-valve ventilation on a patient in whom trauma *is* suspected, follow these steps:

1. Open the patient's airway *using the jaw-thrust maneuver*. Suction and insert an airway adjunct (see later in this chapter) as necessary.
2. Select the correct bag-valve mask size (adult, child, or infant).
3. Kneel at the patient's head. Place thumb sides of your hands along the mask to hold it firmly on the face.

4. Use your remaining fingers to bring the jaw upward, toward the mask, *without tilting the head or neck*.
5. Have the second rescuer squeeze the bag to ventilate the patient as previously described for the nontrauma patient.

Cricoid Pressure ***Cricoid pressure***, also known as the Sellick maneuver, is performed by applying firm backward pressure to the cricoid ring in the patient's neck. The cricoid ring surrounds the trachea, and pushing on it exerts pressure on the esophagus, which is posterior to the trachea, partially occluding the esophagus. This technique is designed to minimize air entry into the esophagus and stomach during positive pressure ventilation. The cricoid ring can be found by palpating the Adam's apple and then identifying the ring (or bump) just inferior. While one provider is providing artificial ventilation, a second provider will place two fingers on this ring and firmly press backward while ventilating. It should be noted that this technique will cause discomfort in the conscious patient and should be limited to those patients who are unconscious or have a severely impaired mental status. You should also not apply cricoid pressure if the patient is vomiting or begins to vomit.

cricoid pressure
pressure applied to the cricoid ring to minimize air entry into the esophagus during positive pressure ventilation. Also called *Sellick maneuver*.

One-Rescuer BVM Ventilation As noted, use of a bag-valve mask by a single rescuer is the last choice of artificial ventilation procedure—behind use of a pocket face mask with supplemental oxygen, a two-rescuer bag-valve-mask procedure, and use of a flow-restricted, oxygen-powered ventilation device. You should provide ventilations with a one-rescuer bag-valve-mask procedure only when no other options are available.

When you perform bag-valve ventilation alone, without assistance from a second rescuer, follow these steps:

1. Position yourself at the patient's head and establish an open airway. Suction and insert an airway adjunct as necessary.
2. Select the correct size mask for the patient. Position the mask on the patient's face as described previously for the two-rescuer BVM technique.
3. Form a "C" around the ventilation port with thumb and index finger. Use your middle, ring, and little fingers under the patient's jaw to hold the jaw to the mask.
4. With your other hand, *squeeze the bag once every 5 seconds*. *For infants and children*, *squeeze the bag once every 3 seconds*. The squeeze should be a full one, causing the patient's chest to rise.
5. Release pressure on the bag and let the patient exhale passively. While this occurs, the bag is refilling from the oxygen source.

If the chest does not rise and fall during BVM ventilation, you should:

1. Reposition the head.
2. Check for escape of air around the mask and reposition your fingers and the mask.
3. Check for airway obstruction or obstruction in the BVM system. Re-suction the patient if necessary. Consider insertion of an airway adjunct if not already done.
4. If none of these methods work, use an alternative method of artificial ventilation, such as a pocket mask or a flow-restricted, oxygen-powered ventilation device.

The BVM may also be used during CPR. In this situation, the bag is squeezed once each time a ventilation is to be delivered. In one-rescuer CPR, it is preferable to use a pocket mask with supplemental oxygen (Figure 9-11) rather than a BVM system. A single rescuer would take too much time picking up the BVM and obtaining a face seal each time a ventilation is to be delivered, in addition to the normal difficulty in maintaining a seal with the one-rescuer BVM technique.

NOTE: *Bag-valve-mask devices should be completely disassembled and disinfected after each use. Because proper decontamination is often costly and time-consuming, many hospitals and EMS agencies use single-use disposable BVMs.*

Artificial Ventilation of a Stoma Breather The BVM can be used to artificially ventilate a patient with a ***stoma***, a surgical opening in the neck through which the patient breathes. Patients with stomas who are found to be in severe respiratory distress or respiratory arrest frequently have thick secretions blocking the stoma. It is recommended that you suction the stoma frequently in conjunction with BVM-to-stoma ventilations.

stoma
a permanent surgical opening in the neck through which the patient breathes.

FIGURE 9-11 One-rescuer CPR using a pocket face mask with supplemental oxygen. The EMT is beside the patient, from which position chest compressions can also be performed. The strap holds the pocket mask in place while the rescuer switches tasks.

POINT OF VIEW

"I still can't tell you why I didn't know it was coming on. I didn't feel right for a few days. Then it hit me. I couldn't move without feeling like I would suffocate. I just couldn't breathe. Couldn't catch my breath. I could tell it was serious when the EMTs came in. It showed in their faces.

"I think I must've started getting even worse, because I remember feeling like I was losing it. I remember them trying to calm me down, but I really felt like I was going to have to be peeled off the ceiling of that ambulance.

"When they tried to put that big mask on my face I felt like it was going to kill me. To take away all my air. I fought it. The EMTs kept calming me and putting that mask on my face. Somehow I calmed down a little and they gave me air or oxygen or something. I made it to the hospital. The doctor told me that the EMTs may have saved my life.

"I appreciate that more than I can say—even if that mask felt pretty intimidating at the time.

As with other BVM uses, a two-rescuer technique is preferred over a one-rescuer technique. To provide artificial ventilation to a stoma breather using a BVM, follow these steps:

1. Clear any mucus plugs or secretions from the stoma.
2. Leave the head and neck in a neutral position, as it is unnecessary to position the airway prior to ventilations in a stoma breather.
3. Use a pediatric-sized mask to establish a seal around the stoma.
4. Ventilate at the appropriate rate for the patient's age.
5. If unable to artificially ventilate through the stoma, consider sealing the stoma and attempting artificial ventilation through the mouth and nose. (This may work if the trachea is still connected to the passageways of the mouth, nose, and pharynx. In some cases, however, the trachea has been permanently connected to the neck opening with no remaining connection to the mouth, nose, or pharynx).

Flow-Restricted, Oxygen-Powered Ventilation Device

flow-restricted, oxygen-powered ventilation device (FROPVD)
a device that uses oxygen under pressure to deliver artificial ventilations. Its trigger is placed so that the rescuer can operate it while still using both hands to maintain a seal on the face mask. It has automatic flow restriction to prevent overdelivery of oxygen to the patient.

A ***flow-restricted, oxygen-powered ventilation device (FROPVD),*** also called a *manually triggered ventilation device*, uses oxygen under pressure to deliver artificial ventilations through a mask placed over the patient's face. This device is similar to the traditional demand-valve resuscitator but includes newer features designed to optimize ventilations and safeguard the patient (Figure 9-12). Recommended features include:

- A peak flow rate of 100 percent oxygen at up to 40 liters per minute
- An inspiratory pressure relief valve that opens at approximately 60 cm of water pressure
- An audible alarm when the relief valve is activated
- A rugged design and construction

FIGURE 9-12 Providing ventilations with a flow-restricted, oxygen-powered ventilation device (FROPVD).

- A trigger that enables the rescuer to use both hands to maintain a mask seal while triggering the device
- Satisfactory operation in both ordinary and extreme environmental conditions

Follow the same procedures for mask seal as recommended for the BVM (Table 9-5). Trigger the device until the chest rises *and repeat every 5 seconds*. If the chest does not rise,

Table 9-5 Use of the Flow-Restricted, Oxygen-Powered Ventilation Device (FROPVD; Manually Triggered Ventilator)

PATIENT	USE OF THE FROPVD
Patient *without* suspected spine injury 	• Open the airway and insert an appropriately sized oral or nasal airway. • Position the thumbs over the top of the mask, with your index fingers over the bottom half. • Place the mask over the face and use the middle, ring, and little fingers to bring the patient's jaw up to the mask. • Trigger the ventilation device until the chest rises. Do not overinflate. • Reevaluate ventilations frequently.
Patient *with* suspected spine injury 	• Open the airway with a jaw thrust and insert an appropriate size airway if no gag reflex exists. • Have an assistant manually immobilize the head and neck. Immobilization of the head between your knees may be acceptable if no assistance is available. • Place the thumb side of your hands along the mask to hold it firmly on the face. • Place the mask on the patient's face as previously described. • Use your remaining fingers to bring the jaw up to the mask without tilting the head or neck. • Trigger the ventilation device until the chest rises. Do not overinflate. • Monitor ventilations.

FIGURE 9-13 An automatic transport ventilator. The coin is shown for scale. *(© Edward T. Dickinson, MD)*

reposition the head, check the mask seal, check for obstructions, and consider the use of an alternative artificial ventilation procedure.

When using the FROPVD on a patient with chest trauma, be especially careful not to overinflate, as you may actually make the chest injury worse. Also, always make sure the airway is fully opened, and watch for chest rise. Make sure you are not forcing excess air to enter the stomach instead of the lungs, causing gastric distention, which could cause the patient to regurgitate and possibly compromise the airway with stomach contents.

If neck injury is suspected, have an assistant hold the patient's head manually or put a rigid collar or head blocks on the patient to prevent movement. (Using your knees to prevent head movement is sometimes recommended but places you too close to the patient, making it difficult to open the airway and assess chest rise properly.) Bring the jaw up to the mask without tilting the head or neck.

The flow-restricted, oxygen-powered ventilation device should be used only on adults unless you have a child unit and have been given special training in its use by your Medical Director.

automatic transport ventilator (ATV)
a device that provides positive pressure ventilations. It includes settings designed to adjust ventilation rate and volume, is portable, and is easily carried on an ambulance.

Automatic Transport Ventilator

The ***automatic transport ventilator (ATV)*** (Figure 9-13) may be used in EMS to provide positive pressure ventilations to a patient in respiratory arrest. The ATV has settings to adjust ventilation rate and volume. These ventilators are very portable and easily carried on

CRITICAL DECISION MAKING

Oxygen or Ventilation?

You have learned several methods to administer supplemental oxygen and to provide ventilations to a patient. It has been said that the decision on when to provide supplemental oxygen (e.g., nonrebreather mask or cannula) or to ventilate (e.g., BVM, FROPVD) is one of the most important decisions you will make.

For each of the following patients, decide whether you would administer oxygen or ventilate the patient.

1. A patient who was found on the floor by a relative. He has no pulse or respirations.
2. A 14-year-old patient who has a broken femur. She is alert; pulse 110, strong and regular; respirations 28, rapid and deep.
3. A 64-year-old male with chest pain. He is alert; pulse 56; respirations 18 and normal.
4. A 78-year-old patient with COPD. He has had increasing difficulty breathing over the past few days. He responds verbally but is not oriented. His pulse is 124; respirations 36 and shallow.

ambulances. When prolonged ventilation is necessary, and when only one rescuer is available to ventilate a patient, the ATV may be beneficial. Caution must be used to be sure the respiratory rate is appropriate for the patient's size and condition. A proper mask seal is required for these devices to effectively deliver ventilation.

OXYGEN THERAPY

Importance of Supplemental Oxygen

CORE CONCEPT
Principles and techniques of oxygen administration

Oxygen administration is often one of the most important and beneficial treatments an EMT can provide. The atmosphere provides approximately 21 percent oxygen. If a person does not have an illness or injury, that 21 percent is enough to support normal functioning. However, patients EMTs come in contact with are sick or injured and often require supplemental oxygen.

Conditions Requiring Oxygen

Patients with the following conditions may require supplemental oxygen:

- **Respiratory or cardiac arrest.** CPR is only 25 to 33 percent as effective as normal circulation. High-concentration oxygen administration is currently recommended when providing artificial ventilations to a patient in respiratory or cardiac arrest.
- **Heart attacks and strokes.** These emergencies result from an interruption of blood to the heart or brain. When this occurs, tissues are deprived of oxygen. Providing extra oxygen is extremely important.
- **Shock.** Since shock is the failure of the cardiovascular system to provide sufficient blood to all the vital tissues, all cases of shock reduce the amount of oxygenated blood reaching the tissues. Administration of oxygen helps the blood that does reach the tissues deliver the maximum amount of oxygen.
- **Blood loss.** Whether bleeding is internal or external, there is a reduced amount of circulating blood and red blood cells, so the blood that is circulating needs to be saturated with oxygen.
- **Respiratory distress and lung diseases.** The lungs are responsible for turning oxygen over to the blood cells to be delivered to the tissues. When the lungs are not functioning properly, supplemental oxygen helps ensure that the body's tissues receive adequate oxygen.
- **Head injuries, other serious injuries, and more.** There are very few emergencies where oxygen administration would not be appropriate. All our body's systems work together. An injury in one part may cause shock that affects the rest of the body.

Oxygen Therapy Equipment

In the field, oxygen equipment must be safe, lightweight, portable, and dependable. Some field oxygen systems are very portable and can be brought almost anywhere. Other systems are installed inside the ambulance so that oxygen can be delivered during transportation to the hospital.

Most oxygen delivery systems (Figure 9-14) contain several items: oxygen cylinders, pressure regulators, and a delivery device (nonrebreather mask or cannula). When the patient is not breathing or is breathing inadequately, additional devices (such as a pocket mask, bag-valve mask, or FROPVD) can be used to force oxygen into the patient's lungs.

Oxygen Cylinders

oxygen cylinder
a cylinder filled with oxygen under pressure.

Outside a medical facility, the standard source of oxygen is the ***oxygen cylinder***, a seamless steel or lightweight alloy cylinder filled with oxygen under pressure, equal to 2,000 to 2,200 pounds per square inch (psi) when the cylinders are full. Cylinders come in various sizes, identified by letters (Figure 9-15). The following cylinders are in common use in emergency care:

- *D cylinder* contains about 350 liters of oxygen.
- *E cylinder* contains about 625 liters of oxygen.
- *M cylinder* contains about 3,000 liters of oxygen.

FIGURE 9-14 An oxygen delivery system.

FIGURE 9–15 For safety, to prevent them from tipping over, oxygen cylinders must be placed in a horizontal position or, if upright, must be securely supported.

Fixed systems on ambulances (commonly called on-board oxygen) include the M cylinder and larger cylinders (Figure 9-16):

- *G cylinder* contains about 5,300 liters of oxygen.
- *H cylinder* contains about 6,900 liters of oxygen.

The *United States Pharmacopoeia* has assigned a color code to distinguish compressed gases. Green and white cylinders have been assigned to all grades of oxygen. Unpainted stainless steel and aluminum cylinders are also used for oxygen. Regardless of the color, always check the label to be certain you are using medical-grade oxygen.

Part of your duty as an EMT is to make certain that the oxygen cylinders you will use are full and ready before they are needed to provide care. The length of time you can use an oxygen cylinder depends on the pressure in the cylinder and the flow rate. You cannot tell if an oxygen cylinder is full, partially full, or empty just by lifting or moving the cylinder. The method of calculating cylinder duration is shown in Table 9-6.

Oxygen cylinders should never be allowed to empty below the safe residual or the tank may be permanently damaged. The safe residual for an oxygen cylinder is when the pressure gauge reads 200 psi or above. Below this point there is not enough oxygen in the cylinder to

FIGURE 9-16 Larger cylinders are used for fixed systems on ambulances.

Table 9-6 Oxygen Cylinders: Duration of Flow

SIMPLE FORMULA

Gauge pressure in psi (pounds per square inch) minus the safe residual pressure (always 200 psi) times the constant (see following list) divided by the flow rate in liters per minute = duration of flow in minutes.

CYLINDER CONSTANTS

D = 0.16	G = 2.41
E = 0.28	H = 3.14
M = 1.56	K = 3.14

EXAMPLE

Determine the life of an M cylinder that has a pressure of 2,000 psi displayed on the pressure gauge and a flow rate of 10 liters per minute.

$$\frac{(2{,}000 - 200) \times 1.56}{10} = \frac{2{,}808}{10} = 280.8 \text{ minutes}$$

allow for proper delivery to the patient. Before the cylinder reaches the 200 psi reading, you must switch to a fresh cylinder.

(**NOTE:** *Some systems or services may require cylinder changes at specific psi levels. Always follow local guidelines.*)

Safety is of prime importance when working with oxygen cylinders. You should:

- *Always* use pressure gauges, regulators, and tubing that are intended for use with oxygen.
- *Always* use nonferrous (made of plastic or of metals that do not contain iron) oxygen wrenches for changing gauges and regulators or for adjusting flow rates. Other types of metal tools may produce a spark should they strike against metal objects.
- *Always* ensure that valve seat inserts and gaskets are in good condition. This prevents dangerous leaks. Disposable gaskets on oxygen cylinders should be replaced each time a cylinder change is made.
- *Always* use medical-grade oxygen. Industrial oxygen contains impurities. The cylinder should be labeled "OXYGEN U.S.P." The oxygen must not be more than 5 years old.
- *Always* open the valve of an oxygen cylinder fully, then close it half a turn to prevent someone else from thinking the valve is closed and trying to force it open. The valve does not have to be turned fully to be open for delivery.
- *Always* store reserve oxygen cylinders in a cool, ventilated room, properly secured in place.
- *Always* have oxygen cylinders hydrostatically tested every 5 years. The date a cylinder was last tested is stamped on the cylinder. Some cylinders can be tested every 10 years. These will have a star after the date (e.g., 4M86MM*).
- *Never* drop a cylinder or let it fall against any object. When transporting a patient with an oxygen cylinder, make sure the oxygen cylinder is strapped to the stretcher or otherwise secured.
- *Never* leave an oxygen cylinder standing in an upright position without being secured.
- *Never* allow smoking around oxygen equipment in use. Clearly mark the area of use with signs that read "OXYGEN–NO SMOKING."
- *Never* use oxygen equipment around an open flame.
- *Never* use grease, oil, or fat-based soaps on devices that will be attached to an oxygen supply cylinder. Take care not to handle these devices when your hands are greasy. Use greaseless tools when making connections.
- *Never* use adhesive tape to protect an oxygen tank outlet or to mark or label any oxygen cylinders or oxygen delivery apparatus. The oxygen can react with the adhesive and debris and cause a fire.
- *Never* try to move an oxygen cylinder by dragging it or rolling it on its side or bottom.

Pressure Regulators

pressure regulator
a device connected to an oxygen cylinder to reduce cylinder pressure so it is safe for delivery of oxygen to a patient.

The pressure in an oxygen cylinder (approximately 2,000 psi in a full tank—varying with surrounding temperature) is too high to be delivered to a patient. A ***pressure regulator*** must be connected to the cylinder to provide a safe working pressure of 30 to 70 psi.

On cylinders of the E size or smaller, the pressure regulator is secured to the cylinder valve assembly by a yoke assembly. The yoke is provided with pins that must mate with corresponding holes in the valve assembly. This is called a pin-index safety system. Since the pin position varies for different gases, this system prevents an oxygen delivery system from being connected to a cylinder containing another gas.

> **NOTE:** *You must maintain the regulator inlet filter. It has to be free of damage and clean to prevent contamination of, and damage to, the regulator.*

Cylinders larger than the E size have a valve assembly with a threaded outlet. The inside and outside diameters of the threaded outlets vary according to the gas in the cylinder. This prevents an oxygen regulator from being connected to a cylinder containing another gas. In other words, a nitrogen regulator cannot be connected to an oxygen cylinder, or vice versa.

Before connecting the pressure regulator to an oxygen supply cylinder, stand to the side of the main valve opening and open (crack) the cylinder valve slightly for just a second to clear dirt and dust out of the delivery port or threaded outlet.

Flowmeters

flowmeter
a valve that indicates the flow of oxygen in liters per minute.

A ***flowmeter***, which is connected to the pressure regulator, allows control of the flow of oxygen in liters per minute. Most services keep the flowmeter permanently attached to the pressure regulator. Low-pressure and high-pressure flowmeters are available.

Low-Pressure Flowmeters Low-pressure flowmeters, specifically the pressure-compensated flowmeter and the constant flow selector valve (Figure 9-17A), are in general use in the field.

- **Pressure-compensated flowmeter.** This meter is gravity dependent and must be in an upright position to deliver an accurate reading. The unit has an upright, calibrated glass tube in which there is a ball float. The float rises and falls according to the amount of gas passing through the tube. This type of flowmeter indicates the actual flow at all times, even though there may be a partial obstruction to gas flow (e.g., from a kinked delivery tube). If the tubing collapses, the ball will drop to show the lower delivery rate. This unit is not practical for many portable delivery systems. Recommended use is for larger (M, G, and H) oxygen cylinders in the ambulance.
- **Constant flow selector valve.** This type of flowmeter, which is gaining in popularity, has no gauge and allows for the adjustment of flow in liters per minute in stepped increments (2, 4, 6, 8 . . . to 15 liters or more per minute). It can be accurately used with the nasal cannula or nonrebreather mask and with any size oxygen cylinder. It is rugged and will operate at any angle.

  When using this type of flowmeter, make certain that it is properly adjusted for the desired flow and monitor it to make certain that it stays properly adjusted. All types of meters should be tested for accuracy as recommended by the manufacturer.

High-Pressure Flowmeters The low-pressure flowmeters just listed will administer oxygen up to either 15 or 25 liters per minute. In some circumstances, however, oxygen is required at higher pressures. This may be necessary for oxygen-powered devices such as the Thumper™ CPR device or for respirators and ventilators, such as the CPAP and BiPAP devices discussed earlier in this chapter. There are several ways you will identify high-pressure connections. One is observing a threaded connection on an oxygen regulator (Figure 9-17B). You may also see thick, green hose-type tubing connected to the high-pressure regulator.

Humidifiers

A ***humidifier*** can be connected to the flowmeter to provide moisture to the dry oxygen coming from the supply cylinder (Figure 9-18). Oxygen without humidification can dry out the mucous membranes of the patient's airway and lungs. In most short-term use, the dryness of the oxygen is not a problem; however, the patient is usually more comfortable when given humidified oxygen. This is particularly true if the patient has COPD or is a child.

humidifier
a device connected to the flowmeter to add moisture to the dry oxygen coming from an oxygen cylinder.

A humidifier is usually no more than a nonbreakable jar of water attached to the flowmeter. Oxygen passes (bubbles) through the water to become humidified. As with all oxygen delivery equipment, the humidifier must be kept clean. The water reservoir can become a breeding

FIGURE 9-17 (A) Low-pressure flowmeters. (Left) A pressure-compensated flowmeter (Right) A constant flow selector valve. (B) High-pressure flowmeter. High-pressure oxygen is delivered through hoses attached to a threaded connector.

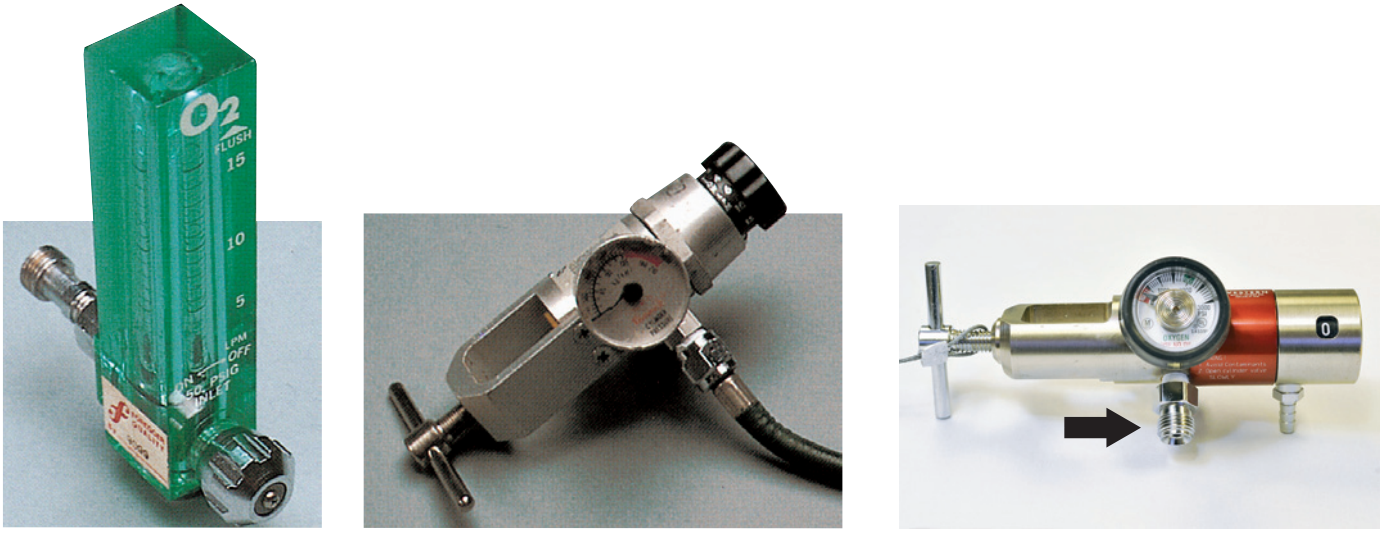


FIGURE 9-18 Humidifier in use on board an ambulance.

ground for algae, harmful bacteria, and dangerous fungal organisms. Always use fresh water in a clean reservoir for each shift. Sterile single-patient-use humidifiers are available and preferred.

In many EMS systems, humidifiers are no longer used because they are not indicated for short transports and because of the infection risk. The devices may be beneficial on long transports and on certain pediatric patients with signs of inadequate breathing.

Hazards of Oxygen Therapy

Although the benefits of oxygen are great, oxygen must be used carefully. The hazards of oxygen therapy may be grouped into two categories: nonmedical and medical.

Nonmedical hazards are extremely rare and can be avoided totally if oxygen and oxygen equipment are treated properly. Some of the most common hazards are:

- The oxygen used in emergency care is stored under pressure, usually 2,000 to 2,200 pounds per square inch (psi) or greater in a full cylinder. If the tank is punctured, or a valve breaks off, the supply tank can become a missile (damaged tanks have been able to penetrate concrete walls). Imagine what would happen in the passenger compartment of an ambulance if such an accident occurred.
- Oxygen supports combustion, causing fire to burn more rapidly. It can saturate towels, sheets, and clothing, greatly increasing the risk of fire.
- Under pressure, oxygen and oil do not mix. When they come into contact, a severe reaction occurs which, for our purposes, can be termed an explosion. This is seldom a problem, but it can easily occur if you lubricate a delivery system or gauge with petroleum products, or allow contact with a petroleum-based adhesive (e.g., adhesive tape).

The medical hazards of oxygen rarely affect the patients treated by the EMT. There are certain patients who, when exposed to high concentrations of oxygen for a prolonged time, may develop negative side effects. These situations are rare in the field:

- **Oxygen toxicity or air sac collapse.** These problems are caused in some patients whose lungs react unfavorably to the presence of oxygen and also may result from too high a concentration of oxygen for too long a period of time. The body reacts to a sensed "overload" of oxygen by reduced lung activity and air sac collapse. Like the other conditions listed here, these are extremely rare in the field.
- **Infant eye damage.** This condition may occur when premature infants are given too much oxygen over a long period of time (days). These infants may develop scar tissue on the retina

of the eye. Oxygen by itself does not cause this condition but it is the result of many factors. Oxygen should never be withheld from any infant with signs of inadequate breathing.

- **Respiratory depression or respiratory arrest.** Patients in the end stage of COPD may over time lose the normal ability to use the body's blood carbon dioxide levels as a stimulus to breathe. When this occurs, the COPD patient's body may use low blood oxygen as the factor that stimulates him to breathe. Because of this so-called hypoxic drive, EMTs have for years been trained to administer only low concentrations of oxygen to these patients for fear of increasing blood oxygen levels and wiping out their "drive to breathe." It is now widely believed that more harm is done by withholding high-concentration oxygen than could be done by administering it.

As an EMT you will probably never see oxygen toxicity or any other adverse conditions that can result from oxygen administration. The time required for such conditions to develop is too long to cause any problems during emergency care in the field. The bottom line is: *Never withhold oxygen from a patient who needs it!*

Administering Oxygen

Scans 9-1 and 9-2 will take you step by step through the process of preparing the oxygen delivery system, administering oxygen, and discontinuing the administration of oxygen. Do not

SCAN 9-1 Preparing the Oxygen Delivery System

1 Select the desired cylinder. Check for label "Oxygen U.S.P."

2 Place the cylinder in an upright position and stand to one side.

3 Remove the plastic wrapper or cap protecting the cylinder outlet.

4 Keep the plastic washer (some set-ups).

(continued)

SCAN 9-1 Preparing the Oxygen Delivery System (continued)

5 "Crack" the main valve for 1 second.

6 Select the correct pressure regulator and flowmeter. Pin yoke is shown on the left, threaded outlet on the right.

7 Place the cylinder valve gasket on the regulator oxygen port.

8 Make certain that the pressure regulator is closed.

9 Align pins (left), or thread by hand (right).

10 Tighten T-screw for pin yoke or . . . Tighten a threaded outlet with a nonferrous wrench.

SCAN 9-1 Preparing the Oxygen Delivery System (continued)

11 Attach tubing and delivery device.

SCAN 9-2 Administering Oxygen

1 Explain to the patient the need for oxygen.

2 Open the main valve and adjust the flowmeter.

3 Place an oxygen delivery device on the patient.

4 Adjust the flowmeter.

(continued)

5 Secure the cylinder during transfer.

DISCONTINUING OXYGEN

1 Remove the delivery device.

2 Close the main valve.

3 Remove the delivery tubing.

4 Bleed the flowmeter.

Table 9-7 Oxygen Delivery Devices

DEVICE	FLOW RATE	OXYGEN CONCENTRATION	APPROPRIATE USE
Nonrebreather mask	12–15 liters per minute	80–90 percent	Delivery system of choice for patients with signs of hypoxia, those short of breath, or those suffering chest pain, suffering severe injuries, or displaying an altered mental status.
Nasal cannula	1–6 liters per minute	24–44 percent	Appropriate for patients who cannot tolerate a mask.
Partial rebreather mask	9–10 liters per minute	40–60 percent	Usually not used in EMS. Some patients may use at home to keep CO levels up.
Venturi mask	Varied, depending on device; up to 15 liters per minute	24–60 percent	A device used to deliver a specific concentration of oxygen. Device delivers 24–60 percent oxygen, depending on adapter tip and oxygen flow rate.
Tracheostomy mask	8–10 liters per minute	Can be set up to deliver varying oxygen percentages as required by the patient; desired percentage of oxygen may be recommended by the home care agency	A device used to deliver ventilations/oxygen through a stoma or tracheostomy tube.

attempt to learn on your own how to use oxygen delivery systems. You should work with your instructor and follow your instructor's directions for the specific equipment you will be using.

Oxygen is administered to assist in the delivery of artificial ventilations to nonbreathing patients, as was discussed earlier in this chapter under "Techniques of Artificial Ventilation." Oxygen is also very commonly administered to breathing patients for a variety of conditions. A number of oxygen-delivery devices and systems are used. Each has benefits and drawbacks. A device that is good for one patient may not be ideal for another. The goal is to use the oxygen-delivery device that is best for each patient.

For the patient who is breathing adequately and requires supplemental oxygen due to potential hypoxia, various oxygen-delivery devices are available. In general, however, the nonrebreather mask and the nasal cannula are the two devices most commonly used by the EMT to provide supplemental oxygen (Table 9-7).

Nonrebreather Mask

The ***nonrebreather (NRB) mask*** (Figure 9-19) is the EMT's best way to deliver high concentrations of oxygen to a breathing patient. This device must be placed properly on the patient's face to provide the necessary seal to ensure high-concentration delivery. The reservoir bag must be inflated before the mask is placed on the patient's face.

nonrebreather (NRB) mask a face mask and reservoir bag device that delivers high concentrations of oxygen. The patient's exhaled air escapes through a valve and is not rebreathed.

To inflate the reservoir bag, use your finger to cover the exhaust port or the connection between the mask and the reservoir. The reservoir must always contain enough oxygen so that it does not deflate by more than one-third when the patient takes his deepest inspiration. This can be maintained by the proper flow of oxygen (15 liters per minute). Air exhaled by the patient does not return to the reservoir (is not rebreathed). Instead, it escapes through a flutter valve in the face piece.

This mask will provide concentrations of oxygen ranging from 80 to 100 percent. The optimum flow rate is 12 to 15 liters per minute. New design features allow for one emergency port in the mask so that the patient can still receive atmospheric air should the oxygen supply fail. This feature keeps the mask from being able to deliver 100 percent oxygen but is a necessary safety feature. The mask is excellent for use in patients with signs of hypoxia or who are short of breath, suffering chest pain, or displaying an altered mental status.

Nonrebreather masks come in different sizes for adults, children, and infants.

FIGURE 9-19 Nonrebreather mask.

Nasal Cannula

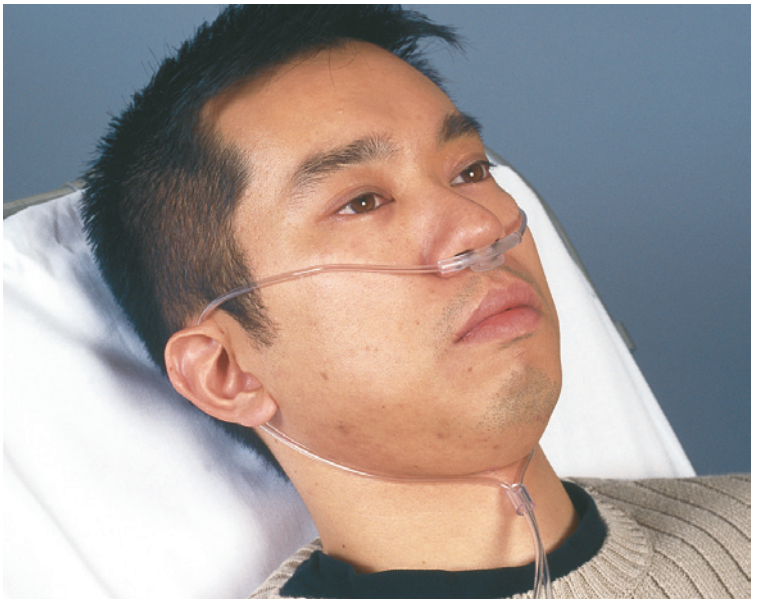
nasal cannula
(NAY-zul KAN-yuh-luh)
a device that delivers low concentrations of oxygen through two prongs that rest in the patient's nostrils.

A ***nasal cannula*** (Figure 9-20) provides low concentrations of oxygen (between 24 and 44 percent). Oxygen is delivered to the patient by two prongs that rest in the patient's nostrils. The device is usually held to the patient's face by placing the tubing over the patient's ears and securing the slip-loop under the patient's chin.

Patients who have chest pain, signs of shock, hypoxia, or other more serious problems need a higher concentration than can be provided by a cannula. However, some patients will not tolerate a mask-type delivery device because they feel "suffocated" by the mask. For the patient who refuses to wear an oxygen face mask, the cannula is better than no oxygen at all. The cannula should be used only when a patient will not tolerate a nonrebreather mask.

When a cannula is used, the liters per minute delivered should be no more than 4 to 6. At higher flow rates the cannula begins to feel more uncomfortable, like a windstorm in the nose, and dries out the nasal mucous membranes.

FIGURE 9-20 Nasal cannula.



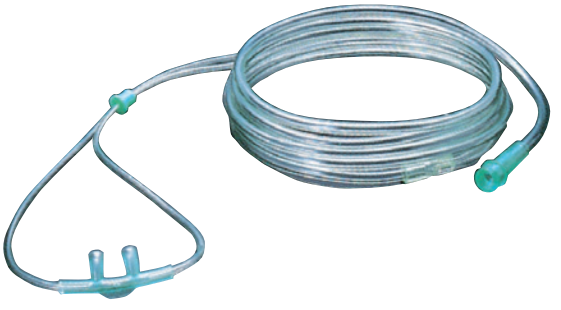


FIGURE 9-21 Partial rebreather mask.

Partial Rebreather Mask

A ***partial rebreather mask*** (Figure 9-21) is very similar to a nonrebreather mask with the exception that there is no one-way valve in the opening to the reservoir bag. This allows the patient to rebreathe about one-third of his exhaled air. This type of mask is used for some patients to preserve the carbon dioxide levels in their blood in order to stimulate breathing. Partial rebreather masks deliver 40–60 percent oxygen at 9–10 lpm. These masks are not typically used in EMS but may be encountered when caring for a patient who uses such a mask at home.

partial rebreather mask
a face mask and reservoir oxygen bag with no one-way valve to the reservoir bag so that some exhaled air mixes with the oxygen; used in some patients to help preserve carbon dioxide levels in the blood to stimulate breathing.

Venturi Mask

A ***Venturi mask*** (Figure 9-22) delivers specific concentrations of oxygen by mixing oxygen with inhaled air. The Venturi mask package may contain several tips. Each tip will provide a

Venturi mask
a face mask and reservoir bag device that delivers specific concentrations of oxygen by mixing oxygen with inhaled air.

FIGURE 9-22 Venturi mask.

FIGURE 9-23 Tracheostomy mask.

different concentration of oxygen when used at the flow rate designated on the tip. Some Venturi masks have a set percentage and flow rate whereas others have an adjustable Venturi port. These devices are most commonly used on patients with COPD.

Tracheostomy Mask

tracheostomy mask
a device designed to be placed over a stoma or tracheostomy tube to provide supplemental oxygen.

A ***tracheostomy mask*** (Figure 9-23) is designed to be placed over a stoma or tracheostomy tube to provide supplemental oxygen. It is typically a small cuplike mask that fits over the tracheostomy opening and is held in place by an elastic strap placed around the neck. These masks are connected to 8 to 10 lpm of oxygen via supply tubing.

SPECIAL CONSIDERATIONS

There are a number of special considerations in airway management:

- **Facial injuries.** Take extra care with a patient's airway if he has facial injuries. Because the blood supply to the face is so rich, blunt injuries to the face frequently result in severe swelling or bleeding that may block or partially block the airway. Frequent suctioning may be required. In addition, insertion of an airway adjunct or endotracheal tube may be necessary.
- **Obstructions.** Many suction units are not adequate for removing solid objects like teeth and large particles of food or other foreign objects. These must be removed using manual techniques for clearing airway obstructions, such as abdominal thrusts, chest thrusts, or finger sweeps, which you learned in your basic life support course and which are reviewed in Appendix A, "Basic Cardiac Life Support Review," at the back of this book. You may need to log roll the patient into a supine position to clear the oropharynx manually.
- **Dental appliances.** Dentures should ordinarily be left in place during airway procedures. Partial dentures may become dislodged during an emergency. Leave a partial denture in place if possible, but be prepared to remove it if it endangers the airway.

PEDIATRIC NOTE

There are several special considerations that you must take into account when assessing and managing breathing in an infant or child (review Figure 8–9 in Chapter 8):

Anatomic Considerations

- In infants and children, the tongue takes up more space proportionately in the mouth than in adults. Always consider using an airway adjunct when performing artificial ventilation.
- The trachea (windpipe) is softer and more flexible in infants and children. Furthermore, small children often have a proportionally larger head, which makes it more difficult to maintain a patent airway. Often padding is necessary behind their shoulders to provide a proper airway position. Always consider this when performing artificial ventilation.
- The chest wall is softer, and infants and children tend to depend more on their diaphragm for breathing. Gastric distention can severely impair the movement of the diaphragm and therefore seriously decrease tidal volumes in children.
- Children burn oxygen at twice the rate adults do. Although they compensate well, hypoxia will often occur more rapidly and decompensation can be swift.

Management Considerations

- When ventilating, avoid excessive pressure and volume. Use only enough to make the chest rise.
- Use properly sized face masks when providing ventilations to ensure a good mask seal.
- Flow-restricted, oxygen-powered ventilation devices are contraindicated (should not be used) in infants and children, unless you have a pediatric unit and have been properly trained in its use.
- Use pediatric-sized nonrebreather masks and nasal cannulas when administering supplemental oxygen.
- Infants and children are prone to gastric distention during ventilations, which may impair adequate ventilations.

ASSISTING WITH ADVANCED AIRWAY DEVICES

You may be called to assist an advanced EMT or paramedic with an advanced airway device. There are two basic types of devices, each with different procedures for use:

- **Devices that require direct visualization of the glottic opening (endotracheal intubation).** A device called a laryngoscope is used to visualize the airway while the tube is guided into the trachea.
- **Devices that are inserted "blindly," meaning without having to look into the airway to insert the device.** These devices include the King LT™ airway, Combitube®, and laryngeal mask airway (LMA™)

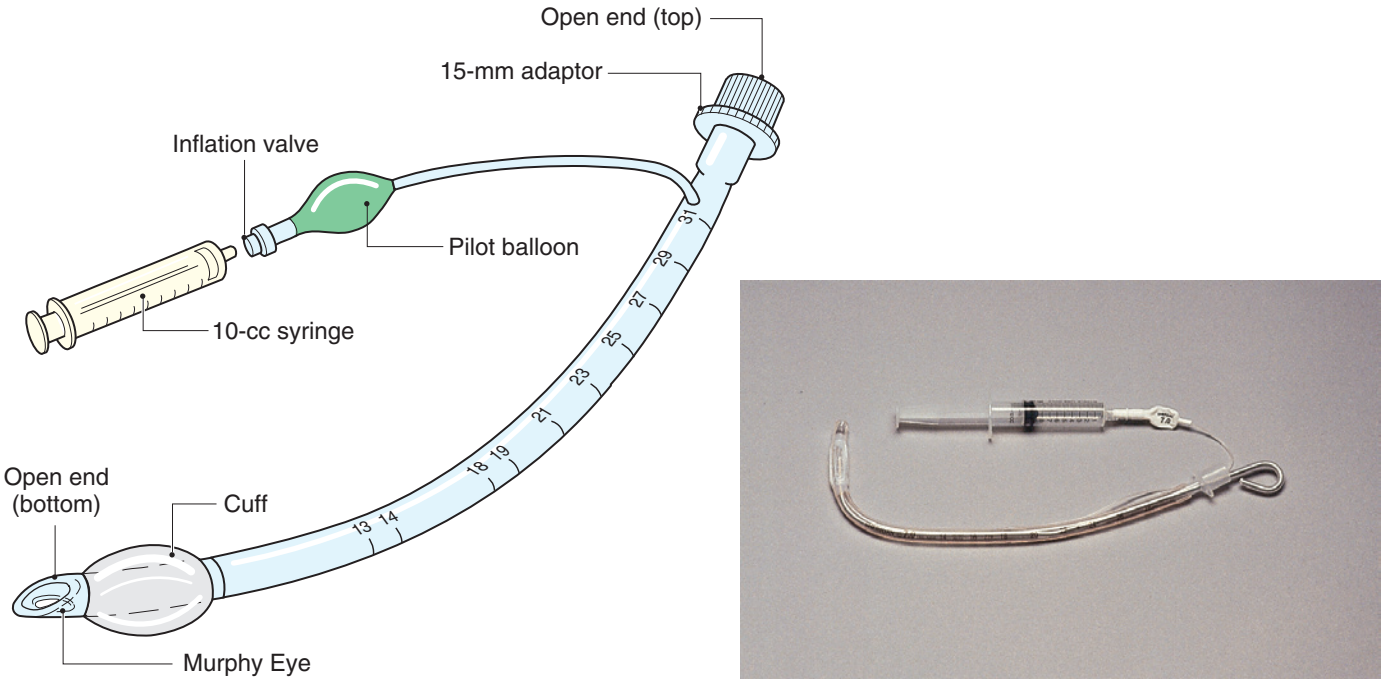
In most states, the decision to use the advanced device and insertion of the device is limited to advanced level providers (always refer to your local protocol). The EMT may be called upon to assist in patient preparation for insertion of the device. The most important thing an EMT can do to further the success of the insertion and benefit to the patient is to assure a patent airway and quality ventilations prior to insertion of the device. Fortunately, this is something EMTs should be doing all the time.

NOTE: *Be especially careful not to disturb the endotracheal tube. Movement of the patient to a backboard, down stairs, and into the ambulance can easily cause displacement of the tube. If the tube comes out of the trachea, the patient receives no oxygen and will certainly die.*

Preparing the Patient for Intubation

Before the paramedic inserts the endotracheal tube, you may be asked to give the patient extra oxygen. This is referred to as hyperoxygenation, and it can easily be accomplished by

FIGURE 9-24 (A) The endotracheal tube and (B) endotracheal tube with stylet in place.



(A) (B)

ventilating with a bag-valve-mask device that is connected to oxygen and includes a reservoir. To do this, ventilate at a normal to slightly increased rate. Do not administer more than 20 breaths/minute for more than 2–3 minutes nor administer breaths more forcefully during this time. Increasing the force of ventilations (bag squeeze) will force air into the stomach and cause vomiting.

The paramedic will then position the patient's head to align the mouth, pharynx, and trachea. This is sometimes referred to as a "sniffing position." The paramedic will remove the oral airway and pass the endotracheal tube (Figure 9-24) through the mouth, into the throat, past the vocal cords, and into the trachea. This procedure requires using a laryngoscope to move the tongue out of the way and provide a view of the vocal cords. The tube may also be passed through the nose. This does not require visualization of the airway.

In order to maneuver the tube past the vocal cords correctly, the paramedic will need to see them. You may be asked to help by gently pressing on the throat to push the vocal cords into the paramedic's view. You will do this by pressing your thumb and index finger just to either side of the throat over the cricoid cartilage, the ring-shaped cartilage just below the thyroid cartilage, or Adam's apple. This procedure is known as cricoid pressure (Figure 9-25).

Once the tube is properly placed, the cuff is inflated with air from a 10-cc syringe. While holding the tube, the paramedic assures proper tube placement by using at least two methods, including auscultation of both lungs and the epigastrium and using a capnometry or an end-tidal CO_2 detector device (Figure 9-26). If the tube has been correctly placed, there will be sounds of air entering the lungs but no sounds of air in the epigastrium. Air sounds in the epigastrium indicate that the tube has been incorrectly placed in the esophagus instead of the trachea so that air is entering the stomach instead of the lungs. The tube position must be corrected immediately by removing the tube, reoxygenating the patient, and repeating the process of intubation.

The correctly positioned tube is anchored in place with a commercially made tube restraint.

The entire procedure of intubation—including the last ventilation, passing the tube, and the next ventilation—should take less than 30 seconds.

You might be asked to assist the advanced providers by monitoring the lung and epigastric sounds throughout the call. Most systems now use continuous end-tidal carbon dioxide detection when an endotracheal tube is in place as one method of monitoring tube placement.

If the tube is pushed in too far, it will most likely enter the right mainstem bronchus, preventing oxygen from entering the patient's left lung. (You can identify this by noting breath sounds on the right side with no sounds over the left or the epigastrium.)

FIGURE 9-25 In cricoid pressure, press your thumb and index finger on either side of the medial throat over the cricoid cartilage.

FIGURE 9-26 An end-tidal CO_2 detector can ensure proper placement of the endotracheal tube.

If the tube is pulled out, it can easily slip into the esophagus and send all the ventilations directly to the stomach (indicated by breath sounds over the epigastrium), denying the patient oxygen. Tube displacement is a fatal complication if it goes unnoticed.

NOTE: *Be especially careful not to disturb the endotracheal tube once it has been correctly placed and secured. Movement of the patient to a backboard, down stairs, and into the ambulance can easily cause displacement of the tube. If the tube comes out of the trachea, the patient receives no oxygen and will certainly die.*

Ventilating the Intubated Patient

When you are asked to ventilate an intubated or "tubed" patient, keep in mind that even very little movement can displace the tube. Look at the gradations on the side of the tube. In the typical adult male, for example, the 22-cm mark will be at the teeth when the tube is properly placed. If the tube moves, report this to the paramedic immediately.

Hold the tube against the patient's teeth with two fingers of one hand (Figure 9-27). Use the other hand to work the bag-valve-mask unit. (A patient with an endotracheal tube offers less resistance to ventilations, so you may not need two hands to work the bag.) If you are ventilating a breathing patient, be sure to provide ventilations that are timed with the patient's own respiratory effort as much as possible so the patient can take full breaths. It is also possible to help the patient increase his respiratory rate, if needed, by interposing extra ventilations. Remember these cautions:

- Pay close attention to what the ventilations feel like. Report any change in resistance. Increased resistance when ventilating with the bag-valve mask is one of the first signs of air escaping through a hole in the lungs and filling the space around the lungs, which is an extremely serious problem. A change in resistance can also indicate that the tube has slipped into the esophagus.
- When the patient is defibrillated, carefully remove the bag from the tube. If you do not, the weight of the unsupported bag may accidentally displace the tube.
- Watch for any change in the patient's mental status. A patient who becomes more alert may need to be restrained from pulling out the tube. In addition, an oral airway generally is used as a bite block (a device that prevents the patient from biting the endotracheal tube). If the patient's gag reflex returns along with increased consciousness, you may need to pull the bite block out a bit.

Finally, during a cardiac arrest in the absence of an IV line for administering medications, you may be asked to stop ventilating and remove the BVM. The paramedic may then inject a medication such as epinephrine down the endotracheal tube. To increase the rate at which medication enters the bloodstream through the respiratory system, you then may be asked to ventilate the patient for a few minutes. (Give ventilations at a faster-than-normal rate.)

FIGURE 9-27 Make sure the endotracheal tube does not move. Hold it with two fingers against the patient's teeth.

Assisting with a Trauma Intubation

Occasionally you will be asked to assist in the endotracheal intubation of a patient with a suspected cervical spine injury. Since using the "sniffing position," which involves elevating the neck, risks worsening cervical spine injury, some modifications are necessary. Your role will change as well. You may be required to provide manual in-line stabilization during the whole procedure.

To accomplish this, the paramedic will hold manual stabilization while you apply a cervical collar. In some EMS systems, the patient may be intubated without a cervical collar in place but with attention to manual stabilization during and after intubation. Since the paramedic must stay at the patient's head, it will be necessary for you to stabilize the head and neck from the patient's side (Figure 9-28). Once you are in position, the paramedic will lean back and use the laryngoscope, which will bring the vocal cords into view. The patient can then be tubed.

FIGURE 9-28 To assist in the intubation of a patient with suspected cervical spine injury, maintain manual stabilization throughout the procedure.

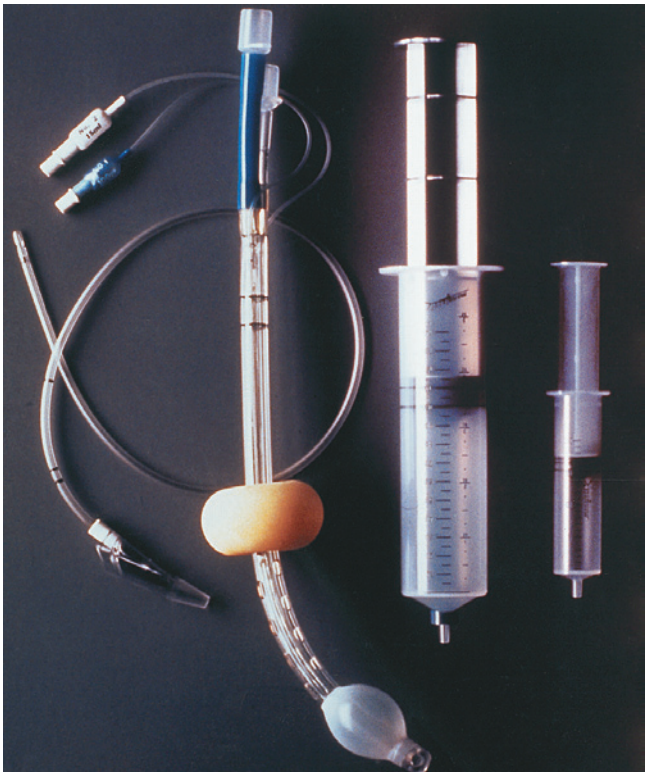
After intubation, you will hold the tube against the teeth until placement is confirmed with both an esophageal detector device and auscultation of both lungs and the epigastrium. Then the tube is anchored. At that time you can change your position to a more comfortable one. However, until the patient is immobilized on a long backboard, it will be necessary to assign another EMS worker to maintain manual stabilization while you ventilate the patient. Never assume that a collar provides adequate immobilization by itself. Manual stabilization must be used in addition to a collar until the head is taped in place on the backboard.

Blind-Insertion Airway Devices

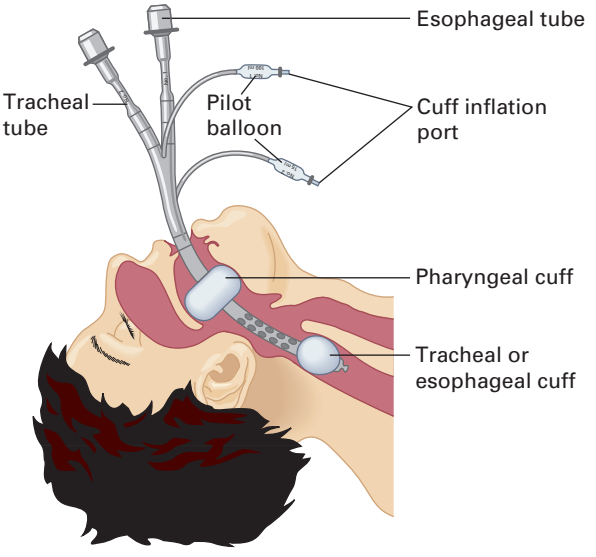
Blind-insertion devices have increased in popularity recently because of the difficulty in inserting endotracheal tubes, a procedure that requires visualizing the glottis opening. Blind-insertion devices include the King LT ™ airway (Figure 9-29), Combitube® (Figure 9-30), and

FIGURE 9-29 The King LT-D™ airway, a disposable version of the King LT™ airway that is recommended for prehospital use. *(© Tracey Lemons/King Systems Corporation, Indianapolis, Indiana)*

FIGURE 9-30 (A) The esophageal tracheal Combitube® and (B) the Combitube® in place.

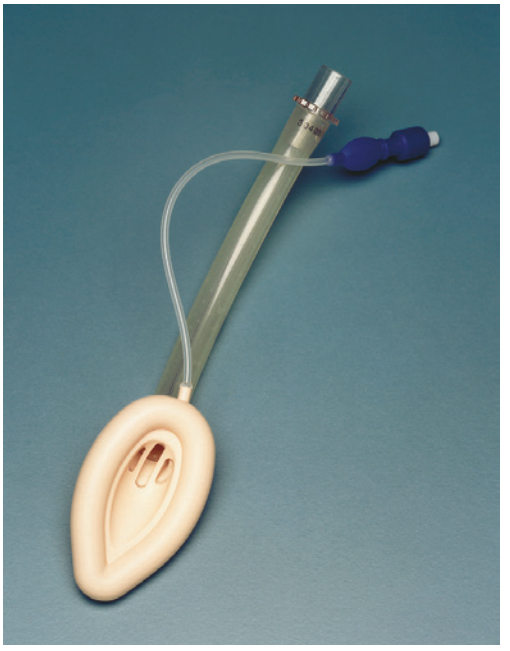


(A)



(B)

FIGURE 9-31 The laryngeal mask airway (LMA™). *(© LMA North America, Inc.)*



laryngeal mask airway (LMA™) (Figure 9-31). A few states have specialized training modules that allow EMTs to use one or more of these devices—always follow your local protocols.

The concepts of preparation for these airways are similar to the procedures listed earlier. The advanced EMT or paramedic will examine the device and test the balloon, mask, or cuff on the distal end of the tube.

One item that is different with blind-insertion devices is the positioning of the head. Blind-insertion devices usually do not require the head to be placed in the sniffing position. Instead, a position known as a "neutral position" where the head is not flexed either backward or forward is the position recommended by manufacturers. Depending on the device, the advanced EMT or paramedic may lubricate the device with a water-based jelly to allow for a smooth insertion.

It remains important that the patient is well-oxygenated prior to insertion of the blind-insertion device.

The advanced EMT or paramedic will listen over both lungs and the epigastrium to assure the device is properly placed. You will be asked to ventilate through the device so this auscultation may be performed. Use caution not to displace the tube during the process.

NOTE: *The Combitube has two ports you can ventilate through. Begin by ventilating in the port labeled #1. Follow the instructions of the advanced provider for further ventilation.*

These blind-insertion devices do not have masks. You will ventilate directly into the tube. There are different guidelines for securing each of these devices. It is important that you follow the same rules as with the endotracheal tube: Do not let go of the BVM while it is attached to the tube. Disconnect the BVM when the patient is moved or defibrillated. Report any obvious tube movement or ventilatory changes to the advanced provider.

CHAPTER REVIEW

Key Facts and Concepts

- Respiratory failure is the result of inadequate breathing, breathing that is insufficient to support life.
- A patient in respiratory failure or respiratory arrest must receive artificial ventilations.
- Oxygen can be delivered to the nonbreathing patient as a supplement to artificial ventilation.
- Oxygen can also be administered as therapy to the breathing patient whose breathing is inadequate or who is cyanotic, cool and clammy, short of breath, suffering chest pain, suffering severe injuries, or displaying an altered mental status.

Key Decisions

- Is the patient breathing? Is the patient breathing adequately (ventilating *and* oxygenating)? Does the patient need supplemental oxygen?
- Is there a need to initiate artificial ventilation?
- Are my artificial ventilations adequate (proper rate and volume)?

Chapter Glossary

alveolar ventilation the amount of air that reaches the alveoli.

artificial ventilation forcing air or oxygen into the lungs when a patient has stopped breathing or has inadequate breathing. Also called *positive pressure ventilation.*

automatic transport ventilator (ATV) a device that provides positive pressure ventilations. It includes settings designed to adjust ventilation rate and volume, is portable, and is easily carried on an ambulance.

bag-valve mask (BVM) a handheld device with a face mask and self-refilling bag that can be squeezed to provide artificial ventilations to a patient. It can deliver air from the atmosphere or oxygen from a supplemental oxygen supply system.

cellular respiration the exchange of oxygen and carbon dioxide between cells and circulating blood.

cricoid pressure pressure applied to the cricoid ring to minimize air entry into the esophagus during positive pressure ventilation. Also called *Sellick maneuver.*

cyanosis (SIGH-uh-NO-sis) a blue or gray color resulting from lack of oxygen in the body.

diffusion a process by which molecules move from an area of high concentration to an area of low concentration.

flowmeter a valve that indicates the flow of oxygen in liters per minute.

flow-restricted, oxygen-powered ventilation device (FROPVD) a device that uses oxygen under pressure to deliver artificial ventilations. Its trigger is placed so that the rescuer can operate it while still using both hands to maintain a seal on the face mask. It has automatic flow restriction to prevent overdelivery of oxygen to the patient.

humidifier a device connected to the flowmeter to add moisture to the dry oxygen coming from an oxygen cylinder.

hypoxia (hi-POK-se-uh) an insufficiency of oxygen in the body's tissues.

nasal cannula (NAY-zul KAN-yuh-luh) a device that delivers low concentrations of oxygen through two prongs that rest in the patient's nostrils.

nonrebreather (NRB) mask a face mask and reservoir bag device that delivers high concentrations of oxygen. The patient's exhaled air escapes through a valve and is not rebreathed.

oxygen cylinder a cylinder filled with oxygen under pressure.

partial rebreather mask a face mask and reservoir oxygen bag with no one-way valve to the reservoir bag so that some exhaled air mixes with the oxygen; used in some patients to help preserve carbon dioxide levels in the blood to stimulate breathing.

pocket face mask a device, usually with a one-way valve, to aid in artificial ventilation. A rescuer breathes through the valve when the mask is placed over the patient's face. It also acts as a barrier to prevent contact with a patient's breath or body fluids. It can be used with supplemental oxygen when fitted with an oxygen inlet.

positive pressure ventilation *See* artificial ventilation.

pressure regulator a device connected to an oxygen cylinder to reduce cylinder pressure so it is safe for delivery of oxygen to a patient.

pulmonary respiration the exchange of oxygen and carbon dioxide between the alveoli and circulating blood in the pulmonary capillaries.

respiration (RES-pir-AY-shun) the diffusion of oxygen and carbon dioxide between the alveoli and the blood (pulmonary respiration) and between the blood and the cells (cellular respiration). Also used to mean, simply, breathing.

respiratory arrest when breathing completely stops.

respiratory distress increased work of breathing; a sensation of shortness of breath.

respiratory failure the reduction of breathing to the point where oxygen intake is not sufficient to support life.

stoma a permanent surgical opening in the neck through which the patient breathes.

tracheostomy mask a device designed to be placed over a stoma or tracheostomy tube to provide supplemental oxygen.

ventilation breathing in and out (inhalation and exhalation), or artificial provision of breaths.

Venturi mask a face mask and reservoir bag device that delivers specific concentrations of oxygen by mixing oxygen with inhaled air.

Preparation for Your Examination and Practice

Short Answer

1. Describe the signs of respiratory distress.
2. Describe the signs of respiratory failure.
3. Name and briefly describe the techniques of artificial ventilation (mouth-to-mask, BVM, FROPVD).
4. For BVM ventilation, describe recommended variations in technique for one or two rescuers and for a patient with trauma suspected or trauma not suspected.
5. Describe how positive pressure ventilation moves air differently from how the body normally moves air.
6. Name patient problems that would benefit from administration of oxygen and explain how to decide what oxygen delivery device (nonrebreather mask, nasal cannula, or other) should be used for a particular patient.

Thinking and Linking

Think back to Chapter 8, "Airway Management," and link information from that chapter with information from this chapter to describe how the process of moving air in and out of the chest might be interfered with by the following dysfunctions:

1. Penetrating trauma to the chest
2. A spinal injury that paralyzes the diaphragm
3. Bronchoconstriction that narrows the air passages
4. A rib fracture
5. A brain injury to the respiratory control center in the medulla

Critical Thinking Exercises

Careful assessment is needed in order to decide if a patient does or does not need artificial ventilation. The purpose of this exercise will be to apply this skill in the following situations.

1. On arrival at the emergency scene, you find an adult female patient who is semiconscious. Her respiratory rate is 7/min. She appears pale and slightly blue around her lips. What immediate actions are necessary? Is this patient in respiratory failure, and if so what signs and symptoms indicate this? Does this patient require artificial ventilations?
2. On arrival at the emergency scene, you find an adult male patient sitting bolt upright in a chair. He looks at you as you come into the room, but he is unable to speak more than two words at a time. He seems to have a prolonged expiratory phase; you hear wheezes, and his respiratory rate is 36. What immediate actions are necessary? Is this patient in respiratory failure, and if so what signs and symptoms indicate this? Does this patient require artificial ventilations?
3. On arrival at the scene of a motor-vehicle crash, you find an adult female patient pacing outside her damaged vehicle. She appears to be breathing very rapidly but acknowledges you as you approach. Her color seems normal and her respiratory rate is 48. What immediate actions are necessary? Is this patient in respiratory failure, and if so what signs and symptoms indicate this? Does this patient require artificial ventilations?

Pathophysiology to Practice

The following questions are designed to assist you in gathering relevant clinical information and making accurate decisions in the field.

1. Describe the elements you would assess to determine if a patient is breathing adequately.
2. You are assessing a breathing patient. Describe what findings might indicate the need to initiate artificial ventilations despite the fact the patient continues to breathe.
3. Describe how you would determine that you have delivered enough air (volume) when ventilating using a bag-valve mask.

Street Scenes

"Dispatch to unit 401, respond to 244 Lisbon St. for a patient with shortness of breath." En route, you make a preliminary plan with your partners, Danielle and Jim. You discuss what equipment the team will bring in and briefly review the immediate life threats associated with shortness of breath. Going into the apartment building, you bring in the stretcher, jump kit, oxygen, portable suction, and BVM unit.

As you approach the apartment, you notice that the hall smells of cigarette smoke. The odor is worse as you enter the unit. Your patient is found sitting at the kitchen table. He is a tall, thin, 70-year-old man. He appears anxious and is obviously having trouble breathing.

Street Scene Questions

1. What is your first priority when starting to assess this patient?
2. Assuming his airway is patent, what are the essential elements in assessing this patient's breathing?
3. What type of emergency care should you be prepared to give?

As you assess the patient, you note he is breathing rapidly with an audible wheeze. He seems very tired. He can only speak one or two words at a time and you notice that his fingernails are blue. You also notice that his respiratory rate slows down and becomes slightly irregular from time to time.

Street Scene Questions

4. Is this patient's breathing adequate (why/why not)?
5. Does this patient require artificial ventilation?

The team decides that this patient is in respiratory failure, is tiring out, and needs immediate ventilation. You connect the BVM to high-concentration oxygen and begin to ventilate the patient. At first the patient is uncooperative and you find it difficult to time your ventilations with his. However, after a few breaths your timing begins to work. About every fourth patient breath you administer a breath to help increase tidal volume. The patient becomes more and more comfortable with this.

Jim continues the assessment while Danielle requests advanced life support backup and prepares for rapid transport.

You continue ventilating as the team loads the patient and initiates transport.