MODULE II

AIRWAY

LEARNING OBJECTIVES

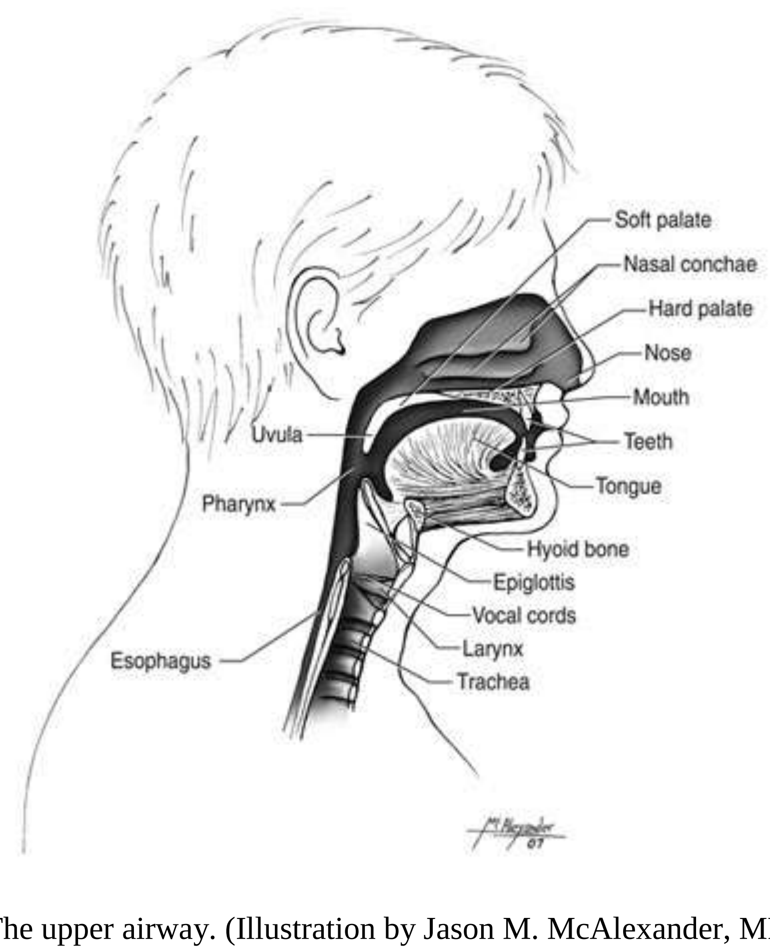
Upon completion of this course, you will be able to:

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

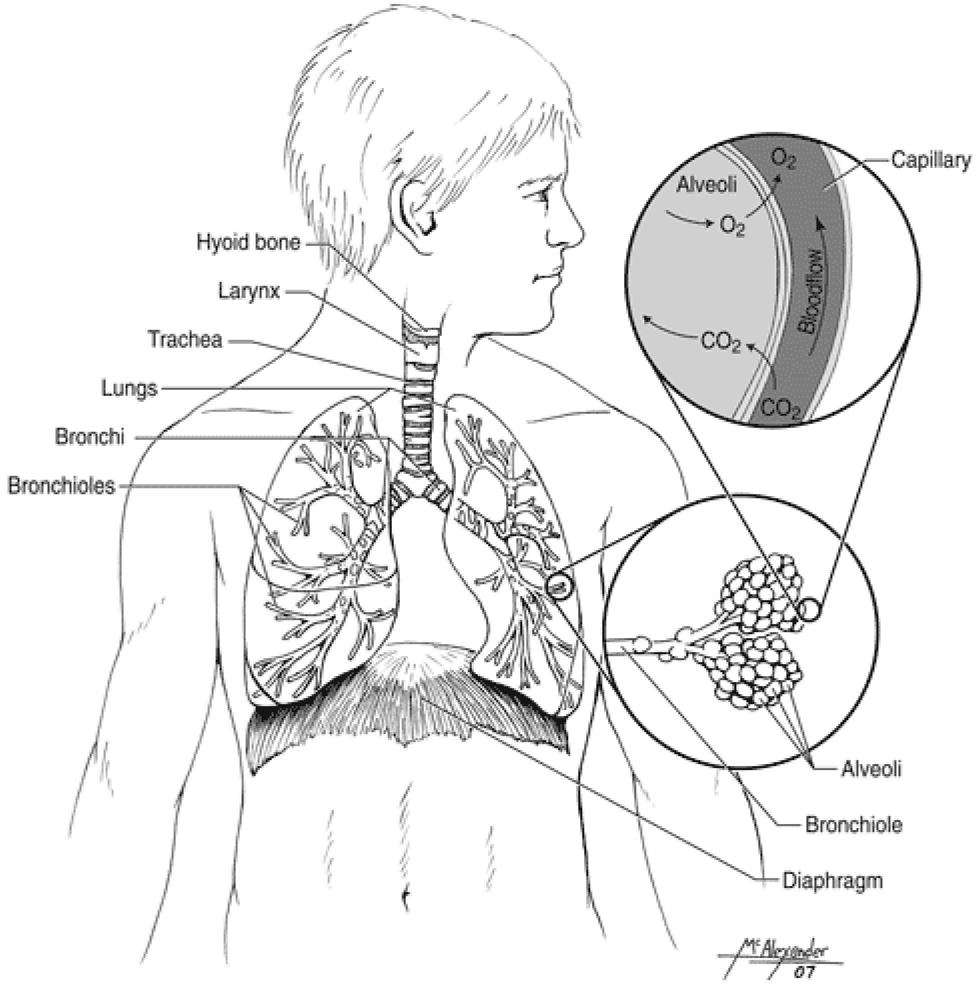
As everyone is aware, the respiratory system is second in importance only to the pumping of the heart. Without a functioning respiratory system (respiration, ventilation, and an open airway) a person will not survive. Therefore, it is imperative that all healthcare providers be skilled in maintaining a patent airway. The function of the airway is to carry inhaled oxygen to the tissues and exhaled carbon dioxide to the outside.

ANATOMY REVIEW

The structures of the upper airway are many, small, and complex. Beginning at the nose and mouth, the air must travel through the **nasopharynx** and **oropharynx**, through the **laryngopharynx**, past the **epiglottis** (which separates the airway from the digestive system), into the **trachea**, which is supported by the cartilages of the neck—specifically the cricoid and thyroid cartilage—and into the **larynx**. The air is then sent down one of two pathways at the carina, either through the right or left mainstem bronchus. The **bronchi** branch numerous (about 23) times into smaller bronchi (Kersten, 1989), **bronchioles**, and finally into terminal bronchioles and **alveoli**, where gas exchange takes place. Any disruption of this pattern will cause illness, sleep disruptions, and death.



The upper airway. (Illustration by Jason M. McAlexander, MFA. Copyright © 2007 Wild Iris Medical Education.)



The lower airway. (Illustration by Jason M. McAlexander, MFA. Copyright © 2007 Wild Iris Medical Education.)

THE PHYSIOLOGY OF BREATHING

Breathing comprises two mechanisms, **inhalation** and **exhalation**. In a normally functioning respiratory system the stimulus to breathe is a buildup of carbon dioxide (CO_2). When the body senses an increase in CO_2, the brain sends messages to the respiratory muscles. This causes the diaphragm to expand and flatten, while the intercostal muscles allow rib expansion. Air then falls into the airways because of a negative air pressure inside the chest relative to ambient air.

Air travels down the bronchopulmonary tree to the terminal bronchioles and the alveoli, where oxygen enters the blood cells and CO_2 is moved into the airways from the cells. Inhalation is considered an active process. As the lungs are now full of "used" air, the brain senses that it is time to exhale and remove the toxins. Through the relaxing of the diaphragm and the other breathing muscles, air is expelled; it is a passive process.

NORMAL LUNG FUNCTION

With adults, the normal respiratory rate is between 12 and 20 breaths per minute. Children normally breathe at rates of between 15 and 30 breaths per minute, and infants between 25 and 50 breaths per minute (USDOT, 2002). Lung volumes vary with height, but normally adequate breathing is something that will make the chest rise and fall visibly and can pass the "look, listen, feel" test of cardiopulmonary resuscitation (CPR) fame (AHA, 2006).

With large individuals it may be difficult to see the chest rise. Look for alternate locations, such as at the neck where the sternocleidomastoid muscles are located. You may also want to place a hand on the chest to feel the depth of respirations. A normal breath is called a tidal breath and its volume is called **tidal volume**. It is possible to calculate the **minute volume** or minute ventilation by multiplying the tidal volume and the respiratory rate. This is difficult to perform in the field and is mostly done using a myriad of advanced respiratory monitoring devices in a hospital or physician's office.

It is important to know normal parameters in order to discern whether a patient is breathing adequately. A patient with a slow and shallow respiratory pattern will need some assistance; so will a patient who is breathing deeply at a rate of 36 per minute. Rhythm regularity is an important quality of breathing; usually, the more regular the breathing pattern, the better. An irregular respiratory pattern is a signal of a serious problem (drug overdose, stroke, spinal cord issues) that may need to be addressed with assisted breathing.

Some critical parameters are:

- Respiratory rate: <12 or >20
- Rhythm: irregular, slow, deep gasps, periods of apnea
- Quality: shallow with little air movement; diminished, noisy, or absent on auscultation; unequal or inadequate chest expansion, which could indicate pneumothorax or fractured ribs (flail chest)
- Increased work of breathing (shortness of breath or dyspnea)
- Skin color: cyanosis, pale, cherry red
- Accessory muscle usage (look at sternocleidomastoids and other neck muscles, intercostal retractions, paradoxical movement either from side to side (as seen in a flail chest) or chest and abdomen (this is more commonly seen in children in extreme distress)
- Nasal flaring (more commonly seen in children; this is considered a late sign of respiratory distress)
- Agonal breathing (see rhythm section above) (USDOT, 2002)

You receive a 911 call to respond to a patient with shortness of breath. On arrival, you note that the patient is having a very difficult time breathing, coughing, or speaking. You ask the appropriate questions and determine that the patient has an upper airway obstruction. During this time the patient loses consciousness. What do you do?

Response

SCENARIO Gently lower him to the floor so that there is no risk of spinal injury. Your first responsibility is to maintain an open airway. To determine if your patient is breathing adequately, you need to evaluate the rate, depth, and quality of the patient's ventilations. If your patient is not breathing, you will need to provide rescue breathing. If you are unable to do so because of an obstruction, you will need to position the patient appropriately and remove any obstructing foreign body. When you find breathing is adequate, assess the circulatory system.

MAINTAINING AN OPEN AIRWAY

Head Tilt–Chin Lift

There are a couple of methods for maintaining an open airway. The most common is the head tilt–chin lift. This is easy, quick, and effective. It is the preferred method for patients in need of an assisted airway when there are no suspected neck injuries (examples: acute cardiac arrest, an unresponsive patient without evidence of trauma, any nontraumatic situation needing an assisted airway).

To perform a head tilt–chin lift maneuver, take one hand and place it on the forehead, pushing slightly upward and backward. Place the fingers of your other hand under the bony portion of the chin and lift up. This will lift the chin far enough away from the neck to displace the tongue, thus creating a patent airway. A towel placed under the shoulders of the patient may assist in maintaining a patent airway. This is only a temporary remedy if patients remain unconscious and unable to maintain their airway on their own. At this point, you must determine if an adjunct airway is needed.

Jaw Thrust

In any situation involving head or neck trauma, the preferred assisted airway is the jaw thrust maneuver (examples: an unresponsive trauma patient, a patient with an unknown mechanism of injury).

This method of creating an open airway is considerably more difficult than the head tilt–chin lift. It requires practice. It also requires that there be enough personnel to perform this technique, as rescuers performing the maneuver cannot remove their hands, once placed, until an adjunct airway is inserted.

To perform a jaw thrust, the rescuer places a hand on each side of the patient's face. If possible or necessary, rescuers can place their elbows on the surface on which the patient is lying for support and stabilization. Then they grasp the angles of the patient's mandible and lift upward. If the patient is responsive, this maneuver may not work because the muscles of the jaw may not be relaxed enough to move.

If there are not enough responders to maintain a jaw thrust or a jaw thrust is not successful in opening the airway, it is acceptable to perform a head tilt–chin lift, taking care to not cause added trauma (AHA, 2006).

CLEARING THE AIRWAY

Coughing is the most effective method of clearing secretions, but often the rescuer must clear the airway of a patient who is unable to do it alone. This requires that you understand what kind of obstructions can occur in the airway. They can include blood, food, teeth, foreign bodies, saliva, sputum, or vomit. It is imperative that the provider be able to remove foreign objects quickly and without additional harm to the patient.

Suction devices are plentiful. An ambulance may have an electric or pneumatic suction setup mounted in the rig. There are also portable devices that can be easily transported to the scene. These may be electrical, pneumatic, or hand-operated. In the hospital, patient rooms may have suction capabilities built into the wall (vacuum) or portable devices. Each has its merits and its drawbacks; this course is not designed to discuss the particulars. However, it is essential that providers be able to use their available devices well and without difficulty.

For most EMT-Bs, using a suction device means suctioning only the mouth and oropharynx. This can be achieved with a rigid-tip device such as a Yankauer or tonsil tip wand. The usual rule is: **Suction only as far as you can see**. Be especially careful when suctioning children and infants because their anatomy is considerably smaller and more fragile.

Soft-tip catheters are usually reserved for nasal suctioning, suctioning through a tracheostomy, or deep suctioning. (This is outside the scope of practice for most EMT-Bs.) These soft-tip catheters (usually 14 French) attach onto the suction tubing, and most have a thumb control to suction on demand. Be extraordinarily careful while suctioning when facial, nasal, or head trauma is present.

Many suction units have adjustable vacuum controls. Suctioning with the least possible pressure is important because there are some significant complications involved with suctioning. Usual vacuum pressures are between 80 and 100 mm Hg. Along with oral and mucosal trauma, complications of suctioning include hypoxia, cardiac dysrhythmias, and hypotension.

It is important to check suctioning equipment prior to need. Everything must be cleaned (some must be sterile) and ready for use at all times. If you are using a portable system, ensure that the battery is charged. If you are using a vacuum gauge, test it to a maximum of 300 mm Hg (USDOT, 2002).

When using a catheter with a thumb control, do not apply suction until it is in the mouth or nose—to limit the possibility of hypoxia or anoxia while suctioning—and limit the suction time to no more than 15 seconds. If the patient continues to have fulminant secretions, it may be necessary to roll the individual to one side until vomiting or bleeding slows. Keeping the airway patent is the goal.

SCENARIO	The patient with whom you're working appears to have an airway obstruction. You quickly ask "Are you choking?" He nods, and you make a number of unsuccessful attempts to remove the object using subdiaphragmatic abdominal thrusts in rapid succession (the Heimlich maneuver). Now he has lost consciousness and is lying on the floor. What is the best method to remove the obstruction? **Response** Protocols are changing following issuance of new guidelines, although your current protocols may not yet have changed. The American Heart Association (2006) no longer advocates the Heimlich maneuver for those who are unconscious. Instead the rescuer should immediately begin cardiopulmonary resuscitation (CPR); use the head tilt–chin lift maneuver to open the airway and then remove any visible foreign body before attempting to deliver two breaths and proceeding with chest compressions. If this patient were a woman in the late stages of pregnancy, chest thrusts rather than the Heimlich maneuver would be the first-line therapy. Because abdominal thrusts can cause serious injury, patients should be encouraged to be examined by a medical provider even if they feel better after their airway obstruction is relieved.

Medical Director Comment
There is research to suggest that chest compressions during CPR increased intrathoracic pressure as much as or more than abdominal thrusts. An unconscious person is likely to benefit more from CPR than from abdominal thrusts, especially if the heart is no longer pumping blood effectively. To simplify the approach to all unresponsive apneic patients, the American Heart Association no longer recommends abdominal thrusts for those who are unconscious from choking. The hope is that if the obstruction cannot be removed with direct visualization it will be dislodged during CPR. Blind finger sweeps to remove an object are also no longer recommended as they have never proven a benefit and are more likely to cause harm to both the patient and the rescuer.

ADJUNCTIVE AIRWAYS

Mouth-to-mouth breathing is still considered a viable means of administering artificial ventilation; according to statistics, disease transmission is low. However, barrier devices such as pocket masks or face shields are a safer alternative. The bag valve mask unit is still preferred for healthcare providers (AHA, 2006).

A pocket mask is a portable mask. These masks are now equipped with some form of barrier device (eg, a mesh filter). Although this device does not protect the provider from all exposures, it does provide some protection. There are many different styles available from numerous manufacturers. Some have oxygen inlets for added O_2. Some have elastic straps to affix the mask to the patient. These devices were developed primarily to provide some distance between the patient and the rescuer.

One advantage of using a barrier device as opposed to other methods is that a barrier device can deliver only the volume of air that reflects the capacity of the rescuer's chest. The volume of air delivered is usually higher than with a bag valve mask. Remember, though, that the current trend is for smaller tidal volumes during resuscitation (adequate to inflate the chest but not large enough to impede blood filling the heart) (AHA, 2006). Another consideration for choosing a barrier device or pocket mask is unfamiliarity with a bag mask unit (see below).

Medical Director Comment

Although the pocket mask may allow you to deliver larger volumes of air, the new AHA guidelines indicate that larger air volumes are unnecessary and may be counterproductive. Larger volumes of air cause increased pressure in the chest, which reduces the amount of blood that can fill the heart and thus reduces the blood flow generated by CPR. Additionally, there is less blood flow to the lungs during CPR, so less volume of oxygen is needed for adequate oxygenation of the smaller volume of blood in the lungs.

If possible, supply oxygen at a high flow rate (15 lpm). Giving supplemental oxygen is best achieved if an O_2 port is offered on the mask itself. If necessary, place a nasal cannula (covered below) on the patient with a higher flow rate; the mask will still seal properly.

If no head or neck injury is suspected, rescuers position themselves either at the head or side of the patient. If positioned at the head, you encircle the mask with both hands while attempting to tilt the head back. Using pressure, hold the mask on the face to ensure an adequate seal. Give breaths into the filter of the mask, being certain that each breath is given over 1 second and there is rise and fall of the chest (AHA, 2006).

If there is no visible chest movement, re-apply the mask and re-attempt the breaths. If side positioning is preferred, align yourself perpendicular to the length of the patient's body. Again, hold down the mask with both hands. With the hand closest to the eyes, hold down the top of the mask. With the hand closest to the feet, hold down the lower portion of the mask. With both hands tilt the head back. Give breaths the same as above.

If neck injury is suspected, perform a jaw thrust with the mask remaining on the face. This is most easily accomplished if the rescuer is positioned at the patient's head. Try not to move the head or neck. Side positioning for a jaw thrust is nearly impossible to do well, but it may be necessary in rare instances.

An **oropharyngeal airway (OPA)** is generally used to displace the tongue when a patient is lying supine and is unconscious with no gag reflex. This device is usually made of rigid plastic—the more rigid the better. It either has one center hole or side slits for air movement. This author has seen an OPA bitten in half during a seizure. The concern then became that the portion of the OPA in the mouth could cause an obstruction or be inhaled.

Proper fit of an OPA is essential. An OPA that is too small may slide back in the throat. An OPA that is too large may cause trauma, illicit a gag and subsequent vomiting, or cause a vagal response. To fit an OPA, the airway is normally measured from the tip of the earlobe to the teeth. Over time, as you are exposed to these devices, it becomes easy to estimate the size needed.

To insert an OPA, you must invert it. The scoop goes upward toward the nose. Open the mouth according to protocol and insert the airway in this upside-down position, sliding the end to the soft palate. Once at the soft palate gently invert the airway while sliding it in the remaining distance so it sits against the teeth and behind the tongue. It remains important to keep the head in the proper position. **If the patient shows signs of gagging, immediately remove the airway and use an alternate device.**

A second method may be used for OPA insertion. This method uses a sideways insertion of the airway. It is as effective as the upside-down technique. The only drawback is that it causes the mouth to be opened slightly wider than the other technique. Both are acceptable, but use your agency's protocol.

For several reasons, nasal airways are used less frequently than oral airways. However, they are exceptional devices. A **nasopharyngeal airway (NPA)** is based on the same concept as the OPA, in that it displaces the tongue and provides a patent airway. An NPA also requires some measurement, but this is more subjective. The airway must be large enough to pass the back of the tongue, but the size of the nares must also be considered. Usually, measuring from the tip of the nose to the earlobe is a fair approximation of size and length. In the past there were nasal airways designed for each of the right and left naris, depending on the bevel of the tip. Now, there appears to be only one manufactured direction of the bevel. Follow your own agency's protocol.

Prior to insertion, be sure to lubricate the tip with a water-soluble lubricant. Inserting a dry airway will cause discomfort and a lot of bleeding. Inserting an NPA takes a bit of practice. Gently insert the NPA into the naris of choice (many people have deviated septa, so be ready to use the other nostril if you encounter resistance), gently easing it into the naris and advancing it posteriorly. There may be a couple of obstacles, which include large nasal turbinates or deviated septums, as it is inserted. As it is inserted, rotate the airway either spirally (AHA, 2006) or back and forth. If the airway does not pass easily at this point, switch nostrils. If it passes through, either secure it with tape or let it remain free.

Advantages of an NPA are that it can be used with a patient who is semi-conscious and has a gag reflex. It can also be a means to deep suction. A patient with a compromised airway, such as a patient suffering from an acute stroke, may benefit from an NPA. Its use is contraindicated in those with some significant facial fractures or skull fractures.

SCENARIO	A patient is found unresponsive, lying supine on the floor. You do not see any obvious signs of trauma. How should you best open the airway? If needed, which adjunct would you use and why? **Response** The answers to this question can vary, partly by choice and partly by protocol. In this case, you have not seen the patient fall so it is probably best to perform a jaw thrust maneuver to open the airway (after first checking if the patient is spontaneously breathing). If you feel that an artificial airway is needed, again, follow protocol, and use the appropriate equipment for the situation. (This was not meant as a trick question, it was designed to make you think about your choices in the given situation.)

BAG VALVE MASK VENTILATION

Although using a **bag valve mask (BVM)** is considered an adjunct to providing adequate breathing it is given its own section because of its importance in emergency care settings. A BVM setup includes a malleable clear mask that should fit snugly on the face; a one-way valve (a duck-bill valve is typical); the bag, itself, which is self-inflating and holds at least 1 liter of air for an adult setup; a room-air inlet (should the oxygen flow be too low); oxygen-supply tubing; an oxygen reservoir (either a plastic bag or a length of corrugated tubing), and standardized 15/22 mm fittings that are able to withstand severe changes in temperatures and weather conditions without tearing or cracking. A BVM can be used with room air (R/A) only or with supplemental oxygen, preferably at a high flow rate (enough to keep the reservoir full).

There are many advantages to using a BVM. First and foremost is the distance it puts between the provider and the patient. Second, it can provide significant supplemental oxygen, second only to a mechanical ventilator. It is available in various sizes for infants, children and adults. This is the adjunct of choice for field resuscitation.

There are also many drawbacks and challenges to using a BVM successfully. A rescuer needs to be adequately trained on its use. The mask must fit snugly or the volume of air is wasted. The head must be in near-perfect alignment or the air will enter the stomach, causing gastric distention and probable vomiting (distention makes it difficult to ventilate because the air in the belly pushes up on the diaphragm). The volumes delivered must be large enough to cause chest rise and fall. An OPA or NPA may be necessary to ensure an open airway.

Using a BVM provides a smaller volume of air per breath than does a pocket mask (or other barrier device), although it delivers a higher concentration of oxygen even using R/A only. In many cases it is difficult to maintain a seal on the mask with a one-person technique. It may be necessary to have two rescuers assist, one to hold the mask, one to ventilate. This is the preferred method, although it may be a luxury if personnel are limited.

Some manufacturers provide a pressure relief valve (pop-off) with their BVM set ups. If the bag you use has a pop-off, you may need to disable it prior to using it for emergency ventilation. These pressure relief valves are designed to pop off at about 45 cm H_2O and reduce the incidence of barotrauma. However, if a patient has high intrathoracic pressures for whatever reason, it may be necessary to use higher pressures in order to ventilate effectively.

As with the pocket mask, the BVM mask should fit snugly on the face. Place an artificial airway, if necessary. Position the mask from the nose to the chin. Place the fingers in the E-C position, where the thumb and forefinger make the shape of the letter C on the top of the mask and the middle, ring, and little finger make the shape of the letter E pulling up the jaw. If only one person is available to perform BVM ventilations this works well (with practice). If two people are available, one person will do the E-C with both hands while the other delivers the breaths. If the mask does not fit well, attempt to reposition it and try again. Be aware that facial hair may cause an ill fit with the mask and that other adjuncts may be needed to achieve proper ventilation.

If it is necessary to perform a jaw-thrust during BVM it is imperative to have at least two—and preferably three—rescuers. One rescuer places an oral or nasal airway. The same rescuer then performs a jaw thrust. The second rescuer attempts an E-C with the mask while maintaining head position. The third rescuer delivers breaths with the BVM. As stressed earlier, it is important not to move the patient's head. However, the AHA (2006) has stated that it is more important to deliver proper ventilations. So, if necessary, perform a gentle head tilt–chin lift, but only if absolutely necessary.

Signs of adequate ventilation are obvious: chest rise and fall, improved color, improved oxygenation. The suggested rate of ventilation is between 12 and 20 per minute, about one every 5 to 6 seconds for an adult. Signs of inadequate ventilation are just the opposite: an inability to see chest rise and fall, color that is worsening, and a drop in oxygenation. Make sure the mask has a tight seal and that the head has the proper alignment; these are the primary difficulties. Also make sure that the airway is patent, with no obstructions.

If a patient is spontaneously breathing, but ventilation is inadequate (too small, too slow), it is easy to augment the breathing by using a BVM. Using the parameters above, assess whether spontaneous ventilation is adequate. If not, place the BVM mask on the patient's face, just as for resuscitation. Use supplemental oxygen, if available, at a high flow rate (15 lpm is preferable). Squeeze the bag when the patient inhales, delivering an adequate-sized breath. If the patient's rate is too low, breathe for the patient at an appropriate rate, every 5 to 6 seconds, delivering a breath large enough to see the chest rise, always attempting to synchronize with the patient's own breathing.

It is important to watch the patient's chest or neck to visualize when they take a spontaneous breath. If the patient is hyperventilating, follow your local protocol. It may be necessary to attempt to assist the patient's breathing, but that may not be possible if the patient is fully alert and agitated.

Occasionally, a rescuer may encounter a tracheostomy or a permanent stoma. A tracheal tube has the same 15/22 mm diameter fitting as an endotracheal tube and therefore a BVM (without the mask) will fit on it. If the patient with a tracheostomy is in need of assisted ventilation via a BVM, deliver the breaths more gently because there will be fewer obstructions and it is a more direct and shorter route to the lower airways.

An open stoma is more difficult to handle. Stomas vary in size and are easily obstructed. First, ensure a patent airway. Suction if necessary and allowable by protocol. A barrier device can be used in attempting mouth to stoma resuscitation, but "there is no published evidence on the safety, effectiveness, or feasibility of mouth-to-stoma ventilation" (AHA, 2005). A BVM will not fit readily over the open stoma, but it is possible that the BVM can be placed over the patient's face with occlusive pressure over the stoma site.

Additionally a BVM with a pediatric or infant mask may fit well enough over the stoma to create a seal to allow ventilation (Bhalla et al., 2004). If you are attempting to ventilate through the stoma and air seems to be immediately leaking out of the patient's mouth or nose, you may need to pinch the nose and seal the mouth as you ventilate and then let go as the patient exhales.

SCENARIO	You have positioned your patient using the head tilt–chin lift maneuver to ensure an airway. You notice respirations are very slow (about 4 per minute), irregular, and deep. You chose to insert an OPA and it is currently in place. The patient does not have a gag reflex. What are your next steps? **Response** If necessary, available, and in your protocol, radio for advanced care because this patient may need to be intubated. Prepare the BVM for use, choosing the appropriate-sized mask, attaching the oxygen (turning it to a high flow) and placing it on the patient's face. If possible, use both EMT-Bs to ventilate, one to hold the mask in place, the other to squeeze the bag. Ensure adequate ventilations at a rate of 12 to 20 per minute, about 1 breath every 5 to 6 seconds. When you can, check the pulse.

ADVANCED AIRWAYS

Advanced airways will not be discussed in this module for EMT-Bs. However, you need to be aware that basic interventions may not be sufficient to ensure adequate breathing. Having personnel and equipment available for advanced airway care is often necessary to preserve a patient's life. Nevertheless, through the years of research carried out by the American Heart Association, it is apparent that the most important functions of airway maintenance are being able to care for a patient at the most basic level by providing an airway and facilitating breathing (AHA, 2005).

OXYGEN THERAPY

Delivering oxygen is one of the most important aspects of care provided by an EMT-B. Although it is considered drug administration, providing oxygen is a skill which an EMT-B can perform. Most patients transported to an Emergency Department (ED) by ambulance receive some form of oxygen therapy. There are many methods of delivery depending on need, amount, and length of use.

Before considering the delivery devices, it is important to review the conditions requiring oxygen. These are:

- Respiratory and/or cardiac arrest
- Heart attack and stroke
- Shock
- Blood volume loss
- Lung diseases, whether acute or chronic
- Head injuries
- Any other situation that may put the body at risk for hypotension and hypoxia (Limmer & O'Keefe, 2005)

The word **hypoxia** is a general term meaning a lack of oxygen. **Hypoxemia** is a term that means a lack of oxygen in the blood. For this course, the term *hypoxia* will be used for both. Some of the main conditions causing hypoxia are:

- Blood loss (mainly due to trauma)
- Smoke inhalation (causes displacement of O_2 by CO_2 in the blood)
- Chronic lung disease
- Any situation where a patient is hypoventilating, such as a drug overdose
- Heart attack

Remember that hypoxia can cause irreparable brain damage by **anoxia** (being without oxygen) and that oxygen therapy is a quick and simple treatment (Limmer & O'Keefe, 2005).

Nasal Cannula

The quickest and easiest method of administering oxygen is by a **nasal cannula**. A nasal cannula is a length of plastic tubing (usually 7 or 14 feet long) on which is attached two prongs designed to fit into the nose. The cannula is attached to an oxygen source at a rate from 1 to 6 lpm. Nasal cannulas used at 1 lpm gives 24% fraction of inspired oxygen (FiO_2), and at 6 lpm the FiO_2 increases to 44%. Conventional cannulas cannot support a flow rate greater than 6 lpm. Some specialized cannulas and flow meters can be set to flow at rates from 1/8 of a liter to 15 lpm. Cannulas are used in noncritical situations and for those who cannot wear a mask. Patients at home can use cannulas for continuous oxygen.

Simple Mask

A simple mask is a plastic mask that can be used in most situations requiring a moderate flow rate of between 6 and 10 lpm (40%–60% FiO_2). Simple masks at 6 lpm give 40% FiO_2, and at 10 lpm administer 60%. They have side holes to be used for exhalation and for air entrainment if the flow rate is not high enough. There is usually an elasticized strap to hold it in place. A length of tubing connects the mask to an oxygen source. The mask is not equipped to handle a rate higher than 10 lpm, nor is it designed as a resuscitative device. The patient must be spontaneously breathing. Never use any mask at less than 6 lpm, as CO_2 will build up in the mask and could suffocate the patient. Many ambulance companies no longer use this mask because there are more comprehensive devices available.

Nonrebreathing Mask

A nonrebreathing mask is one of the most preferred oxygen delivery devices. Nonrebreathers are rather complicated and the EMT-B must know how to use them properly or serious damage to the patient can result. They have a plastic mask and oxygen tubing just like the simple mask, but this device is meant to provide high flow and high concentration oxygen. The highest FiO_2 can be obtained by using the nonrebreathing mask. At 10 lpm the FiO_2 is 70% to 75%, and when used at 15 lpm the patient may receive 100% FiO_2.

The mask has side ports that are fitted with one-way valves to ensure a high concentration of oxygen and prevent breathing room air. It also has a reservoir bag to capture the pure oxygen. Between the reservoir bag and the mask is another one-way valve. This valve is designed so that the patient can inhale both from the oxygen supplied by the source and from the reservoir, providing an oxygen concentration close to 100%. The one-way valve also prevents rebreathing of exhaled air. Never allow the reservoir bag to deflate (although it does not need to be completely inflated at all times). Instead, increase the flow rate to ensure that an adequate volume of air is available to the patient.

You have a patient who is complaining of chest pain. What mode of oxygen would you choose and why?

SCENARIO **Response**

Know your protocols. The answer is to use a nonrebreather at 15 lpm. Although the patient is spontaneously breathing, the extra oxygen can reduce myocardial workload and take some of the strain off the heart muscle.

FLOW-RESTRICTED, OXYGEN-POWERED VENTILATION DEVICE

We discuss the flow-restricted, oxygen-powered ventilation device (FROPVD, or demand valve) because it is still available; however, in many areas these devices are no longer used. A FROPVD is a ventilator of sorts, and uses very high pressures to deliver the breaths. There is a face mask that must seal well on the patient's face. On the mask is the demand valve that utilizes a one-way valve, a demand button, and a regulator or pressure reducer.

The FROPVD utilizes high-pressure oxygen tubing that can deliver pressures up to 50 psi. Each time the demand valve is pressed, air is quickly pushed toward the patient. This means the patient must have a patent airway—and probably needs an airway adjunct in place. A breath is delivered as long as the button is depressed. You must be careful when using this device.

Advantages of a demand valve are:

- It can deliver 100% oxygen.
- Only one rescuer is needed to provide a good seal on the mask and thus a substantial breath.
- It can be used in extreme environmental conditions.

Conversely, there are a number of disadvantages. **When used improperly, FROPVDs can cause irreparable damage to the patient, including death.** For this reason, many fire departments and ambulances no longer use these devices. Because a breath is being delivered as long as the demand button is depressed, the volume of air delivered to the patient can be quite large and it is delivered with great force. It is imperative that rescuers using this device never take their eyes from the patient's chest.

If chest trauma is present it is best not to use the demand device because pneumothorax or barotrauma could result. The patient's head must be in alignment or air will be pushed into the stomach.

Absolute contraindications for using the demand device are:

- Patients with COPD, suspected cervical spinal injury, or chest injury (especially flail chest)
- Infants or children (Limmer & O'Keefe, 2005)