The airway is the portal of entry for oxygen into the human body. Establishing an airway is the first priority of resuscitation because, without an adequate airway, all other medical treatments are futile. All airways established in the out-of-hospital setting must be considered difficult airways; the importance of knowing when to intubate and what to do in the case of a technically challenging airway is not often appreciated. Several recent studies have highlighted the high failure rate for prehospital intubations as well as significant complications with this procedure. The most devastating is unrecognized esophageal intubation.

In this chapter, we will briefly review some basic principles of airway assessment and the approach to tracheal intubation. The
focus will be on identification of the difficult airway and critical thinking about alternatives for airway management. Several basic and advanced airway measures will be discussed, including rapid-sequence intubation. The chapter also stresses appropriate methods of monitoring the patient after the airway has been secured. It should be emphasized that methods of airway control and the use of alternative airway devices should be dictated by local protocols and authorized by medical direction.

You are dispatched on an emergency call for an "unconscious unknown." As you reach the dispatched location, you are met by a man who frantically explains that he found his wife unconscious beside the bed after complaining of a severe headache. You quickly survey the area for any obvious hazards and move in to evaluate the patient.

You find an elderly female breathing eight times per minute with shallow, snoring respirations and a pool of fresh vomit beside her. She has obvious forward curvature in her neck and a small, recessed chin.

How would you proceed with the immediate resuscitation of this patient?

Anatomy and Physiology

Upper Airway Anatomy

The upper airway begins at the openings of the nose and mouth and ends in the trachea at the bottom of the larynx.

Air enters the body through the nose and mouth. Here, the air is warmed, humidified, and filtered before passing into a larger cavity called the pharynx. The posterior portion of the nose is the nasopharynx, and the large cavity in the back of the mouth is the oropharynx. The pharynx represents the common beginning for both the respiratory and digestive systems. Distally, the pharynx divides into two channels: The esophagus leads to the digestive tract; the trachea leads to the lungs. With vomiting, gastric contents enter the pharynx, where they may gain access to the tracheobronchial tree if the airway’s protective mechanisms fail.

The muscular tongue is the largest structure to occupy the oral cavity. Because of its size, the tongue is the most common source of airway obstruction and an obstacle to simple intubation, particularly in patients with an altered level of consciousness. The tongue has significant muscular attachment to the mandible, or jawbone, which explains why anterior movement of the mandible (as in a chin lift) moves the tongue forward and often relieves airway obstruction.

A large cartilaginous structure, the epiglottis, protects the trachea from blood, secretions, vomitus, and material intended for the digestive system (see Figure 3-1). Most tracheal intubation techniques require manipulation of the epiglottis. In front of the epiglottis is a recess that forms at the base of the tongue, called the vallecula. Ligaments attach the base of the tongue to the epiglottis, so that pulling the deep portions of the tongue forward, as
with a curved laryngoscope blade, also elevates the epiglottis. The aryepiglottic folds, along with the epiglottis, define the glottic opening. The upper portion of the epiglottis is innervated by the ninth cranial nerve (glossopharyngeal nerve), whereas the lower portions of the epiglottis and vocal cords are innervated by the tenth cranial nerve (vagus nerve). Stimulation of the lower portions of the epiglottis may produce laryngospasm. Injury to the branches of the vagus nerve (superior laryngeal nerve and recurrent laryngeal nerve) may result in permanent hoarseness.

Beneath the epiglottis is the larynx, the upper portion of the trachea, which contains the vocal cords. This structure is located in front of the fourth and fifth cervical vertebrae. The false vocal cords lie above the true vocal cords. The larynx is defined externally by the thyroid cartilage, or Adam’s apple. Just below this area is the cricoid cartilage or cricoid ring. This is the only completely circular support in the tracheobronchial tree. Direct pressure on the anterior surface of the thyroid cartilage occludes the esophagus, which lies posteriorly, and may help prevent passive aspiration. There is a small diamond-shaped membrane between the thyroid cartilage and cricoid ring called the cricothyroid membrane. This is an important landmark for establishing a surgical airway. As the larynx projects into the pharynx, it defines deep posterior recesses called the pyriform fossa. This is a site where a tracheal tube tip may commonly become lodged, particularly during blind insertion procedures.

An obstruction of the airway is often characterized by its location. Supraglottic obstruction occurs above the larynx, whereas subglottic obstruction occurs at the level of the larynx or below.

There are three major axes in the normal airway: the oral axis, the pharyngeal axis, and the laryngeal axis (see Figure 3-2). In the normal resting individual, these axes are not well aligned. In order to be successful in performing an endotracheal intubation, these three axes must be as closely aligned as possible. Proper positioning of the patient in the “sniffing position” may help to better align these axes and provide improved visualization through the oropharynx, increasing the likelihood of success. Conversely, any condition that hinders proper alignment and visualization will result in a difficult airway.
Upper Airway Physiology

A major function of the larynx is protection of the upper airway, which is in continuity with the alimentary system. During swallowing or coughing, contraction of the laryngeal muscles leads to downward movement of the epiglottis and tight closure of the glottic opening. These movements serve to protect the tracheobronchial tree. Laryngospasm is an exaggerated form of this protective mechanism.

In defining whether a patient is in need of airway protection, it is difficult clinically to determine whether these airway protection mechanisms remain intact. The testing of a gag reflex is not a reliable indicator. Therefore, it should be assumed that any patient who needs continued assistance to maintain a patent airway requires aggressive airway management.

Manipulation of the upper airway produces characteristic physiological responses. For example, the manipulation of the upper airway that occurs during intubation typically results in the release of systemic catecholamines (epinephrine and norepinephrine). Clinically, the result is an elevation in blood pressure and heart rate during the intubation process, which is generally well tolerated unless the patient has an elevated intracranial pressure (e.g., from intracerebral hemorrhage) or underlying cardiac disorder (e.g., cardiogenic shock). Beta-blocking agents and opioid drugs such as morphine sulfate or fentanyl have been used to protect against these effects.

A separate reflex independently produces a rise in intracranial pressure during intubation attempts. This effect can be particularly harmful if not addressed because brain blood flow is determined by the difference between mean arterial blood pressure and intracranial pressure. If the mean arterial blood pressure remains unchanged, then the intubation attempt can produce a significant reduction in brain blood flow during the procedure. Lidocaine, administered intravenously or by local spray, may blunt this airway response.
Lower Airway Anatomy

The lower airway begins at the point where the larynx branches into right and left main-stem bronchi. This point is known as the carina. The right main-stem bronchus branches off at a lesser angle than the left main-stem bronchus. For this reason, aspirated foreign matter is more likely to enter the right lung. For the same reason, a tracheal tube, if advanced too far, usually comes to rest in the right mainstem bronchus rather than the left.

Below the cricoid ring, the trachea is characterized by a series of cartilaginous rings that support this portion of the airway. Each of these tracheal rings is C-shaped. The trachealis muscle completes the circular support of each ring. The trachea proceeds distally until it divides at the carina into the right and left mainstem bronchi.

The bronchi subdivide into smaller and smaller bronchioles that terminate at the saclike alveoli. The exchange of oxygen and carbon dioxide takes place between the alveoli and the pulmonary capillaries (see Figure 3-3).

Respiratory Physiology

The major functions of respiration are to provide oxygen for cellular metabolism and to eliminate carbon dioxide produced by metabolic processes of the body. In addition, because of the relationship of carbon dioxide to acid–base balance, the lungs provide the most rapid physiological response to pH changes in the body.

Oxygen is derived from our external environment and is drawn into the lungs during the inspiratory phase of respiration (see Figure 3-4a). During this phase, the chest wall expands as the intercostal and neck muscles contract and the diaphragm flattens. This action creates negative pressure (a vacuum) within the lungs, drawing oxygen and other gases from the
environment through the trachea into the respiratory tree. Inspiration is an active process that requires the expenditure of significant energy.

The major determinants of the alveolar content of oxygen include the inspired fraction of oxygen (generally 21 percent of room air) and the ventilatory rate as reflected in the measured concentration of arterial carbon dioxide.

During expiration (Figure 3-4b), the diaphragm and ribs return to their normal resting state. Positive pressure is created within the chest cavity, which forces gases (particularly carbon dioxide) out of the chest. In most cases, expiration is a passive process and requires no energy consumption. However, in asthmatic patients and those with chronic obstructive pulmonary disease (COPD), there may be obstruction of airflow along with reduced elasticity of the lungs, and exhalation becomes an active process, also expending energy.

In patients with respiratory failure, ventilation is performed by emergency care personnel using manual or mechanical techniques (e.g., bag-valve-mask ventilation or portable transport ventilation). In this case, inhalation is based on positive pressure forcing oxygen and other gases into the lungs, with passive exhalation of carbon dioxide by the patient.

Two factors affect the ability to ventilate a patient adequately: resistance and compliance. **Resistance** refers to the ease with which gases flow into an open space (e.g., airway resistance to ventilation).

**Compliance** is the mathematical description of the elasticity of the lungs and is defined as the change in lung volume produced by a change in pressure. A decrease in compliance can be appreciated as an increase in the effort needed to “bag” a patient. Greater pressure is needed to achieve the same lung volume in patients with decreased lung compliance, such as patients with COPD.

Once oxygen reaches the alveoli, it must then pass into the small capillaries that are found in the distal portions of the lungs. This process is
known as diffusion. It is usually a very efficient process, owing in part to the tremendous surface area of the alveoli and the small distance between the alveolar and capillary membranes.

For diffusion to occur most efficiently, all of the oxygenated alveoli must come in contact with unoxygenated blood from the pulmonary arterial system. The degree of contact between oxygenated alveoli and unoxygenated blood circulating to the lungs is known as the ventilation/perfusion match, or the V/Q match, with “V” standing for ventilated lung segments and “Q” standing for pulmonary perfusion. In an ideal V/Q match, all ventilated segments of the lung (V) are equally matched by capillary perfusion from the pulmonary circulation (Q). Normally, there is some physiological mismatch between ventilation (V) of alveoli and blood flow (Q) through the alveolar capillaries, or perfusion. For example, when the patient is upright, there is better ventilation of the upper segments of the lung, but less blood flow through the same segments because of the effects of gravity. This physiological mismatch (V/Q mismatch) accounts for the fact that the measured difference between alveolar and arterial oxygen concentration is approximately 5 to 15 mmHg.

Any further mismatch of ventilation and perfusion of lung segments will cause unoxygenated blood to mix with oxygen-enriched blood leaving the lungs, creating a condition known as pulmonary shunting (see Figure 3-5).

**Figure 3-5**

Diffusion of oxygen from alveoli to capillaries: (a) normal, (b) shunting, (c) atelectasis.
This shunting can occur when a segment of lung is collapsed (atelectasis), when pneumonia is present, or when the patient experiences a pulmonary embolism. In each condition, the alveolar-arterial difference will be greater than 15 torr. Damage to the alveoli (e.g., from cigarette smoking, asbestos inhalation, or fluid accumulation from pulmonary edema) will also prevent effective diffusion and increase the difference between alveolar and arterial oxygen. In addition, any process that increases the interstitial space between the alveolus and the pulmonary capillary, such as pulmonary edema, may reduce the efficiency of oxygen diffusion.

Ultimately, oxygen that enters the bloodstream must be transported to the tissues. Although some oxygen (less than 1 percent) may be dissolved in the plasma (the noncellular portion of the blood), most oxygen is transported to the tissues bound to hemoglobin, a protein found on the outside of red blood cells. The normal level of hemoglobin is between 12 and 14 g of protein per dL of blood. Patients with anemia (especially less than 7 g/dL of hemoglobin), therefore, are less able to provide adequate oxygen delivery to tissues.

Under normal conditions, the measured arterial concentration of dissolved oxygen is 80 to 100 torr. Measured oxygen levels below 80 torr are known as hypoxemia. This condition contrasts with hypoxia, which is the inadequate delivery of oxygen to the tissues. It should be remembered that oxygen delivery depends on both an adequate arterial oxygen content and an adequate cardiac output.

**Oxygen Supplementation**

Many patients with medical illness have greater oxygen requirements than when they are in their normal healthy state. As a result, higher oxygen concentrations, above the normal 21 percent that is present in the air we breathe, must be made available to the patient. A variety of methods are available to increase the amount of inspired oxygen, including the nasal cannula, the nonrebreather mask, the simple face mask, the partial rebreather mask, and the Venturi mask.

A few points are worthy of emphasis here. Any ill patient who requires greater concentrations of oxygen should not have oxygen withheld for any reason. This is particularly true of patients with underlying COPD. (See Chapter 5.) There has been an undue fear that providing higher oxygen concentrations will depress respiration in these patients; however, the damaging effects of oxygen deprivation far outweigh any potential for respiratory depression, especially in the relatively short duration of prehospital care.

Also, remember that blood oxygen saturation as measured by pulse oximetry is not a true reflection of tissue oxygen concentration. Therefore, you should not assume that because the patient has an acceptable oxygen saturation reading, adequate concentrations of oxygen are reaching the tissues.

Finally, you should remember that at the end of expiration, approximately 2500 mL of air remain in the lungs. Placing the patient on high concentrations of oxygen prior to performing an endotracheal intubation provides him with an oxygen reserve to draw on during the procedure. It has been shown that healthy individuals who are chemically paralyzed after breathing 100 percent oxygen take more than six minutes to experience a significant decrease (< 90 percent) in their blood oxygen saturation. Therefore, all patients for whom you are considering endotracheal intubation should be placed on high-concentration oxygen prior to the procedure.

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**Clinical Insight**

Patients who require oxygen because of an underlying disease process should never have supplemental oxygen withheld because of chronic underlying lung disease. The patient’s need for oxygen should supersede any concern about depressing the patient’s respiratory drive by administering high concentrations of oxygen.
Indications for Airway Management

All patients who are unable to protect their airway adequately should be considered candidates for definitive airway management.

The most common reason for airway management is the inability to maintain airway patency, usually as the result of a depressed level of consciousness. This inability generally occurs in patients with drug or alcohol intoxication, head injury, stroke, seizure, or other metabolic disease. Patients who have an alteration in mental status should be closely assessed for their ability to maintain an open airway. If they fail to maintain an open airway, definitive airway control should be established. Patients who maintain a gag reflex may still require tracheal intubation if other indications for airway management are present.

Another important group of patients who require airway management are those with signs of hypoxia or respiratory failure. The most extreme example is the patient with cardiorespiratory arrest. However, any respiratory ailment (see Chapter 5) may progress to the point where ventilatory support and acute airway management are indicated.

Finally, any patient who presents with a medical condition that may ultimately result in airway compromise should have his airway addressed before airway compromise actually develops. For example, an anaphylactic reaction may result in angioedema involving the upper airway and may require early airway intervention. Infections such as Ludwig's angina (infection involving the soft tissues of the anterior portion of the neck) and retropharyngeal abscesses (see Chapter 5) may also eventually lead to airway compromise. Here again, you must carefully monitor the patient's airway for any evidence of deterioration.

Ventilation Equipment and Techniques

Many patients are not capable of supporting their own ventilatory needs. This is common in patients with conditions that cause central nervous system depression (e.g., drug overdose, alcohol intoxication, metabolic diseases, stroke) or in patients with respiratory failure. Ventilatory failure must be addressed promptly. A variety of alternative ventilatory support methods are available. Selection depends on the equipment available and the perceived advantages of each technique. These methods include mouth-to-mask ventilation, two-person bag-valve-mask ventilation, and flow-restricted, oxygen-powered ventilation. The single-person bag-valve-mask technique is believed to be the least effective method of ventilation.

Effective bag-valve-mask ventilation is an important skill and one that is poorly performed in the emergency care environment. In addition, it is essential to be able to ensure effective bag-valve-mask ventilation if the provider is authorized to use paralytic drugs, since this technique is an essential rescue technique should intubation fail. There are several predictors of difficulty with effective bag-valve-mask ventilation. These can be remembered by the mnemonic MOANS (see Walls, Murphy, Luten, and Schneider, 2004, in “Further Readings”). The letter M stands for “mask seal” and refers to patients who have mechanical barriers, such as facial hair or facial trauma, to maintaining an adequate seal. The letter O suggests “obstruction of the upper airway,” which may preclude good ventilation. The letter A

angioedema an immunologically produced swelling of the skin, mucous membranes, or internal organs.
stands for “age.” It has been noted that bag-valve-mask ventilation becomes increasingly difficult after age 65. The letter N means “no teeth.” Remember that the edentulous patient may be very difficult to ventilate; dentures should remain in place during bag-valve-mask ventilation. Finally, the letter S stands for “stiff.” Patients with poor lung compliance, such as asthmatics, are difficult to ventilate with a bag-valve-mask technique.

### Indications for Airway Management

Patients requiring airway management are those who have:

- An altered mental status or a depressed level of consciousness (as with drug or alcohol intoxication, head injury, stroke, seizure, or metabolic disease)
- Signs of hypoxia or respiratory failure
- A medical condition, like anaphylaxis or epiglottitis, that may ultimately result in airway compromise

With each technique, the rescuer provides positive-pressure ventilation. This means that, instead of air being drawn into the lungs as the result of negative pressure created by an expanding thorax, the rescuer forces air into the lungs. In addition to providing assistance to ventilation, this procedure reduces the patient’s oxygen requirements by reducing the energy requirements during respiration.

Take care to avoid injuring the patient by ventilating too aggressively. Aggressive ventilation can lead to complications, including pneumothorax, pneumomediastinum, and air in the subcutaneous tissues. Additionally, overly aggressive ventilation can cause gastric distention and increased risk of aspiration. Insufflation of air into the stomach raises the pressure in the stomach above that which can be occluded by the normal muscular tension in the lower esophageal sphincter muscle. Cricoid pressure may help to avoid this complication but may actually worsen ventilation if performed improperly. Cricoid pressure has been de-emphasized in recent national guidelines.

To apply cricoid pressure (see Figure 3-6), first locate the cricoid ring. It is the first cartilaginous ring beneath the thyroid cartilage. Use your thumb...
and index finger to apply firm pressure on the anterior portion of the cricoid ring in order to occlude the esophagus. Do not perform this maneuver if the patient is actively vomiting because esophageal rupture may result.

Cricoid pressure prevents air from being forced into the stomach by resisting a pressure gradient of up to 100 torr. It has been suggested that cricoid pressure reduces the risk of gastric distention and aspiration, although this is also controversial. Additionally, during attempts at tracheal intubation, this procedure forces the glottic opening posteriorly into the intubator’s field of vision. Finally, if the intubation is performed properly, the tracheal tube can be felt to pass beneath the thumb and index finger of the person applying cricoid pressure, an additional method of confirming proper tube placement.

### Airway Assessment

To assess and manage a patient’s airway and ventilation, you should always take an organized approach, working from the most basic to the more complex methods of airway and ventilatory support (see Figure 3-7). Constant reassessment of the patient is imperative because airway needs and the degree of ventilatory assistance required may vary whenever the patient’s clinical condition changes. Finally, you must also consider any limitations placed on your scope of practice as defined by local medical direction.

The first question to be considered is: Does the patient have a patent airway? If there is any evidence of upper-airway obstruction, the initial approach should involve either a head-tilt, a chin-lift, or a jaw-thrust maneuver (if trauma is suspected) to support the airway. If the patient is unconscious, then an oropharyngeal airway is used to provide continuing airway support; in the lethargic patient, a nasopharyngeal airway is better tolerated. Patients who require continued airway support are candidates for tracheal intubation.

The next consideration is: Does the patient have an adequate ventilatory effort? Is there evidence of respiratory failure? Patients who are unable to support their ventilatory needs require assisted ventilation. Noninvasive methods of ventilation, such as continuous-positive-airway-pressure (CPAP) ventilation, should be considered. (See Chapter 5.) As stated earlier, the selection of the appropriate support should be based on the equipment available, the skills of the rescuer, and the needs of the patient. Mouth-to-mask ventilation, demand-valve ventilation, or bag-valve-mask ventilation should be considered. Here again, if the patient requires a prolonged period of assisted ventilation, tracheal intubation must be considered.

One final consideration is the need for oxygen supplementation. Does the patient appear hypoxic or have a clinical condition such as shock or chest pain that requires oxygen supplementation? Any patient who requires oxygen supplementation should receive as close to 100 percent inspired oxygen as possible. Spontaneously breathing patients should be placed on a nonrebreather mask. Patients who are being assisted with a bag-valve mask should have a reservoir attached to the ventilation device to ensure near 100 percent inspired oxygen.

Continue patient assessment, using clinical indicators, cardiac monitoring, and pulse oximetry. Establish a definitive airway in any patient who requires continued airway support, who remains hypoxic, or who demonstrates persistent ventilatory failure.
Open airway with head-tilt, chin-lift, or jaw-thrust maneuver. If patient is unresponsive, insert oropharyngeal airway; if patient is lethargic (has gag reflex; oropharyngeal airway not tolerated), insert nasopharyngeal airway.

Continuous patient monitoring: clinical, ECG, pulse oximetry

Initiate one of the following:
- Surgical cricothyroidotomy
- Retrograde intubation
- Needle cricothyroidotomy

Continuous patient monitoring: clinical, ECG, pulse oximetry, PETCO₂

Provide assisted ventilations via mouth-to-mask, demand-valve device, or bag-valve-mask.

Inability to maintain patent airway? Need for continued ventilatory support? Persistent hypoxia?

Continuous patient monitoring: clinical, ECG, pulse oximetry

Establish an alternative airway (Combitube, PtL, laryngeal airway, or LMA) or intubate by one of the following methods:
- Nasotracheal intubation
- Oral intubation with rapid-sequence induction
- Digital intubation (patient unconscious)

Successful ventilation and oxygenation?

Yes
- Continuous patient monitoring: clinical, ECG, pulse oximetry, PETCO₂

No
- Initiate one of the following:
  - Retrograde intubation or needle cricothyroidotomy
  - Surgical cricothyroidotomy
  - PtL, Combitube, or a supraglottic airway

FIGURE 3-7
Airway, ventilation, and oxygenation treatment pathway.
Prior to establishing a definitive airway, assess the patient’s anatomy to determine if you will have difficulty securing an airway. Here again, a mnemonic—LEMON—is helpful. The first part of assessing an airway is to Look at the patient for signs that the intubation may be difficult. Features such as facial trauma, a recessed mandible, a thick neck, or swelling from infection or edema are obvious clues to airway difficulty. Next, Evaluate the anatomy by using simple measurements (see Figure 3-8). The patient should be able to open his mouth to accommodate three fingers. In addition, the distance from the tip of the mandible to the hyoid bone should be at least three fingers’ width. Finally, at least two fingers should fit from the hyoid bone to the top of the larynx. In the cooperative patient, make a Mallampati classification by asking the patient to fully open his mouth when possible (see Figure 3-9). Obese patients also pose a difficult airway due to the redundancy of soft tissues in the neck. Pregnant females are also at greater risk of airway difficulty. Finally, you should assess the patient’s Neck mobility. Elderly patients with arthritis and exaggerated lordosis pose a particular challenge, as do trauma patients with cervical collars. Using the LEMON characteristics, you will get a fairly good assessment of the ease or difficulty of attempts to intubate the patient. Remember that of all patients whom trained anesthesiologists assess and expect to be “easy” intubations, up to 3 percent turn out to have unanticipated difficult airways.
Successful placement of a tracheal tube is the definitive method of securing an airway. You can deliver oxygen directly to the lungs and can manipulate the patient’s tidal volume. Meanwhile, the tracheal tube protects the tracheobronchial tree from contamination by vomit, blood, or secretions. It is assumed that the student is proficient in the technique of tracheal intubation, in confirming proper tube placement, and in dealing with the complications of this airway technique. Data suggests that experienced emergency care providers are successful in more than 95 percent of cases within three attempts. However, those who infrequently perform the procedure have low success and high complication rates. The discussion that follows will focus on the 5 percent of patients with difficult airways.

One aid to tracheal intubation should be mentioned at this point: the gum elastic bougie. It has been used to assist in tracheal intubation when there is inadequate visualization of the vocal cords. The gum elastic bougie is a long, tubelike device with a flexible tip that can be inserted behind the epiglottis and passed blindly through the vocal cords. The tracheal tube is slid over the proximal end of the device and advanced into the trachea, with the gum elastic bougie acting as a guide (see Figure 3-10). Consider using a gum elastic bougie when, despite all your attempts to reposition the patient, your visualization of the vocal cords is still inadequate.

Remembered that you can perform tracheal intubation without sedating medications only in patients who are profoundly obtunded or who are in cardiac arrest. In many other cases, intubation requires the use of adjunctive sedative and/or paralytic agents (see “Rapid-Sequence Intubation” later in this chapter) or the use of a combination of sedating medications in low doses and local tracheal anesthesia to depress protective reflexes.

Patient-monitoring equipment should be available for any patient with suspected airway compromise and during any airway procedure:

- Cardiac monitor
- Pulse oximeter

Place the cardiac monitor and the pulse oximeter on the patient before you begin the intubation procedure, unless you are performing the intubation for a truly emergent condition, such as apnea. The ECG tracing and
oxygen saturation should be monitored continuously during the intubation procedure.

Following clinical assessment of successful endotracheal tube placement, it is essential to have available an additional method of assessing appropriate tube placement, that is, one of the following (see Figure 3-11):

- End-tidal CO₂ detection device
- Esophageal detection device (bulb or syringe type)

These devices supplement clinical protocols used to determine correct placement of the tracheal tube in the trachea. Evidence suggests that clinical methods alone may not identify improper tube placement in a significant percentage of cases.

Alternative Methods of Intubation

**Nasotracheal Intubation**

Nasotracheal intubation may be employed as an alternative to orotracheal intubation. This blind approach is commonly used in the out-of-hospital environment because it offers a number of advantages over the orotracheal approach. The technique can be successfully performed with the patient in a...
variety of positions. Unlike orotracheal intubation, it can be accomplished when the patient is in an upright or semiupright position. Also, the nasotracheal route is better tolerated by the patient who is lethargic but not unconscious. Finally, it is an alternative approach where difficulties in the oropharynx make an orotracheal approach impossible. You may use the nasotracheal approach for patients with seizures and a clenched jaw, patients with significant swelling in the oropharynx, or patients with trismus (contraction of the muscles of mastication) as the result of infectious processes.

The nasotracheal approach also has disadvantages. Blind nasotracheal intubation requires some skill and persistence compared to the orotracheal approach. The success rate for the procedure is significantly lower than for tracheal intubation, and soft tissue injury is more common with this technique. In addition, the patient must have some spontaneous ventilatory effort for the procedure to be performed successfully. The technique cannot be performed on a completely apneic patient.

Finally, there are some delayed consequences of nasotracheal intubation that must be considered. As a rule, tracheal tubes inserted nasotracheally have a smaller lumen than those inserted by the orotracheal route. Smaller tracheal tubes increase airway resistance, which may increase the work of spontaneous ventilation and, therefore, it may be difficult to get the patient off a mechanical ventilator. In addition, some hospital procedures, such as bronchoscopy, can be performed only with a size 8.0-mm tracheal tube or larger. Such tubes are typically too large to be used for nasotracheal intubation. Finally, nasotracheal intubation has a higher incidence of complications, including sinusitis and soft tissue injury.

### Indications for Nasotracheal Intubation

Nasotracheal intubation is appropriate as an alternative to orotracheal intubation when the patient:

- Cannot be placed in a supine position
- Is lethargic but not unconscious
- Has difficulties with the oropharynx, such as swelling or copious secretions that inhibit visualization of the vocal cords
- Has a clenched jaw

The following equipment is needed for nasotracheal intubation:

- Oxygen source
- Bag-valve mask
- Tracheal tube
- Water-soluble lubricant
- Syringe
- Suctioning equipment
- Method to secure the tracheal tube (tape, intravenous tubing, or a commercially available device)
- Stethoscope

Nasotracheal intubation should be undertaken in the following manner (see Figure 3-12):

1. The patient should be well oxygenated with 100 percent oxygen, with a full face mask in the case of a spontaneously breathing patient or a bag-valve
Nasotracheal Intubation

**FIGURE 3-12a**
Make sure the equipment has been assembled and tested.

**FIGURE 3-12b**
Oxygenate the patient well, using 100 percent oxygen.

**FIGURE 3-12c**
Position head and insert lubricated tube into the nare.

**FIGURE 3-12d**
Advance the tube until properly placed.

**FIGURE 3-12e**
Confirm tube placement.

**FIGURE 3-12f**
Secure the tube and reconfirm tube placement.
mask in the case of a patient with decreased ventilatory effort. Administer high-concentration oxygen for approximately three to five minutes. Prepare the nasal passage by passing a nasopharyngeal airway prior to the procedure. Lubricate a nasopharyngeal airway, and place it in the nostril in which the insertion will be attempted. A water-soluble lubricant should be used, preferably lidocaine jelly. Also administer a vasoconstricting agent, such as 0.25 percent phenylephrine (Neo-Synephrine), prior to an attempt. Remove the nasal airway just prior to the intubation attempt.

2. Pass a lubricated 6.5- to 7.5-mm tracheal tube directly posterior through the nare. You may feel some resistance. You can overcome it by gently rotating the tube, but do not use significant force. “Curl” the tube prior to the procedure to allow a significant anterior displacement of the tip of the tube during insertion. Alternatively, an Endotrol tube can be used. This tube has a cable that is used to curl the tip of the tube more anteriorly when the ring attached to the cable is pulled during the procedure.

3. Gently and slowly push the tube through the pharynx to the point at which breath sounds are heard loudest. At this point, the tube is resting just above the glottic opening. Advancing the tube beyond this point results in a marked decrease in the sounds heard. You can aid auscultation by removing the bell of the stethoscope and placing the open tubing in the adapter end of the tracheal tube. Alternatively, a whistlelike device called the Beck Airway Airflow Monitor (BAAM) is available that can be placed over the tracheal tube adapter to augment the breath sounds.

4. Observe the patient for each inspiration. During a deep inspiration, quickly advance the tube. The result should be that the tube passes through the vocal cords when they are wide open. Typically, the patient will buck and cough after successful intubation. A prominence noted on either side of the larynx suggests that the tube has come to rest in the pyriform fossa. If this happens, pull the tube back and rotate it laterally during subsequent attempts. Occasionally, slight flexion or extension of the neck is required to assist in proper placement.

5. Confirm tube placement. Do this after inflating the balloon cuff with 5 to 10 mL of air.

6. Secure the tube, using an appropriate method. Make a note of the centimeter marking of the tracheal tube as it rests against the opening of the nare. As a general guideline, the tracheal tube adapter should be within a few centimeters of the nares. Reconfirm this marking and tube placement after any patient movement or transfer.

Complications for nasotracheal intubation are similar to those for orotracheal intubation. As already mentioned, infectious complications and soft tissue injury are more common with the nasotracheal technique. It should also be mentioned that, once the nasotracheal tube has been advanced into the pharynx, a laryngoscope blade can be used to locate the tube tip. If necessary, with the use of Magill forceps the tube can be advanced past the vocal cords in a technique similar to that used for orotracheal intubation.

Digital Intubation

Digital intubation is a blind intubation technique that enables emergency care personnel to pass a tracheal tube when the patient is unresponsive and is in a position that is not conducive to oral or nasal intubation. In addition,
consider this alternative approach when other methods of intubation have already been attempted unsuccessfully in the unconscious patient. The digital technique is particularly useful when secretions prevent adequate visualization of the cords or when equipment failure precludes appropriate visualization. This technique requires minimal equipment because the care provider guides the tube into the larynx using his fingers only. The major risk of this procedure is injury to the care provider from the patient’s teeth, causing direct exposure to oral secretions. The technique should be reserved for those patients who have a severely depressed level of consciousness, are unresponsive, or are chemically paralyzed.

The following equipment is needed for digital intubation:

- Oxygen source
- Bag-valve mask
- Tracheal tube
- Stylet
- Water-soluble lubricant
- Syringe
- Suctioning equipment
- Method to secure the tracheal tube (tape, intravenous tubing, or a commercially available device)
- Stethoscope

Digital intubation should be performed in the following manner (see Figure 3-13):

1. The patient should be well oxygenated with 100 percent oxygen. Use a full face mask in the case of a spontaneously breathing patient or a bag-valve

**FIGURE 3-13**

(a) To perform digital intubation, insert the index finger and the middle finger of your dominant hand into the patient’s mouth and pull the base of the tongue forward. Locate the epiglottis and pull it forward, using your middle finger. (b) Use your other hand to advance the lubricated tube and stylet through the mouth, past the vocal cords, and into the trachea.
mask in the case of a patient with decreased ventilatory effort. Administer high-concentration oxygen for approximately three to five minutes.

### Indications for Digital or Lighted-Stylet Intubation

Digital intubation or lighted-stylet intubation is appropriate as an alternative to orotracheal or nasotracheal intubation when the patient:

- Has a severely depressed level of consciousness, is unresponsive, or is chemically paralyzed
- Is in a position not conducive to orotracheal or nasotracheal intubation
- Has copious secretions that inhibit visualization of the vocal cords
- Has already had an unsuccessful intubation attempt with orotracheal intubation using a rapid-sequence intubation (RSI) technique

2. Insert the index and middle finger of your dominant hand into the patient's mouth and use them to pull the base of the tongue forward. You can insert a bite block to prevent the patient from injuring you. Locate the epiglottis and pull it forward, using your middle finger.

3. Use your other hand to advance the lubricated tube through the mouth. (The lubricated stylet will have been placed in the lumen of the tube and molded into a J shape.) Then, slide the tube past the vocal cords into the trachea, using your index and middle fingers to guide the tube.

4. Remove the stylet and inflate the balloon cuff with 5 to 10 mL of air.

5. Confirm tube placement using the methods described earlier for orotracheal intubation.

6. Secure the tube using an appropriate method. Make a note of the centimeter marking of the tracheal tube as it rests against the corner of the mouth. Reconfirm this marking and tube placement after any patient movement or transfer.

### Lighted-Stylet Intubation

Lighted-stylet intubation takes advantage of the fact that a high-intensity light at the end of a stylet can be seen through the soft tissues of the neck when the stylet is properly placed in the trachea. In this technique, the tracheal tube and lighted stylet are advanced blindly into the mouth, guided toward the larynx, and then slid into the trachea.

The indications for this technique are similar to those for other blind methods; consider it when orotracheal intubation is not practical because of the patient's position, copious secretions, or equipment failure. The procedure is somewhat limited because it is difficult to appreciate the light emitted from the stylet in the presence of bright ambient lighting, such as direct sunlight. However, lighted-stylet intubation is better tolerated than digital intubation and puts the care provider at less risk.

The following equipment is needed for lighted-stylet intubation:

- Oxygen source
- Bag-valve mask
Tracheal tube
Special high-intensity lighted stylet
Water-soluble lubricant
Syringe
Suctioning equipment
Method to secure the tracheal tube (tape, intravenous tubing, or a commercially available device)

Lighted-stylet intubation should be performed in the following manner (see Figure 3-14):

1. The patient should be well oxygenated with 100 percent oxygen. Use a full face mask in the case of a spontaneously breathing patient or a bag-valve mask in the case of a patient with decreased ventilatory effort. Administer high-concentration oxygen for approximately three to five minutes.

2. Thread the tube over the distal portion of the lighted stylet and fit the adapter to the end of the tube. Bend the stylet to a curved J or hockey stick configuration just beyond the end of the tracheal tube.

3. Advance your index and middle fingers into the patient’s mouth, depressing the base of the tongue. Use your thumb to stabilize the chin. Alternatively, use the laryngoscope to elevate the tongue. Advance the tube and stylet deep into the pharynx, along the midline, so the tip passes the epiglottis.

**FIGURE 3-14**

(a) To perform lighted-stylet intubation, insert the index finger and the middle finger of your dominant hand into the patient’s mouth, depressing the base of the tongue. Advance the tube and stylet deep into the pharynx and past the epiglottis. (b) The tip of the stylet is correctly placed in the trachea if you can see a distinct, bright light in the middle portion of the neck.
4. The tip of the stylet is in the correct position if you can see a distinct, bright light in the middle portion of the neck after the stylet has been advanced. After confirming that the light is distinctly visible, advance the tube 1 to 2 cm and withdraw the stylet.
   a. If the light you see across the neck is faint or diffuse, the tube is in the esophagus. Remove the tube and the stylet, and bend the distal portion of the stylet into a more pronounced curve before reattempting intubation.
   b. If you see a distinct, bright light lateral to the thyroid cartilage, the tip of the stylet has been advanced into the pyriform fossa. Withdraw the tube and the stylet, and redirect them toward the midline.

5. After inflating the balloon cuff with 5 to 10 mL of air, confirm tube placement using the methods described earlier for orotracheal intubation.

6. Secure the tube, using an appropriate method. Make a note of where the centimeter marking of the tracheal tube rests against the corner of the mouth. Reconfirm this marking and tube placement after any patient movement or transfer.

### Alternative Airway Devices

Although tracheal tube placement by direct visualization is the definitive way to manage the patient’s airway, a high degree of manual skill and frequent practice are required to remain proficient. Alternative devices have been developed that provide adequate ventilation for the patient and can be inserted reliably with less training. The devices discussed in this section are inserted by use of a blind technique and are an acceptable and reliable method of ventilating and oxygenating patients. Skill is required to assess the appropriate lumen through which to ventilate the patient.

Historically, the esophageal obturator airway (EOA) was the first of these devices to be used as an alternative method of ventilation. The obturator protected the airway by sealing off the esophagus. The device was later modified to allow passage of a nasogastric tube into the stomach to relieve gastric distention. This modification was called an esophageal gastric tube airway (EGTA). Although both devices provide effective ventilation when used properly, a significant complication was the unrecognized insertion of the obturator into the trachea, leading to hypoxia and death in many cases. As a result, these devices are no longer used, and most services have replaced them with the PtL or Combitube described in the following sections.

The PtL airway and the esophageal-tracheal Combitube were refinements on the concept of the EOA/EGTA that offered the additional safety factor and benefit of being able to ventilate the trachea if the device came to rest in that position. However, each device also allows occlusion of the pharynx and indirect ventilation of the trachea using an alternative port.

### Pharyngotracheal Lumen Airway

The PtL airway is designed as a longer tube passing through a shorter, wider tube, each with its own distal balloon (see Figure 3-15). A stylet is placed in the lumen of the longer tube, which is designed to rest in either the trachea or the esophagus. The shorter tube has a larger balloon that, when inflated, occludes the pharynx.
During insertion, if the longer tube is inserted into the trachea, then the stylet is removed and the trachea is directly ventilated through the ventilation port. If, however, the esophagus is intubated, the distal balloon is inflated to occlude the esophagus, and ventilation is performed using the port attached to the shorter tube. In this case, ventilation of the trachea occurs indirectly because the pharynx and esophagus are occluded and the ventilations are directed into the trachea. One unique feature of this airway device is that the balloon cuffs can be inflated separately or simultaneously. Because the pharyngeal balloon occludes the pharynx, it offers the advantage of preventing blood or secretions in the mouth or nose from entering the trachea.

The greatest limitation with the use of the PtL is that the care provider must determine whether the longer tube has been placed in the esophagus or the trachea. Studies have shown that this skill is difficult to master without a significant amount of training and supervision.

The device is used in patients who are unconscious and without a gag reflex, and in whom an orotracheal or nasotracheal intubation could not be accomplished or is not within the scope of practice of the emergency care provider. Approval by the service medical director is needed before the device is used.

The PtL is not used in patients younger than 16 years of age or shorter than 5 feet tall. It should not be used in patients with known esophageal disease or patients who may have ingested a caustic substance.

The following equipment is needed:
- Oxygen source
- Bag-valve mask
- PtL
- Water-soluble lubricant
- Syringe
- Suctioning equipment
- Stethoscope

PtL insertion should be performed in the following manner (see Figure 3-16):

1. The patient should be well oxygenated with 100 percent oxygen. Use a full face mask in the case of a spontaneously breathing patient or a bag-valve
mask in the case of a patient with decreased ventilatory effort. Administer high-concentration oxygen for approximately three to five minutes.

2. The patient's head should be hyperextended slightly. Pull the jaw and tongue forward using your nondominant hand. Insert the PtL through the mouth along the natural curve of the pharynx. Continue to pass the tube until the teeth strap is at the level of the patient's teeth.

3. Fasten the neck strap around the patient's neck. Inflate both balloon cuffs simultaneously by breathing into the common balloon port with a sustained effort.

4. After cuff inflation, ventilate the shorter, wider tube. If no air is heard entering the epigastrium, and the chest rises and falls symmetrically, then the longer balloon is occluding the esophagus. Air is being forced into the trachea as the result of esophageal and pharyngeal occlusion. Continue to ventilate using this port.

5. If air is heard entering the stomach and the chest is not rising with each breath, then the longer tube has been inserted into the trachea. Remove the stylet and use the bag-valve device to ventilate the 15-mm port attached to the longer tube. Reconfirm tube placement by listening to the lungs and epigastrium. An end-tidal CO₂ detector or esophageal detection device can be used to determine tube placement.

If the patient should regain consciousness or develop a gag reflex, remove the PtL as soon as possible. Turn the patient onto the left side in a slight Trendelenburg position. Deflate the balloons and quickly withdraw the airway. A nasogastric tube can be passed into the port that is not ventilated to allow for removal of stomach contents prior to airway removal. Suction equipment should be available because vomiting is common after removal.

**Esophageal-Tracheal Combitube Airway**

The Combitube is similar in basic design to the PtL with some minor differences. Instead of having one tube inside the other, a partition separates the two lumens of the Combitube (see Figure 3-17). There is a ventilation port for each lumen. The longer, blue tube (#1) is the proximal port; the shorter, clear tube (#2) is the distal port, which opens at the distal end of the tube.
The Combitube has two inflatable cuffs: a 100-mL cuff just proximal to the distal port and a 15-mL cuff just distal to the proximal port. Like the PtL, the Combitube is designed so it can be seated in either the esophagus or the trachea. Ventilation is first attempted through the longer, blue port (#1), which will be successful if the device has been placed in the esophagus and is most common. If ventilation through port #1 is not successful, the tube has been placed in the trachea, and ventilation through the shorter, clear port (#2) will be successful.

The Combitube has the same limitations as the PtL, in that appropriate use depends on the rescuer’s ability to identify correct placement. Contraindications for use are similar to those for the PtL.

The following equipment is needed:

- Oxygen source
- Bag-valve mask
- Combitube
- Water-soluble lubricant
- Syringe
- Suctioning equipment
- Stethoscope

Combitube insertion is performed in the following manner:

1. The patient should be well oxygenated with 100 percent oxygen. Use a full face mask in the case of a spontaneously breathing patient or a bag-valve mask in the case of a patient with decreased ventilatory effort. Administer high-concentration oxygen for approximately three to five minutes.
2. The patient’s head should be placed in a neutral position. Pull the jaw and tongue forward using your nondominant hand. Insert the Combitube through the mouth along the natural curve of the pharynx. Continue to pass the tube until the black rings on the device are at the level of the patient’s teeth.

3. Inflate both cuffs, first the proximal cuff with 100 mL of air, then the distal cuff with 15 mL of air.

4. Use a bag-valve mask to ventilate through the longer, blue port (#1). If no air is heard entering the epigastrium, and the chest rises and falls symmetrically, then ventilation is successful. Air is being forced out of openings along the tube, and because the esophagus and the pharynx are occluded by the inflated cuffs, the oxygen has nowhere to go but into the trachea (see Figure 3-18a). Continue to ventilate using this port.

5. If air is heard entering the stomach, and the chest is not rising with each breath, then assume that the tube has been inserted into the trachea. Use a bag-valve device to ventilate through the shorter, clear port (#2), which will force air into the trachea through the distal end of the tube (see Figure 3-18b).

6. Confirm tube placement by listening to both the lungs and the epigastrium. An end-tidal CO₂ detector or esophageal detection device can be used to further confirm tube placement.

If the patient should regain consciousness or develop a gag reflex, remove the Combitube as soon as possible. Turn the patient onto the left side in a slight Trendelenburg position. Deflate the balloons and quickly withdraw the

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**FIGURE 3-18**

(a) With the Combitube, first ventilate through the longer, blue tube (#1). Ventilation will be successful if the tube has been placed in the esophagus, as is most common. (b) If ventilation through tube #1 is not successful, ventilate through the shorter, clear tube (#2). Ventilation will be successful if the tube has been placed in the trachea.
airway. Suction equipment should be available because vomiting is common after removal.

**Laryngeal Mask Airway**

The laryngeal mask airway (LMA) is an alternative airway device that provides direct ventilation through the glottic opening. The airway is inserted without direct visualization of the glottis. The airway consists of three components: airway tube, mask, and inflation line (see Figure 3-19). When properly inserted, the LMA lies just above the glottic opening (that is, it is a supraglottic airway). Two bars that sit over the mask aperture prevent the epiglottis from occluding the lumen. Ventilation is performed via a standard 15-mm adapter that can be connected to a ventilation bag. The device is most useful for patients who cannot be intubated by conventional methods and in whom bag-valve-mask ventilation is not possible. Studies have shown that the device can be used with only a minimal amount of training, and success rates are comparable to those with tracheal intubation.

The device comes in sizes ranging from 1 to 6. Sizes 2, 2½, and 3 are for children. Size 4 is typically used for women and size 5 for men.

To insert a standard LMA, the following equipment is needed:

- Oxygen source
- Bag-valve mask
- Laryngeal mask airway
- Water-soluble lubricant
- Syringe
- Suctioning equipment
- Stethoscope

LMA insertion should be performed in the following manner (see Figures 3-20 and 3-21):

1. The patient should be well oxygenated with 100 percent oxygen. Use a full face mask in the case of a spontaneously breathing patient or a bag-valve
LMA Insertion

**FIGURE 3-20a**
Tightly deflate the cuff so it forms a smooth "spoon shape." Lubricate the posterior surface of the mask with water-soluble lubricant.

**FIGURE 3-20b**
Hold the LMA like a pen, with the index finger at the junction of the cuff and the tube.

**FIGURE 3-20c**
With the patient's head extended and the neck flexed, carefully flatten the LMA tip against the hard palate.

**FIGURE 3-20d**
Use your index finger to push cranially, maintaining a pressure on the tube with your finger. Advance the mask until you feel definite resistance at the base of the hypopharynx.

**FIGURE 3-20e**
Gently maintain cranial pressure with one hand while removing your index finger.

**FIGURE 3-20f**
Without holding the tube, inflate the cuff with just enough air to obtain a seal (to a pressure of approximately 60 cm H₂O).

### Maximum LMA Cuff Inflation Volumes

<table>
<thead>
<tr>
<th>LMA Size</th>
<th>Cuff Volume (air)</th>
<th>LMA Size</th>
<th>Cuff Volume (air)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>up to 4 mL</td>
<td>3</td>
<td>up to 20 mL</td>
</tr>
<tr>
<td>1½</td>
<td>up to 7 mL</td>
<td>4</td>
<td>up to 30 mL</td>
</tr>
<tr>
<td>2</td>
<td>up to 10 mL</td>
<td>5</td>
<td>up to 40 mL</td>
</tr>
<tr>
<td>2½</td>
<td>up to 14 mL</td>
<td>6</td>
<td>up to 50 mL</td>
</tr>
</tbody>
</table>

*Source: LMA Instruction Manual, Table 5, p. 28*
The laryngeal mask airway (LMA) in place.

2. Place the patient's head in the classic sniffing position. The cuff of the LMA should be completely deflated. Lubricate the posterior portion of the mask.

3. Pull the jaw and tongue forward, using your nondominant hand. Insert the LMA through the mouth along the natural curve of the pharynx, holding the device like a pencil at the junction of the tube and mask with the aperture facing forward. Continue to pass the tube until resistance is met.

4. Inflate the cuff to approximately 60 cm H₂O once the device is properly seated. This is approximately 30 mL of air for a size 4 mask; a size 5 mask will require approximately 40 mL (see inflation volumes chart with Figure 3-20). Failure to maintain a good seal above the glottic opening may indicate overinflation of the cuff.

5. Ventilate the patient using a ventilation bag with peak airway pressures not to exceed 20 cm H₂O. This method reduces the amount of gastric insufflation. An end-tidal CO₂ detection device can be used to confirm placement.

A modification of the standard LMA, an intubating LMA (the LMA-Fastrach), is available. A tracheal tube that can be passed through the LMA-Fastrach allows successful intubation of the patient. In this device, the standard LMA has been modified by the addition of a rigid steel shaft with a handle that lies over the ventilating tube. Additionally, there is a V-shaped ramp at the mask aperture that directs the tracheal tube toward the glottic opening. Finally, an epiglottic elevating bar replaces the two bars found on the standard LMA (see Figure 3-22). Insertion of the LMA-Fastrach device requires more skill on the part of the operator, as does the subsequent passing of the tracheal tube through the device.

Insertion of the LMA-Fastrach (see Figure 3-23) is similar to insertion of the standard LMA, except that the handle is held as the LMA-Fastrach is
LMA-Fastrach Insertion

FIGURE 3-23a
Hold the LMA-Fastrach handle parallel to the patient’s chest. Position the mask tip so it is flat against the hard palate just posterior to the upper incisors.

FIGURE 3-23b
Swing the mask into place in a circular movement, maintaining pressure against the palate and posterior pharynx.

FIGURE 3-23c
Inflate the mask, without holding the tube or handle, to a pressure of approximately 60 cm H₂O.

FIGURE 3-23d
Connect the LMA-Fastrach to the bag-valve mask or other ventilation device and ventilate the patient before intubating.

FIGURE 3-23e
Hold the LMA-Fastrach handle steady while gently inserting a lubricated tracheal tube into the metal shaft.

FIGURE 3-23f
If you feel no resistance, continue to advance the tracheal tube, while holding the LMA-Fastrach steady, until you have accomplished intubation. Following successful intubation, remove the LMA-Fastrach and ventilate the patient well.
advanced and seated against the glottis and the cuff inflated. A ventilation bag can then be connected to the adaptor at the end of the LMA-Fastrach handle to ventilate the patient. To insert a tracheal tube, lift the handle of the LMA-Fastrach upward as you advance the lubricated tube through the lumen of the LMA-Fastrach handle. Passage with minimal resistance indicates proper placement of the tracheal tube. Compatible tracheal tubes are available.

The LMA-Fastrach should be removed following successful intubation, and the patient should be well ventilated. The mask cuff is then inflated, and the 15-mm tracheal tube adapter is removed. While removing the LMA-Fastrach, using a curved motion on the handle, apply forward pressure to the proximal end of the ETT. Once the end of the ETT is level with the end of the LMA-Fastrach handle, insert the stabilizing rod, and completely withdraw the LMA-Fastrach.

Aspiration is the major complication with the use of an LMA. This is a particular concern with pregnant patients and those with gastric distention from bag-valve-mask ventilation. The device does not fully protect the glottic opening. Other complications include laryngospasm, airway trauma, and unsuccessful placement in less than 2 percent of patients. Specific complications with the LMA-Fastrach are posterior pharyngeal edema and posterior distracting force applied to the cervical spine with insertion of the device in patients with potential spinal cord injury.

If the patient should regain consciousness or develop a gag reflex, remove the LMA as soon as possible. Turn the patient onto the left side in a slight Trendelenburg position. Deflate the cuff and quickly withdraw the airway. Suction equipment should be available because vomiting is common after removal.

Other Supraglottic Airways

Several newer supraglottic devices designed to be placed in the upper airway using a blind technique. These include the perilaryngeal airway (Cobra PLA), laryngeal tube airway (King LT), oropharyngeal airway (PA(xpress)), and pharyngeal airways (SLIPA, COPA). Each of these devices is inserted via a blind technique. In the case of the King LT, the end of the device is directed to the proximal esophagus. Inflation of the properly sized device essentially seals the oropharynx and, in some cases, the proximal esophagus, so that air is forced into the airway. The King LT-D (disposable version) is recommended for prehospital use (see Figure 3-24). These devices are more reliable in not being directed into the trachea, are simpler to use, and can provide effective ventilation.
Surgical Techniques of Airway Control

Placement of a tracheal tube using an orotracheal or nasotracheal approach is the ideal method of securing an airway in a patient who requires it. Unfortunately, all emergency care providers will encounter the rare patient who, either for technical reasons or because of medical contraindications, cannot be intubated by any of these approaches. Such patients include those with anatomical distortion of the landmarks used for intubation (e.g., patients with prior head and neck surgery) and those with direct obstruction of upper airway structures (e.g., from infection or anaphylaxis).

Indications for a Surgical Airway

A surgical technique is appropriate in patients in whom an emergency airway is indicated and in whom tracheal intubation cannot be achieved and alternative ventilatory devices have failed. Patients at high risk for requiring a surgical airway:

- Have anatomical distortion of the landmarks used for intubation (e.g., those with prior head or neck surgery)
- Have direct obstruction of upper airway structures (e.g., from infection or anaphylaxis)

In those patients where an emergency airway is indicated and where tracheal intubation cannot be achieved and other ventilation measures have failed, a surgical approach to securing an airway should be immediately considered. Remember that an important consideration prior to attempting a surgical airway in the field is to consider whether a less invasive procedure (e.g., a bag-valve mask, PtL, Combitube, or LMA) can be used to effectively ventilate the patient. In general, surgical approaches are most successful when they are attempted in a controlled environment.

Note that the inclusion of surgical techniques in this text does not authorize their use by local providers. To use surgical techniques, the emergency care provider must have prior authorization by the local medical director.

With all surgical techniques, location of the cricothyroid membrane is critical to successful insertion. This membrane is located anteriorly between the lower thyroid cartilage (Adam’s apple) and the cricoid ring (see Figure 3-25).

**Clinical Insight**
Surgical approaches to airway management should be the method of last resort to secure an airway. When attempting a tracheal intubation, you should have at least one alternative method available to secure the airway if you are unsuccessful. If the patient has been adequately sedated or paralyzed, digital intubation or a lighted-stylet intubation would be an alternative method for performing a tracheal intubation. In other cases, an LMA, PtL, or Combitube should be attempted before a surgical airway is used.
You can best locate the cricothyroid membrane by identifying the broad, flat thyroid cartilage. Palpate the superior portion of this structure to appreciate the thyroid notch. The notch is the most common site for misplacement of a surgical airway. Then, slide your fingers along the thyroid cartilage toward the patient's feet until you feel the first ring-like structure, which is the cricoid ring. The diamond-shaped recess lying above the superior portion of the ring is the cricothyroid membrane. You will appreciate this as a soft depression in the cartilage.

As with all airway procedures, you should be aware of hazards that will make surgical approaches more difficult. Thus, any patient with distortion of the anterior neck anatomy due to prior surgery or radiation, infection, trauma, or simple obesity will make the surgical airway more challenging to perform.

### Surgical Airway Techniques

Surgical techniques of airway control include:

- Needle cricothyroidotomy/percutaneous transtracheal jet ventilation
- Retrograde intubation
- Surgical cricothyroidotomy

### Needle Cricothyroidotomy/Percutaneous Transtracheal Jet Ventilation

Needle cricothyroidotomy is the penetration of the cricothyroid membrane with a needle. Percutaneous transtracheal jet ventilation is a technique in which a needle cricothyroidotomy is ventilated with high-pressure oxygen driven into the tracheobronchial tree. It should be remembered that this procedure is only a temporary solution to airway management until a more definitive airway can be established. Although the patient can receive an adequate supply of oxygen with this technique, the success of percutaneous transtracheal ventilation is limited by the accumulation of carbon dioxide within the patient's body. Therefore, this method of ventilation may be used safely for only 30 to 45 minutes.

Oxygen is supplied to the patient with this technique via the 50-psi pressure port on the oxygen tank regulator. To allow this, the proximal end of commercially manufactured jet ventilation tubing is threaded so it will securely attach to the threaded high-pressure port on the tank regulator. Additionally, the commercially manufactured oxygen tubing is reinforced so it is capable of handling the high pressure that is needed for this technique to work. Because of the high pressure required, it is recommended that the jet ventilation technique not be used if the commercially manufactured high-pressure ventilation equipment is not available. Only in an extreme emergency should an alternative to the commercial equipment be used to perform jet ventilation. This alternative is created by removing the bag-valve-mask adapter from a 3.0-mm tracheal tube and using it as an interface between the IV catheter hub and the BVM. Ventilation can then be performed via the BVM, with oxygen flowing under slow but firm pressure. If exhalation difficulty is encountered, an additional 14- or 12-gauge needle can be placed beside the first one as an additional exhalation port.

It should be remembered that a patient younger than age 12 does not have complete circular support of the trachea. Consequently, a surgical
Cricothyroidotomy is not used in this age group; needle cricothyroidotomy is the emergency airway of choice in children younger than age 12.

The following equipment is needed for percutaneous transtracheal jet ventilation:

- Antiseptic solution
- 14- or 12-gauge over-needle catheter
- 10-mL syringe
- High-concentration oxygen source
- Oxygen tubing with connector and opening or valve

Percutaneous transtracheal jet ventilation should be performed in the following manner (see Figure 3-26):

1. Locate the cricothyroid membrane. Cleanse the skin on the neck overlying the cricothyroid membrane as much as practical.

2. Stabilize the skin using the thumb and the index finger of your nondominant hand. Advance the needle, with the syringe attached, into the lower half of the cricothyroid membrane at a 45-degree angle toward the feet.

3. Advance the catheter while applying negative pressure on the syringe. The drawing of air into the syringe signifies needle entry into the trachea.

4. Slide the catheter off the needle and advance it until the hub rests against the neck. Affix the catheter to the skin.

5. Attach the oxygen tubing to the hub. The other end of the tubing should be attached to a high-concentration oxygen source.

6. Ventilate the patient by depressing the trigger on the valve of the jet ventilation tubing to direct oxygen into the trachea for one second. Release the trigger for a total of two seconds to allow exhalation (see Figure 3-27). The chest wall should be seen to rise and fall symmetrically, and no swelling should be noted in the neck.

Complications of this technique include improper placement of the puncture, particularly into the thyroid notch. Puncturing the posterior wall...
of the trachea and extension into the esophagus have been reported. Although there are few major blood vessels in the area, severe hemorrhage and hematoma formation have been reported, occasionally leading to shock, infection, and airway compromise. The thyroid gland, which is just below the cricothyroid membrane, may be damaged during the procedure. Finally, air may be found in the soft tissues of the neck or in the mediastinum if the catheter tip is improperly placed in the subcutaneous tissues.

**Retrograde Intubation**

Retrograde intubation is a procedure in which a guidewire is passed, using a needle cricothyroidotomy, to direct a tracheal tube into proper position. This technique differs from a standard needle cricothyroidotomy in that the needle is directed toward the head, allowing the guidewire to pass from below the glottis into the mouth. The tracheal tube is then placed over the guidewire, guided into the trachea, and subsequently positioned. This technique is particularly useful in patients whose medical conditions result in a loss or distortion of the normal airway landmarks, such as patients with angioedema, severe burns, or surgical resection of the larynx.
To perform retrograde intubation, insert the needle, with the syringe attached, into the lower half of the cricothyroid membrane at a 45-degree angle toward the head. Pass the wire through the needle into the oropharynx. Grasp the distal end of the wire and pull it out through the mouth. Engage the wire with the end of the tracheal tube. Pull the tracheal tube into position in the trachea. Confirm proper tube placement.
The following equipment is needed for retrograde intubation:

- Oxygen source
- Bag-valve mask
- Antiseptic solution
- 14- or 12-gauge over-needle catheter
- 10-mL syringe
- Guidewire
- Appropriately sized tracheal tube

Retrograde intubation should be performed in the following manner (see Figure 3-28):

1. Locate the cricothyroid membrane. Cleanse the skin on the neck overlying the cricothyroid membrane as much as practical.

2. Stabilize the skin using the thumb and the index finger of your nondominant hand. Advance the needle, with the syringe attached, into the lower half of the cricothyroid membrane at a 45-degree angle toward the head.

3. Advance the catheter while applying negative pressure on the syringe. The drawing of air into the syringe signifies needle entry into the trachea.

4. Slide the catheter off the needle and advance it until the hub rests against the neck.

5. Pass the wire through the catheter and continue to advance the wire, watching for it to appear in the patient’s oropharynx. A J-wire should be used to prevent puncturing of soft tissues. It should measure at least 24 inches for ease of handling. Grasp the distal end of the wire (with a hemostat, if available), and pull it out through the mouth. Be sure to also hold the proximal end so the wire is not pulled completely through the catheter.

6. Then, place the distal end of the guidewire through the lumen of the tracheal tube or through the Murphy eye (small opening at the tip of the tracheal tube). While maintaining traction at both ends of the guidewire, slide the tube into the oropharynx along the guidewire until you meet resistance. At this point, the tip of the tracheal tube is resting below the glottis at the level of the cricothyroid membrane.

7. Withdraw the catheter and guidewire with one hand while applying slight downward pressure to the end of the tracheal tube. As you pull the guidewire beyond the end of the tracheal tube, there will be a decrease in resistance at the end of the tube, which will allow you to advance it into the trachea.

8. Confirm proper tube placement in a manner similar to that used for other methods of intubation.

Although there are no absolute contraindications to this technique, it requires a great deal of manual dexterity. The procedure may also be time-consuming in inexperienced hands. It should be used only by those care providers who are trained in the technique and with the approval of local medical direction.

The complications for this technique are similar to those listed for needle cricothyroidotomy. In addition, damage to the vocal cords and oropharynx is possible from the guidewire and tracheal tube.
Surgical Cricothyroidotomy

The technique of surgical cricothyroidotomy involves a direct incision of the cricothyroid membrane and subsequent passage of an appropriate airway. Although a tracheostomy tube can be used and several commercial cricothyroidotomy kits are available (e.g., Rusch QuickTrach®), placement of a standard tracheal tube through the incision is an acceptable method of securing an airway in the prehospital setting. Normally, the tube should be about one full size below the typical selection used for an orotracheal approach. Thus, in an adult male, a size 7.0 is appropriate for placement through the cricothyroid incision, whereas a 6.0 or 6.5 should be used in an adult female.

Remember that a surgical incision in the neck is a very invasive solution to airway management and should be considered only after other measures have failed. The care provider should consider less invasive measures such as bag-valve-mask ventilation until a more controlled environment can be reached. However, if these measures do not succeed in providing appropriate oxygenation and ventilation, then a surgical cricothyroidotomy should be attempted, provided that this technique is within the provider’s scope of practice as defined by local medical direction. A surgical airway should not be attempted in children younger than age 12 because the cricoid ring is the only circular support in pediatric patients.

The following equipment is needed for a surgical cricothyroidotomy:

- Oxygen source
- Bag-valve mask
- Antiseptic solution
- Scalpel blade (#10 or #11)
- Hemostats (optional)
- Appropriately sized tracheal tube

A surgical cricothyroidotomy should be performed in the following manner (see Figure 3-29):

1. Locate the cricothyroid membrane. Cleanse the skin on the neck overlying the cricothyroid membrane as much as practical.
2. Stabilize the skin using the thumb and the index finger of your nondominant hand. Make a 2-cm longitudinal incision through the skin over the cricothyroid membrane.
3. Use the scalpel blade to puncture directly through the cricothyroid membrane.
4. Use your little finger to maintain patency of the puncture. Insert the handle of the scalpel into the incision, and rotate the handle 90 degrees to open the incision. Alternatively, you can insert the tips of the hemostat into the incision and open them to provide access to the trachea.
5. Insert the tracheal tube into the trachea with the tip directed toward the feet. The tube should be inserted only 1 to 2 centimeters beyond the end of the balloon cuff. Alternatively, you may shorten the tube by cutting off the top few centimeters and reinserting the 15-mm adapter. This process may make the tube easier to manage.
6. Inflate the cuff and stabilize the tube. Ventilate the patient using a standard ventilation bag.
7. Verify tube placement, using the methods described earlier.
Several commercially available kits use a needle cricothyroidotomy through which a guidewire and dilator are passed to expand the opening in the cricothyroid membrane. A tracheostomy tube is ultimately placed through this opening into the trachea.

The complications of surgical cricothyroidotomy are similar to those listed for needle cricothyroidotomy. Because a larger incision is made, hemorrhage and local infection can be significant problems with a surgical approach.

**Rapid-Sequence Intubation**

Emergency care providers must often secure a patent airway under the most difficult conditions. In the ideal situation, the intubation process is undertaken in controlled conditions similar to those provided for patients undergoing
elective surgery. Unfortunately, emergency patients have generally not been well prepared prior to intubation; specifically, it must be assumed that emergency patients have a full stomach prior to the procedure.

However, given these limitations, the intubation process can be somewhat controlled with the aid of drugs that produce a profound state of sedation and amnesia (induction) and the addition of drugs that produce muscular paralysis (paralytic agents). This procedure is most commonly used when the patient has a clinical condition that requires emergent intubation (e.g., impending respiratory failure) but is too awake or combative to tolerate the procedure. This organized sequence of induction and paralysis is commonly referred to as a rapid-sequence intubation or sometimes as a rapid-sequence induction. This procedure is not without consequences. Studies have shown that rapid-sequence induction can result in worsening outcomes when used in the out-of-hospital setting. Successful use requires frequent practice, careful patient monitoring, strong medical oversight, and constant review of the performed procedures.

It must be immediately noted that, in terms of prehospital airway control, this process is far from rapid. In fact, proper performance of the procedure requires precise timing and a deliberate attention to details. Often, this procedure takes significantly more time than standard intubation procedures.

Prior to undertaking a rapid-sequence intubation, you should anticipate any difficulties. If possible, ask the patient about previous intubation procedures and complications with anesthetic or sedative agents. Perform an airway assessment using the LEMON mnemonic mentioned previously in this chapter under “Airway Assessment.” Physical findings that also suggest a difficult intubation are a short, thick neck; prominent central incisors; a small mandible; limited motion of the jaw or neck; or previous surgical or traumatic alteration of the anatomy.

Additionally, an assessment of the ease of bag-valve-mask ventilation is imperative prior to attempting a rapid-sequence intubation (see the MOANS mnemonic discussed under “Ventilation Equipment and Techniques” earlier in the chapter). Remember that if a paralytic agent is administered and the attempt fails, assisted ventilation must be carried out until the effects of the paralytic agent are gone and spontaneous ventilatory effort returns.

**General Procedure**

An overall outline of rapid-sequence intubation is presented in the following paragraphs. The specific medications used during the procedure will vary according to local protocol. It must again be emphasized that preparation prior to the procedure, having a rescue airway available, and adequate personnel are the keys to a successful rapid-sequence intubation.

1. The procedure begins with early preparation of all materials. An appropriately sized tracheal tube with an intact balloon cuff should be available. A working laryngoscope and suction equipment should also be ready. Finally, any medications used in the procedure are drawn up and accessible for immediate administration.

2. Hyperoxygenate the patient for approximately three to five minutes. Filling the lungs with 100 percent oxygen will allow the patient to maintain adequate oxygen saturation during the procedure without ventilatory assistance. Place the spontaneously breathing patient on high-concentration oxygen by nonrebreather mask. Do not attempt to assist the patient’s breathing if ventilation is adequate because such an
attempt will increase the risk of gastric distention and subsequent aspiration. If, however, the patient does not have an adequate ventilatory effort, assist ventilations using a bag-valve-mask device with 100 percent oxygen. Four to five full-volume breaths are required to produce a fully oxygenated patient. Cricoid pressure may be applied if bag-valve-mask ventilation is required.

3. Closely monitor the patient throughout the procedure. At a minimum, perform cardiac monitoring and continuous pulse oximetry. Closely observe the patient's level of consciousness and spontaneous movements throughout the procedure.

4. There are several medications you may wish to consider before initiating the procedure in order to protect against side effects that are associated with the rapid-sequence intubation technique. These may include the following:

   a. Atropine may be administered to prevent bradycardia that develops with the use of certain paralytic medications and is associated with the intubation procedure. This drug is particularly useful in pediatric patients; give a dose of 0.02 mg/kg (minimum dose of 0.1 mg). The adult dose is 0.5 to 1.0 mg IV, which is administered three minutes before the procedure.

   b. Lidocaine may be administered to prevent the rise in intracranial pressure that is associated with the use of succinylcholine and with the intubation procedure itself. A dose of 1.0 to 1.5 mg/kg IV is given several minutes before the procedure.

   c. A “defasciculating” dose of a nondepolarizing paralytic agent may be administered if succinylcholine is used. (Fasciculations are fine muscular movements that occur following administration of succinylcholine.) The dose is typically one-tenth of the normal intravenous dose of the chosen agent. As an example, a defasciculating dose of vecuronium is 1 mg; a normal paralyzing dose is approximately 10 mg IV push. Recent literature has de-emphasized the importance of the “defasciculating” dose of medication.

5. Then, administer an induction dose of a sedative/hypnotic agent in order to produce a state of sedation and facilitate the procedure. Ideally, this medication will also result in a state of amnesia for the procedure. Several agents are available and should be chosen based on the training of the provider and the clinical condition of the patient.

6. In conjunction with the induction agent, administer a paralyzing agent until a state of complete muscular relaxation is achieved. Bag-valve mask ventilation should be administered only if oxygen saturation drops to less than 90 percent.

7. Carry out orotracheal intubation as quickly and carefully as possible. Confirm tube placement, using the standard methods described previously, and inflate the tracheal tube cuff. If used, cricoids pressure should be released at this time. Finally, secure the tube in place.

8. Additional sedation and paralysis of the patient should be based on local protocol.

**Sedative Agents**

Several pharmacologic agents can be chosen to produce a state of sedation prior to paralyzing a patient for intubation. The agents vary in their ability
to produce an appropriate level of sedation. Other properties of these medications include analgesia (pain relief) and amnesia (inability to recall the procedure). These agents should be used in conjunction with paralytic medications. Keep in mind that many of these agents have a shorter duration of action than the paralytic agents. Therefore, multiple doses must be administered while the patient remains paralyzed. Some of the more common agents used to produce sedation are listed as follows.

**SPECIFIC SEDATIVE AGENTS**

**Midazolam**  Midazolam is a short-acting benzodiazepine medication that produces both sedation and amnesia. In addition, the drug reduces anxiety associated with the procedure (anxiolysis). The drug has no analgesic properties. The usual induction dose of midazolam is 0.1 mg/kg IV, with a typical adult dose of 5 to 10 mg. Older patients are particularly sensitive to the drug. The drug has an onset of action of 60 to 90 seconds and a duration of action of approximately 30 minutes. In addition to significant respiratory depression, midazolam can cause significant hypotension. Diazepam (Valium) can be used in doses of 0.2 mg/kg, but it has both a longer onset and a longer duration of action. Other disadvantages of diazepam include pain on intravenous injection and prolongation of the effects of neuromuscular blocking agents. Finally, lorazepam (Ativan) 0.1 mg/kg can also be given. Both diazepam and lorazepam are rarely used for induction; rather, they are used as sedative agents.

**Thiopental**  Thiopental is an ultra-short-acting barbiturate medication. This drug produces sedation but does not have analgesic or amnestic properties. The typical dose of thiopental is 3 to 5 mg/kg. The onset of action is within 30 seconds of administration, with a duration of action of 5 to 10 minutes as the drug is redistributed from the brain to other tissues. Like the benzodiazepines, thiopental can produce both respiratory depression and hypotension. The drug should be used with extreme caution in patients with decreased circulating volume and hypertension because it has a profound effect on blood pressure in these patients. In addition, the drug may cause laryngospasm. Finally, an exaggerated vagal response, along with increased mucous secretions, has been noted with this agent. As a result, the drug should be used cautiously in patients with airway obstruction, severe cardiac disease, and asthma.

**Methohexital**  Methohexital is a rapid-acting barbiturate. It has similar actions to thiopental, and both drugs have the potential advantage of reducing intracranial pressure. The drug has no analgesic properties. The dose of methohexital is 0.75 to 1.5 mg/kg IV. Pain may be noted at the injection site. The onset of action is 30 to 45 seconds (approximately one arm-to-brain circulation) with a duration of action of 2 to 4 minutes, although some effects of the drug last for hours after administration. The complications are similar to those for thiopental.

**Propofol**  Propofol is a rapid-acting phenol that can be used to produce rapid anesthesia. Like the onset of methohexital, the onset of propofol is rapid (15 to 30 seconds). Recovery is rapid following intravenous injection. Disadvantages of the drug include pain on injection, profound cardiac depression (particularly in the elderly or in hypertensive patients when the drug is rapidly injected). The drug is given to adults at a total dose of 2.0 to
2.5 mg/kg. The dose should be reduced by one-half in the elderly. A continuous infusion can be used for long-term sedation.

**Fentanyl** Fentanyl is an opioid narcotic that is 100 times more potent than morphine. The drug can produce a state of sedation and also has potent analgesic effects. A typical sedating dose is 3 to 5 mcg/kg. This dose produces an effect within approximately 90 seconds that has a duration of action of 30 to 40 minutes. As with other sedating agents, hypotension can occur, although its cardiovascular effects are minimal. With fentanyl, hypotension is typically caused by parasympathetically induced bradycardia. At higher doses, muscular rigidity (particularly of chest muscles) can be produced, especially with rapid administration. Fentanyl is not as useful as other agents in this setting because of the longer time to onset of action and the variable effect of the drug at the dose cited.

**Ketamine** Ketamine is a drug chemically related to phencyclidine (PCP) that produces a state called dissociative anesthesia. This drug has sedative, analgesic, and amnestic properties. The drug can cause an increase in heart rate and in myocardial oxygen demand, so it should be used cautiously in patients with severe coronary artery disease. Ketamine can also produce bizarre hallucinations, which can be prevented by an accompanying administration of a benzodiazepine. However, the hemodynamic and respiratory effects of the drug are few. In particular, it can be administered safely to patients who are mildly hypotensive. Ketamine also causes bronchodilation, so it is useful in intubating patients with reactive airway disease. The dose is 2 mg/kg IV, which produces an effect within 60 seconds. The duration of action is 10 to 15 minutes. Ketamine does not depress protective airway reflexes, and as a result, laryngospasm can occur with intubation attempts when this drug is used.

**Etomidate** Etomidate is a nonbarbiturate sedative/hypnotic agent. The drug is useful because of its rapid onset, short duration of action, and limited side effects. The drug is administered at a dose of 0.3 to 0.6 mg/kg IV. Pain may be noted at the injection site. The drug has a peak duration of action at 2 to 4 minutes. Jerking of the muscles (myoclonus) may be noted after the drug has been given. The patient may also experience nausea and vomiting after use of the drug. Repeated doses of the drug may be given safely without evidence of cumulative effects. The drug should be used with caution in those patients who are thought to be septic, as it depresses the body’s production of steroids, an important part of the stress response.

**Neuromuscular Blockade**

The major agent used to achieve a successful intubation with a rapid-sequence technique is a paralyzing medication. To understand the various medications and their consequences, you must understand the basics of transmission at the **motor endplate** (see Figure 3-30). The motor endplate is the point at which the nerve and muscle interact so the nerve impulse is converted into a muscular contraction.

For a muscular contraction to occur, an impulse must be conducted down the nerve to the motor endplate. When the impulse reaches the endplate, stored **acetylcholine** (a chemical messenger) is released and diffuses...
across to receptors on the muscle side of the motor endplate. The binding of acetylcholine to the appropriate receptors creates an electrical change along the muscle cell that, in turn, leads to chemical changes within the muscle cell and results in muscular contraction. It is important to note that acetylcholine acts as a chemical messenger for both the sympathetic and the parasympathetic nervous systems.

Paralytic agents produce their effects in one of two ways: as depolarizing agents or as nondepolarizing agents. **Depolarizing agents** are chemically similar to acetylcholine and act by binding to the receptor sites, causing a spontaneous contraction of all muscles. The receptor sites then remain occupied by the depolarizing agent and are thus unable to produce any further contractions. Succinylcholine, which is structurally two acetylcholine molecules bound together, is the only clinically available depolarizing agent.

**Nondepolarizing agents** also combine with the acetylcholine receptors on the muscle cells. However, no chemical changes occur at these sites, and therefore, no depolarization occurs. Instead, there is an inability to generate any muscular contractions because the receptor sites are now occupied by the nondepolarizing drug. There are many available nondepolarizing agents, which vary in their onset, duration of action, and associated side effects.

**DEPOLARIZING AGENTS**

**Succinylcholine** As noted earlier, succinylcholine acts by causing widespread contractions of the muscles and by remaining chemically bound to the motor endplate receptors. Clinically, these contractions are manifested
by fasciculations, which are weak, disorganized contractions of various muscles. Bound succinylcholine makes the muscles unresponsive to acetylcholine released at the nerve ending until the drug is metabolized. The enzyme responsible for the breakdown of succinylcholine is called pseudocholinesterase.

The standard adult dose of succinylcholine is 1.5 to 2 mg/kg IV push. It has an onset of action of 30 to 60 seconds. The duration of its effect is from 3 to 10 minutes. The rapid onset and short duration of action make succinylcholine nearly ideal for use in a rapid-sequence intubation. If the patient cannot be successfully intubated, ventilation need be supported for only about 10 minutes before spontaneous respirations recover.

Succinylcholine has some important side effects that must be considered in patient selection. The drug can cause an elevation in the serum potassium level. This is a particular concern in patients with existing elevation in their potassium levels (e.g., patients with chronic renal failure), as well as in patients with neuromuscular disorders (Guillain-Barré syndrome, stroke, myasthenia gravis) or extensive tissue injury (e.g., from major trauma, burns, muscular diseases, sepsis, and tetanus). In the latter group, potassium elevation is noted only after days of injury; therefore, succinylcholine can be used in early airway management of these patients.

Succinylcholine causes a rise in intracranial, intragastric, and intraocular pressure. In head-injured patients, pretreatment with lidocaine may prevent the unwanted rise in intracranial pressure.

Finally, because acetylcholine acts at many sites in the sympathetic and parasympathetic nervous systems, a variety of effects may be seen, including bradycardia, tachycardia, hypertension, and cardiac dysrhythmias. Bradycardia can be prevented by pretreatment of the patient with atropine.

**NONDEPOLARIZING AGENTS**

**Vecuronium**  Vecuronium is an intermediate-acting nondepolarizing agent. At a dose of 0.1 mg/kg, vecuronium has an onset of action of approximately 1 minute with a peak effect in 3 to 5 minutes. Vecuronium has a duration of action of 30 to 45 minutes. The duration of action may be prolonged in hypothermic patients. In general, vecuronium has few side effects.

**Pancuronium**  Pancuronium is a long-acting nondepolarizing agent. An administered dose of 0.04 to 0.1 mg/kg produces paralysis in 2 to 3 minutes, with a duration of effect of 60 to 75 minutes. Increases in heart rate and hypertension have been seen with the use of pancuronium. Histamine release, which is a significant problem with other nondepolarizing agents and is manifested by hypotension and flushed skin, is not prominent with the use of pancuronium. However, because of its long duration of action and relatively long onset of action, it is more commonly used in maintaining paralysis than as a primary paralyzing agent in a rapid-sequence intubation.

**Rocuronium**  Rocuronium is a short-acting nondepolarizing agent. At a dose of 0.6 to 1.2 mg/kg, rocuronium has an onset of action of approximately 1 minute with a peak effect in 2 to 3 minutes. Rocuronium has a duration of action of 20 to 30 minutes. Like vecuronium, rocuronium has few side effects. The drug should be used with caution in patients with liver disease and obesity.
It should be noted that the preceding is not a definitive list of all drugs used for rapid-sequence intubation; new drugs are being introduced constantly. You should refer to emergency medicine or anesthesia texts for a more complete discussion of these medications.

Guidelines for Management of the Difficult or Failed Airway

General Patient Assessment

Orotracheal intubation is the generally accepted standard for airway control. However, not every attempt at orotracheal intubation is successful. Two concepts must be introduced: the difficult airway and the failed airway. After your initial airway assessment, you will characterize as a difficult airway any patient in whom you have identified obvious barriers to successful intubation (LEMON). On the other hand, failure to successfully intubate the trachea within three attempts or to maintain an oxygen saturation above 90 percent with bag-valve-mask ventilation or an alternative airway suggests a failed airway.

Airway Management Decisions

The decision to intubate a patient in respiratory failure or cardiopulmonary arrest is not difficult; basically, standard orotracheal intubation techniques without the assistance of medications are employed. This procedure is referred to as a “crash intubation.” Similarly, awake patients who require a definitive airway and are felt to have excellent anatomy should be considered for a rapid-sequence intubation (RSI), if allowed by protocol. If not, a medication-assisted technique (using sedative doses of the induction agents previously described) may be used. In each case, an alternative airway (PtL or Combitube; LMA or supraglottic airway) should always be available as a backup.

Once you have identified the patient as a potential difficult airway, there are several considerations. First, consider the ability to perform adequate bag-valve-mask ventilation. If there is a high likelihood of success and the practitioner has great skill and experience in endotracheal intubation, an RSI may still be considered. A gum elastic bougie should be available; techniques such as backward, upward, and rightward pressure (BURP) or external laryngeal manipulation (ELM) should be employed; and an alternative airway should be immediately available. Additionally, once the patient is paralyzed, you can consider digital intubation.

The disadvantage of an RSI is that it takes away a protected airway, a result that, in general, is not ideal when a difficult intubation is anticipated. An alternative is either a blind technique such as nasotracheal intubation or lighted-stylet intubation; alternatively, you may attempt a medication-assisted intubation, using smaller doses of the induction agents, only to the point where the patient can tolerate airway manipulation with a laryngoscope. Finally, you must strongly consider the insertion of an alternative airway.

As already noted, failure to intubate within three attempts or failure to maintain an oxygen saturation above 90 percent with bag-valve mask ventilation suggests a failed airway. When this occurs, there is greater urgency
in establishing an airway. Remember, first, that when three intubation attempts are made, something must be done differently with each attempt. Simple changes on subsequent attempts may include repositioning the patient, switching to a different laryngoscope blade type (curved or straight), changing intubators, or using a gum elastic bougie. Other options, such as using a direct visualization device (e.g., Airtraq; see Figure 3-31a) or an indirect visualization device (e.g., GlideScope Ranger; see Figure 3-31b), may also be considered.

Once a failed airway is recognized, the first option is to insert an alternative airway to determine if the oxygen saturation can be maintained at more than 90 percent. If this approach is immediately successful, continue to ventilate through the PtL or Combitube, LMA, or pharyngeal airway device. However, once it is determined that the patient can be neither intubated nor ventilated, then a surgical airway technique must be employed (surgical cricothyroidotomy, needle cricothyroidotomy, or retrograde intubation).

Most important, each emergency care provider should be familiar with the techniques available for airway management in his EMS system and with the preferred methods employed in cases of both a difficult airway and a failed airway.

**Patient Monitoring**

In managing a patient’s airway and ventilation, we must remember that we are manipulating some of the body’s most basic functions. These manipulations often produce a response in the patient, usually involving the sympathetic and parasympathetic nervous systems. As a result, it is important that the patient be closely monitored when any airway maneuver or ventilation technique is used.

The following parameters should be continuously monitored in any patient who is having interventions involving the airway or ventilation: patient condition, cardiac monitoring, blood oxygenation, blood pressure evaluation. Additionally, if the patient is intubated, continuous waveform capnography is recommended (see Figure 3-32).
OBSERVATION OF THE PATIENT

Clinical observation of the patient is extremely important. Often, emergency care personnel are guilty of using technology such as cardiac monitoring, pulse oximetry, and capnometry or capnography as a substitute for sound clinical skills.

For any patient who requires an airway intervention, frequently assess the level of consciousness, as well as the skin color and mucous membranes. The skin and mucous membranes should be carefully observed for signs of adequate oxygenation. The presence of cyanosis, particularly in the mucous membranes around the mouth, suggests inadequate oxygenation. Patients should become more alert and calm after an airway intervention, as oxygen is delivered to the brain. If, however, the patient becomes less responsive or more agitated following an intervention, problems with the delivery of oxygen to the patient must be considered.

For patients who are receiving assisted ventilations, continually observe the chest wall for an adequate rise and fall with each ventilation. If a mask is used, assess the effectiveness of the seal and the depth of ventilations. In addition, consider the ease of ventilation, which reflects both peak airway pressure and lung compliance. The patient should demonstrate the signs of appropriate oxygenation suggested previously.

CARDIAC MONITORING

An additional component of patient assessment is continuous cardiac monitoring (see Figure 3-33). Patients who require supplemental oxygen are at
risk of developing hypoxia. Among the early signs of hypoxia are cardiac rhythm disturbances, including tachycardia and bradycardia, as well as premature atrial and ventricular beats. Ventricular tachycardia, ventricular fibrillation, pulseless electrical activity, and asystole are rhythms that develop with profound hypoxia.

Another important argument for continuous cardiac monitoring is that any manipulation of the patient's airway produces strong autonomic (parasympathetic and sympathetic) responses from the body. Tachycardic rhythms and bradycardia can develop with instrumentation of the upper airway. In addition, the patient's blood pressure can show significant changes during the procedure (see Figure 3-34). If a significant bradycardic response develops, consider an administration of atropine 0.5 to 1.0 mg IV prior to further attempts at airway manipulation.

**PULSE OXIMETRY**

Pulse oximetry (see Figure 3-35) is useful in providing a continuous measurement of blood oxygenation. Specifically, pulse oximetry measures the amount of hemoglobin saturation. (Remember that hemoglobin is the blood protein responsible for oxygen transport, but it also may become saturated with other gases, such as carbon monoxide.) The emergency care provider should be aware of those situations where pulse oximetry readings may be inaccurate (e.g., poor perfusion, cold extremities) or misleading (e.g., carbon monoxide poisoning).

**Clinical Insight**

Remember that hemoglobin containing bound carbon monoxide has absorptive properties similar to those of oxyhemoglobin. Therefore, a patient with significant carbon monoxide poisoning may appear to have normal oxygen saturations as measured by pulse oximetry. As a result, pulse oximetry is not useful in determining oxygen saturation or the response to oxygen therapy in carbon monoxide poisonings.
Capnography is the determination of carbon dioxide (CO₂) levels during the phases of ventilation. Some units simply display a numerical value (capnometry) of the CO₂ reading at the end of each breath (end-tidal CO₂ designated as PETCO₂) (see Figure 3-36).

The level of CO₂ is determined by an adapter, placed in the ventilation circuit, that emits infrared light. CO₂ levels are determined by absorption of a specific wavelength of light. Alternatively, some disposable CO₂ detectors take advantage of a color change that is caused by expired CO₂. As a rule, the level of CO₂ measured by capnometry is approximately 2 to 5 torr lower than the level in arterial blood, but wide patient-to-patient variability exists.

Other units display a continual tracing of CO₂ levels (capnography) (see Figure 3-37). Continuous end-tidal CO₂ measurements are useful as a measure of the adequacy of ventilation, particularly in patients who have undergone tracheal intubation. In addition, the presence of end-tidal CO₂ reflects appropriate placement of the tracheal tube in the trachea. As a result, continuous waveform capnography is highly recommended for intubated patients. Many systems require a measurement of end-tidal CO₂ after tracheal tube placement as a method of confirming appropriate tube placement.
Summary

Ensuring adequate oxygenation and appropriate ventilation is the first priority you must address in any patient with medical illness.

Patients with depressed mental status, structural airway problems, or inadequate ventilation require support to maintain an open airway and appropriate ventilation. The methods available to ensure an adequate airway and ventilation include manual airway maneuvers, mechanical airway adjuncts, and tracheal intubation.

Although orotracheal intubation remains the ideal method of providing definitive airway and ventilatory support, a variety of alternatives exist, especially in managing patients with predicted airway difficulty. These alternatives are nasotracheal intubation, digital intubation, lighted-stylet intubation, and several surgical airway approaches. For those situations in which definitive intubation is not possible, options such as the PtL, Combitube, LMA, or pharyngeal airway can assist in airway support.

Patients who require such support should be monitored carefully with repeated clinical observation, cardiac monitoring, and continuous pulse oximetry. Capnometry or capnography is useful for patients who require tracheal intubation.

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SCENARIO FOLLOW-UP

A man reports that he found his wife unconscious after complaining of a severe headache. As you approach this unresponsive patient, you continue to assess the area for any immediate hazards. You put on your gloves, mask, and eye shield because it is clear that the patient will require immediate airway intervention and ventilatory support. Noting that there does not appear to be any evidence of direct trauma, you perform an immediate head-tilt, chin-lift maneuver as you instruct your partner to bring the airway supplies and suction to the patient’s side.

You quickly clear the oropharynx of larger food particles, sweeping with your fingers, then use a tonsil tip catheter to clear the upper airway. The patient responds minimally to these maneuvers, and her skin color and respiratory rate fail to improve. After your partner returns with a bag-valve-mask device and an oxygen source, you begin two-person bag-valve-mask ventilation. A third rescuer applies a cardiac monitor and pulse oximeter. The patient’s heart rate increases from 50 to 80 beats per minute with ventilation, and the pulse oximetry improves from 80 to 96 percent saturation. However, the patient’s mental status and respiratory rate do not improve. You deduce that the patient will require prolonged ventilatory and airway support and decide that tracheal intubation is immediately indicated.

Although you believe that a standard orotracheal intubation would be best, the amount of vomitus and secretions in the oropharynx are likely to make this difficult. In addition, the patient is elderly, so the mobility of her neck is probably limited, making good bag-valve-mask ventilation difficult. Additionally, the small, recessed jaw makes adequate alignment of the appropriate oral, pharyngeal, and tracheal axes unlikely. The patient also has some reflexive movement of the mouth; therefore, a digital approach is not likely to be safe. Recognizing a potential difficult airway, you select a nasotracheal approach, realizing that it may be difficult to perform with the patient’s shallow respirations. Fortunately, you are successful in this approach, and after suctioning the tracheal tube using a flexible catheter, you proceed with further stabilization of the patient.

You transport the patient to the hospital. Later, you receive a note from the patient’s husband thanking you for helping his wife and letting you know that she has recovered from an intracerebral hemorrhage and is now in a rehabilitation facility making steady progress.
Further Reading