Over the last few decades, several important changes have occurred in emergency airway management. Bag-mask ventilation has been supplemented by intermediate, or backup, ventilation devices like the laryngeal mask airway (LMA), the Combitube, and the laryngeal tube. These have become important devices for the initial resuscitation of apneic patients and for rescue ventilation when intubation fails. Noninvasive positive-pressure ventilation (NPPV) is now used in place of tracheal intubation in some critically ill patients. Despite these advances, basic techniques such as opening the airway, oxygenation, and bag-mask ventilation remain the cornerstones of good emergency airway management. Airway maintenance without endotracheal intubation is one of the most important emergency airway management techniques to keep patients alive until a definitive airway can be established.

This chapter describes basic airway skills including opening the airway, O₂ therapy, NPPV, bag-mask ventilation, and intermediate ventilation devices. Because of the complexity of these skills and decisions, providers should develop a simple, organized approach to emergency airway management, being cognizant that when a specific intervention has failed, it is time to move rapidly to a different approach. Developing a simple preconceived algorithm that employs proven techniques and is applicable to a broad range of clinical scenarios will help providers manage difficult, anxiety-provoking emergency airways.

THE CHALLENGE OF EMERGENCY AIRWAY MANAGEMENT

Although other specialists are sometimes available, most emergency airways are managed by emergency clinicians. Airway management in the emergency department (ED) is much different from airway management in the controlled setting of the operating room. Likewise, conventional airway management tools may be ineffective in the uncontrolled prehospital environment. Major challenges include hypoxia, shock, and the presence of vomit, blood, or excessive secretions in the airway. Many patients are uncooperative and combative, making it impossible to examine their airway prior to choosing an intubation technique. Medical history, allergies, and even the current diagnosis are often unknown before emergency airway management begins. Time constraints, lack of patient cooperation, and the risk of vomiting limit the use of optimal techniques, such as awake intubation. In trauma patients, the risk of cervical spine injury limits optimal head and neck positioning for bag-mask ventilation and laryngoscopy. All of these factors increase the risk of complications due to emergency airway management. As many as 1% of all emergency airways require a surgical approach.

BASIC AIRWAY MANAGEMENT TECHNIQUES

Opening the Airway

The first concern in the management of the critically ill patient is adequacy of the airway. Upper airway obstruction most commonly occurs when patients are unconscious or sedated. It can also occur with injury to the mandible or muscles that support the hypopharynx. In these situations, the tongue moves posteriorly into the upper airway when the patient is lying supine. Upper airway obstruction caused by the tongue can be relieved by positioning maneuvers of the head, neck, and jaw; nasopharyngeal or oropharyngeal airways; or continuous positive airway pressure (CPAP).

Pulse oximetry (SpO₂) has greatly improved our ability to monitor oxygenation of patients at risk of airway or ventilatory compromise. These monitors are accurate under most conditions and allow clinically subtle deterioration to be recognized quickly. SpO₂ monitors are standard equipment in all emergency airway settings.

Manual Airway Maneuvers

Airway obstruction in unconscious patients may be due to posterior displacement of the tongue; however, research in obstructive sleep apnea and CPAP shows that the concept of the airway collapsing like a flexible tube may be more accurate (Fig. 3–1A). Upper airway obstruction may cause snoring or stridor, but an apneic patient or one
who is moving minimal air may not exhibit any audible evidence of upper airway obstruction. Therefore, every unconscious patient has a potential upper airway obstruction.

More than 30 years ago, Guildner\(^{10}\) compared different techniques for opening obstructed upper airways and found that the head-tilt/chin-lift and the jaw-thrust techniques were effective (see Fig. 3–1\(B\) and \(C\)). Modern airway textbooks still describe the head-tilt/chin-lift and the jaw-thrust maneuvers, but also describe the “triple airway maneuver,” which is a combination of head-tilt, jaw-thrust, and mouth opening.\(^{4,11}\)

It is widely accepted that the jaw-thrust-only (without head-tilt) maneuver should be performed in patients with suspected cervical spine injury, but this technique is sometimes ineffective and there is no evidence that it is safer than the head-tilt/chin-lift maneuver.\(^{12}\) In 2005, the American Heart Association (AHA)\(^{13}\) concluded that airway maneuvers are safe during manual in-line stabilization of the cervical spine, but highlighted evidence that all airway maneuvers cause some spinal movement. Both the chin-lift and the jaw-thrust maneuvers have been shown to cause similar substantial movement of the cervical vertebrae.\(^{14,15,16,17,18}\) The AHA recommended that “in a victim with a suspected spinal injury and an obstructed airway, the head-tilt/chin-lift or jaw-thrust (with head-tilt) techniques are feasible and may be effective for clearing the airway,” while emphasizing that “maintaining an airway and adequate ventilation is the over-riding priority in managing a patient with a suspected spinal injury.”\(^{13}\)

Despite the lack of evidence for the jaw-thrust-only (without head-tilt) technique, many experienced airway providers believe that this technique is effective and valuable.\(^{4,19}\) It is certainly reasonable to attempt the jaw-thrust-only technique before employing the chin-lift/head-tilt technique in patients with possible cervical spine injury.\(^{11}\)

Importantly, the addition of CPAP may relieve airway obstruction when simple manual positioning maneuvers fail. Meier and colleagues\(^9\) showed that adding CPAP to the chin-lift and jaw-thrust maneuvers decreased stridor and improved the nasal fiberoptic view of the glottic opening in anesthetized children.

The Head-Tilt/Chin-Lift Maneuver

To perform the head-tilt/chin-lift maneuver, place the tips of the index and middle fingers beneath the patient's chin (see Fig. 3–1\(B\) ). Lift the chin cephalad and toward the ceiling. The upper neck will naturally extend when the head tilts backward during this maneuver. Apply digital pressure on only the bony prominence of the chin and not on the soft tissues of the submandibular region. The final step of this maneuver is to use the thumb to open the patient's mouth while the head is tilted and the neck is extended.
The Jaw-Thrust Maneuver

To perform the jaw-thrust maneuver, place the tips of the middle or index fingers behind the angle of the mandible (see Fig. 3–1C). Lift the mandible toward the ceiling until the lower incisors are anterior to the upper incisors. This maneuver can be performed in combination with the head-tilt/chin-lift maneuver or with the neck in the neutral position during in-line stabilization.

The Triple Airway Maneuver

The “triple airway maneuver” is described by many authors as the best manual method for maintaining a patent upper airway. The most common description of this maneuver is head-tilt, jaw-thrust, and mouth opening. Other authors describe the triple maneuver differently, as a combination of upper cervical extension (head-tilt), lower cervical flexion, and jaw protrusion (jaw-lift). The triple airway maneuver has been described as a technique for providers with advanced airway skills. No studies exist to support the assertion that this technique is more effective than the head-tilt/chin-lift or jaw-thrust maneuvers. However, the triple maneuver is commonly mentioned in the anesthesia literature and is probably very effective.

Patient Positioning

The best way to position a patient's head and neck to open the upper airway is to mimic how patients with upper airway obstruction position themselves, sitting upright while leaning their head and neck forward. This is known as the "sniffing position" and is achieved by flexion of the lower cervical spine and atlanto-occipital extension (tilting the head backward). In the supine adult, this is accomplished by elevating the patient's head 1 to 4 inches (much more in obese patients) while maintaining head-tilt. The sniffing position is contraindicated in patients with cervical spine injuries. In young children, this position is often achieved without lifting the head because the occiput of the child is relatively large, so the lower cervical spine is normally flexed when the child is lying supine on a flat surface.

Airway management is usually easiest when patients are in the supine position; however, the lateral position may be best for patients who are actively vomiting and those with excessive upper airway bleeding or secretions. Some evidence suggests that rotating patients to the lateral position may not prevent aspiration. Patients with suspected cervical spine injury should have their head immobilized with in-line stabilization if they need to be rolled to the lateral position. Airway management maneuvers may be limited or difficult when patients are in the lateral position.

Foreign Body Airway Obstruction

Abdominal Thrusts (Heimlich Maneuver), Chest Thrusts, Back Blows/Slaps

The 2005 International Consensus Conference on Cardiopulmonary Resuscitation and Emergency Cardiopulmonary Care evaluated the evidence for different techniques for clearing foreign body airway obstruction. They found good evidence for the use of chest thrusts, abdominal thrusts, and back blows/slaps. However, insufficient evidence exists to determine which technique is the best and which should be used first. Some evidence exists that chest thrusts may generate higher peak airway pressures than the Heimlich maneuver.

The technique of subdiaphragmatic abdominal thrusts to relieve a completely obstructed airway was popularized by Dr. Henry Heimlich and is commonly referred to as the “Heimlich maneuver.” The technique is most effective when a solid food bolus obstructs the larynx. In the conscious patient, stand behind the upright patient. Circle the arms around the patient's midsection with the radial side of the clenched fist placed on the abdomen, midway between the umbilicus and the xiphoid. Then grasp the fist with the opposite hand and deliver an inward and upward thrust to the abdomen (Fig. 3–2A). A successful maneuver will cause the obstructing agent to be expelled from the patient's airway by the force of air exiting the lungs. Abdominal thrusts can also be performed on unconscious, supine patients. For this position, kneel next to the patient's pelvis facing cephalad (see Fig. 3–2B). Place the palmar bases of the hands in an overlapping fashion on the upper abdomen, in the same location as in the upright technique. Deliver inward, upward thrusts with the same objective as the upright method. Abdominal thrusts are relatively contraindicated in pregnant patients and those with protuberant abdomens. Potential risks of subdiaphragmatic thrusts include stomach rupture, esophageal perforation, and mesenteric laceration, compelling the rescuer to weigh the risks and benefits of this maneuver. Use a chest position for pregnant patients (see Fig. 3–2C).
Alternatively, manage foreign body airway obstruction with chest compressions (back blows in an inverted infant) identical to those delivered during cardiopulmonary resuscitation (CPR) (see Fig. 3–2D). The theory is the same as for abdominal thrusts, to expel the obstructing agent by forcing air out of the lungs. Some data suggest that chest compressions may create higher peak airway pressures than the Heimlich maneuver. A combined (simultaneous) chest compression and subdiaphragmatic abdominal thrust may produce even higher peak airway pressures and should be considered when the standard techniques fail.

Back blows are often recommended for infants and small children with foreign body airway obstruction. Some authors have argued that back blows may be dangerous and may drive foreign bodies deeper into the airway, but there is no convincing evidence of this phenomenon. As for the other techniques, anecdotal evidence suggests that back blows are effective. However, no convincing data indicate that back blows are more or less effective than abdominal or chest thrusts. Back blows may produce a more pronounced increase in airway pressure, but over a shorter period of time than the other techniques. The AHA guidelines suggest back blows in the head-down position (see Fig. 3–2D) and head-down chest thrusts in infants and small children with foreign body airway obstruction. The AHA does not recommend abdominal thrusts in infants, because infants may be at higher risk of iatrogenic injury. From a practical standpoint, back blows should be delivered with the patient in a head-down position, which is easier in infants than in larger children.

Any patient with a complete airway obstruction may benefit from chest compressions, abdominal thrusts, or back blows. Give CPR to all unconscious patients with airway obstruction. It is important to realize that more than one technique is often required to clear foreign body airway obstruction, so multiple techniques should be applied in a rapid sequence until the obstruction is relieved. Perform a finger sweep of the patient’s mouth only if a solid object is seen in the airway. It is recommended to suction newborns rather than give them back blows or abdominal thrusts.
Suctioning

Patient positioning and airway opening maneuvers are often inadequate to achieve complete airway patency. Ongoing hemorrhage, vomitus, and particulate debris often require suctioning. Several types of suctioning tips are available. A large-bore dental-type suction tip is the most effective for clearing vomitus from the upper airway because it is less likely to become obstructed by particulate matter. The tonsil tip (Yankauer) suction device can be used to clear hemorrhage and secretions. Its rounded tip is also less traumatic to soft tissues; however, the tonsil tip device is not large enough to effectively suction vomitus.

A large-bore dental-type tip device, such as the HI-D Big Stick suction tip (SSCOR, Inc., Sun Valley, CA; www.sscor.com) should be readily available at the bedside during all emergency airway management. The large-bore tip allows rapid clearing of vomitus, hemorrhage, and secretions.

A limiting feature of many suction catheters is the diameter of the tubing. Vomitus may obstruct the standard \( \frac{1}{4} \) -inch-diameter catheter. A \( \frac{5}{8} \) -inch-diameter suction catheter (Conmed Corp.) has been shown to significantly decrease suction time of viscous and particulate material.

Keep suctioning equipment connected and ready to operate; everyone participating in emergency airway management should know how to use it. Interposition of a suction trap close to the suction device prevents clogging of the tubing with particulate debris. A trap that fits directly onto a tracheal tube has been described, and the use of this device allows effective suctioning during intubation.

No specific contraindications to airway suctioning exist. Complications of suctioning may be avoided by anticipating problems and providing appropriate care before and during suctioning maneuvers. Nasal suction is seldom required, except in infants, because most adult airway obstruction occurs in the mouth and oropharynx.

Avoid prolonged suctioning because it may lead to significant hypoxia, especially in children. Do not exceed 15 seconds for suctioning intervals and give supplemental O\(_2\) before and after suctioning. Naigow and Powasner found that suctioning consistently induced hypoxia in dogs and that it was best avoided by hyperventilation with high-concentration O\(_2\) before and after suctioning.

Perform suctioning under direct vision or with the aid of the laryngoscope. Forcing a suction tip blindly into the posterior pharynx can injure tissue or convert a partial obstruction to a complete obstruction.

Artificial Airways: Oropharyngeal and Nasopharyngeal Airways

Indications and Contraindications

Once the airway has been opened with manual maneuvers and suctioning, artificial airways, such as the nasopharyngeal and oropharyngeal airways, can facilitate both spontaneous breathing and bag-mask ventilation. Semiconscious patients who require a head-tilt/chin-lift or jaw-thrust maneuver to open their airways may develop hypoxia because of recurrent obstruction if these maneuvers are discontinued. O\(_2\) supplementation and a nasopharyngeal airway may be all the support that is necessary.

Patients who are unresponsive or apneic are usually easier to ventilate with a bag-mask device when an oropharyngeal airway is in place. In the ED, patients who tolerate an oropharyngeal airway should probably be intubated.

Artificial Airway Placement

The simplest and most widely available artificial airways are the oropharyngeal and nasopharyngeal airways (Fig. 3–3). Both are intended to prevent the tongue from obstructing the airway by falling back against the posterior pharyngeal wall. The oral airway also may prevent teeth clenching. The oropharyngeal airway may be inserted by either of two procedures. One approach is to insert the airway in an inverted position along the patient’s hard palate. When it is well into the patient’s mouth, rotate the airway 180° and advance it to its final position along the patient’s
tongue, with the distal end of the airway lying in the hypopharynx. A second approach is to open the mouth widely, use a tongue blade to displace the tongue, and then simply advance the airway into the oropharynx. No rotation is necessary when the airway is placed in this manner. This technique may be less traumatic but it takes longer.

**Figure 3–3** Simple artificial airways. Oropharyngeal (A) and nasopharyngeal (B) airways. To insert the oropharyngeal airway first measure (C) then open the mouth with the thumb and index finger (D), insert with the **curve upward** and rotate to pass over the base of the tongue (E). It may help to pull the jaw forward during passage. To insert the nasopharyngeal tube, first measure (F), then lubricate and gently pass the entire device through the most patent nostril (G) until the flared tip is at the nasal orifice. H, A bag-mask is then used to ventilate with either airway in place. (A–H, From Thomsen T, Setnik G [eds]: Procedures Consult—Emergency Medicine Module. Copyright 2008 Elsevier Inc. All rights reserved.)

The nasopharyngeal airway is very easy to place. Simply advance it into the nostril and direct it along the floor of the nasal passage in the direction of the occiput, not cephalad. **Advance it fully until the flared external tip of the airway is at the nasal orifice.**

Both oropharyngeal and nasopharyngeal airways are available in multiple sizes. To find the correct size for either device, estimate by measuring it along the side of the patient’s face prior to insertion. The correct size oropharyngeal airway will extend from the corner of the mouth to the tip of the earlobe. The correct size nasopharyngeal airway will extend from the tip of the nose to the tip of the earlobe.

Both oropharyngeal and nasopharyngeal airways provide airway patency similar to that of the head-tilt/chin-lift maneuver. The nasal airway is better tolerated by semiconscious patients and is less likely to induce vomiting in those with an intact gag reflex.
Complications

The nasopharyngeal airway may cause epistaxis and may be dangerous in patients with significant facial fractures and basilar skull fractures. Semiconscious patients with nasopharyngeal airways may deteriorate and require intubation, so they should be monitored closely.

The oropharyngeal airway may induce vomiting when placed in patients with an intact gag reflex. The oropharyngeal airway may also cause airway obstruction if the tongue is pushed against the posterior pharyngeal wall when it is inserted. The oropharyngeal airway should not be used as a definitive airway.

OXYGEN THERAPY

Adequate O₂ delivery depends upon the inspired partial pressure of O₂, alveolar ventilation, pulmonary gas exchange, oxygen-carrying capacity of the blood, and cardiac output. The easiest factor to manipulate is the partial pressure of inspired O₂, accomplished by simply increasing the fraction of inspired oxygen with supplemental O₂.

Indications and Contraindications

Resuscitate all patients in cardiac arrest or respiratory arrest with 100% O₂. The most certain indication for supplemental O₂ is the presence of arterial hypoxemia, defined by a PaO₂ <60 mm Hg or arterial oxygen saturation (SaO₂) less than 90%. Normal subjects will begin to experience memory loss at an arterial oxygen partial pressure (PaO₂) of 45 mm Hg and loss of consciousness occurs at a PaO₂ of 30 mm Hg. Chronically hypoxic patients can adapt and function quite well with a PaO₂ of 50 mm Hg or lower.

When tissue hypoxia is present or suspected, give O₂ therapy. Shock states resulting from hemorrhage, vasodilatory states, low cardiac output, and obstructive lesions can all lead to tissue hypoxia and should benefit from supplemental O₂. Whatever the cause of the shock state, the administration of O₂ is indicated until the situation can be thoroughly evaluated and cause-specific therapy is instituted.

Respiratory distress without documented arterial hypoxemia is a common indication for O₂ administration, although no evidence exists to support this practice. O₂ therapy for acute myocardial infarction is often recommended, but there is no difference in outcomes between patients receiving O₂ or those receiving room air after myocardial infarction. The AHA gives a class I recommendation for O₂ only in patients with hypoxemia, cyanosis, or respiratory distress. Although O₂ is routinely administered to acute stroke patients, no convincing evidence exists that this practice is beneficial without documented hypoxia; it is not recommended by current guidelines. It is reasonable to administer O₂ to hypotensive patients and those with severe trauma until tissue hypoxia can be definitively excluded.

Administer O₂ to patients with carbon monoxide poisoning. The half-life of carboxyhemoglobin is 4 to 5 hours in a subject breathing room air but can be decreased to approximately 1 hour by the administration of 100% O₂ by non-rebreather face mask at atmospheric pressure.

There are no contraindications to O₂ therapy when a definite indication exists. The risks of hypoxemia are grave and undeniable. O₂ therapy should never be withheld from a hypoxemic patient for fear of complications or clinical deterioration. CO₂ retention is not a contraindication to O₂ therapy. Rather, it demands that the clinician administer O₂ carefully and recognize the potential for respiratory acidosis and clinical deterioration. Although the mechanism of respiratory acidosis developing in COPD patients administered O₂ is debated, its occurrence is not. Caution should be used when administering supplemental O₂ to patients with an arterial carbon dioxide pressure over 40 mm Hg, but it should not be withheld.
Oxygen Delivery Devices

High-flow delivery systems provide an  that is relatively constant despite changes in the patient's respiratory pattern. The Venturi mask is the high-flow delivery device that is widely available (Fig. 3–4A and inset). Room air is entrained into the system through entrainment ports and mixes with the O2 provided from the O2 source.

The proportion of entrained air, and therefore the , is constant and is determined by the velocity of the O2 jet and size of the entrainment ports. Because the total gas flow (O2 plus air through entrainment ports) meets or exceeds the patient's inspiratory flow rate, no additional entrainment of air occurs around the mask, thereby minimizing changes in as the patient's respiratory pattern changes. The mask is continuously flushed by the high flow of gas, preventing the accumulation of exhaled gases in the mask. Venturi masks are packaged with multiple inserts, each with a different size orifice for O2 inflow. is determined by selecting the appropriate colored insert and O2 flow rate according to the manufacturer's instructions. The inspiratory flow rate for a resting adult is about 30 L/min, a rate matched by the total gas flow provided by the Venturi mask at all settings. However, a patient with respiratory distress may have an inspiratory flow rate of 50 to 100 L/min. If the inspiratory flow rate exceeds the total gas flow delivered by the mask, additional air will be entrained around the mask and the will decrease. Masks with higher ratings entrain less outside air and, therefore, provide less total flow. Caution should be used with masks rated above 35% in patients with respiratory distress because the may be significantly reduced with high inspiratory flow rates.

Figure 3–4  A–C, Using a wall oxygen source, high-flow oxygen masks provide the entire ventilatory requirement using a Venturi valve. The port size of the valve ensures that the correct proportions of oxygen and entrained (environmental) air are mixed to obtain a fixed oxygen concentration. Low-flow oxygen masks do not provide the entire ventilatory requirement. Air is drawn in through the loose-fitting mask to supplement the oxygen flow rate. A, A chronic obstructive pulmonary disease (COPD) patient can be accurately given 28% oxygen with this mask. Inset: Principle of the venture mask. B, Bilevel positive airway pressure (BiPAP) or continuous positive airway pressure (CPAP) has beneficial effects on the physiology of congestive heart failure and COPD and may be used to avoid intubation. The value of CPAP vs. BiPAP is controversial. Note: Severe neck flexion shown here may limit effectiveness of this intervention. Reposition the patient or perform tracheal intubation. C, When initiating BiPAP, it is best to let the patient hold the mask on his or her own face for several minutes before securing the mask with the head straps. Patients must be monitored closely for clinical decompensation and mask movement. Extremely anxious or hypoxic patients cannot tolerate the mask and feel smothered, and they are best intubated. Patients with facial hair may have problem with a tight mask fit.
Low-flow delivery devices provide gas flow that is less than the patient's inspiratory flow rate. The difference between the patient's inspiratory flow and the flow delivered by the device is met by a variable amount of room air being drawn into the system. Patients with normal respiratory rates and tidal volumes will require less outside air than those in respiratory distress and will, therefore, receive a higher $\text{FiO}_2$. As a patient's inspiratory flow changes, so will the $\text{FiO}_2$ they receive from a low-flow device.

The prongs of a cannula deliver a constant flow of $O_2$ that accumulates in the nasopharynx and provides a reservoir of oxygen-enriched air for inspiration. The $\text{FiO}_2$ delivered by nasal cannulas is determined by many factors including respiratory rate, tidal volume, pharyngeal geometry, and $O_2$ flow. Most importantly, at a constant $O_2$ flow rate, the $\text{FiO}_2$ varies inversely with the respiratory rate. Despite this limitation, nasal cannulas are very comfortable for patients and are the most common low-flow $O_2$ delivery device.

Simple masks receive a constant flow of $O_2$ from the $O_2$ source and have multiple vent holes. During inspiration, the oxygen-enriched air that has accumulated in the mask, along with room air entrained through the vent holes, is inhaled. During expiration, 200 cc (the approximate volume of the mask) of exhaled gases are deposited in the mask with the rest exiting through the vent holes. The continuous flow of $O_2$ then partially washes out the mask prior to the next inspiration. The mask itself provides the reservoir of oxygen-rich gas for inhalation. A complex interplay between mask volume, tidal volume, respiratory rate, and $O_2$ flow determines the $\text{FiO}_2$ actually delivered to the patient.

A partial rebreathing mask incorporates a bag-type reservoir to increase the amount of $O_2$ available during inspiration, thereby requiring less outside air to be entrained. Non-rebreathing masks are similar to partial rebreathing masks but have a series of one-way valves. One valve lies between the mask and the reservoir and prevents exhaled gases from entering the reservoir. Two valves in the side of the mask permit exhalation while preventing the entry of outside air. In practice, one of these valves is often removed to permit inhalation in the event of an interruption of $O_2$ flow to the mask. A variable amount of air can still leak around the mask. This outside air and the exhaled gases remaining in the mask dilute the $O_2$ from the reservoir and prevent the mask from providing 100% $O_2$. $O_2$ flow to the mask should be sufficient to prevent collapse of the bag during inspiration. As with all low-flow devices, the $\text{FiO}_2$ delivered varies with the patient's respiratory pattern. Many clinicians have the misconception that a non-rebreathing mask can provide an $\text{FiO}_2$ near 100%. In practice, a non-rebreathing mask usually delivers an $\text{FiO}_2$ of about 70%.

**Procedure**
In selecting the proper delivery device, consideration should be given to the clinical condition of the patient and the amount of O2 needed. High-flow systems should generally be used for patients who need precise control of $\text{FiO}_2$, such as COPD patients with chronic respiratory acidosis. Low-flow masks are appropriate for patients who need supplemental O2 but do not require precise control of $\text{FiO}_2$. Nasal cannulas are best suited to patients who do not require a high $\text{FiO}_2$ and will not be harmed by the lack of precise control. In most patients receiving supplemental O2, an initial $\text{FiO}_2$ of 25% to 35% (1–3 L/min) delivered by nasal cannula is appropriate. A higher $\text{FiO}_2$, delivered by mask, may be needed in patients with significant hypoxemia, end-organ dysfunction, or respiratory distress. An initial $\text{FiO}_2$ of 24% to 28% delivered by Venturi mask is indicated for patients with hypoxemia and chronic respiratory acidosis.

Frequent clinical assessment and SpO2 are needed in all patients receiving O2 therapy. Periodic determination of blood gases is imperative for those at risk of developing respiratory acidosis. Equilibration of SaO2 after changes in supplemental O2 occurs within 5 minutes.

$\text{FiO}_2$ should be titrated to achieve therapeutic goals while minimizing the risk of complications. An SaO2 of 90% to 95% (PaO2 ≈ 60–80 mm Hg) is an appropriate target for most patients receiving supplemental O2. Increases above these levels do not add appreciably to the O2 content of blood and are unlikely to confer an additional benefit. One may exceed these parameters in patients with shock and end-organ dysfunction, but the added risk and small potential benefit should be considered on an individual basis. In patients with COPD, SaO2 of 90% (PaO2 ≈ 60 mm Hg) should be the goal of O2 therapy. Mechanical ventilation should be considered when oxygenation goals cannot be achieved without progressive respiratory acidosis.

**Preoxygenation for Rapid-Sequence Intubation**

Preoxygenation prior to rapid-sequence induction (RSI) and intubation may allow a significantly longer safe apneic period. Providing maximal $\text{FiO}_2$ with a non-rebreather mask for 3 to 5 minutes is recommended. Alternatively, a series of eight vital capacity breaths from a high $\text{FiO}_2$ system, such as a non-rebreather mask or a bag-valve-mask device, may be used if there is no time for standard preoxygenation.

Preoxygenation, if possible or practical to institute, is one the most important aspects of RSI. It allows much more time for the intubation procedure and significantly increases the chance of successful intubation on the first attempt.
Failure to preoxygenate prior to RSI is often a critical factor when a straightforward emergency airway becomes an airway disaster.

**Complications of Oxygen Therapy**

Worsening of CO₂ retention leading to progressive respiratory acidosis and obtundation in COPD patients is the complication most likely to be seen in the ED. This phenomenon is well documented and was first described by Barach in 1937.[62] It has been attributed to several mechanisms including loss of hypoxic respiratory drive, 

\[ \frac{\dot{V}}{\dot{Q}} \]

ventilation-perfusion mismatch and decreased hemoglobin affinity for CO₂ (Haldane effect). This avoidable complication is best prevented by administering O₂ to chronic CO₂ retainers only when there is an indication, administering it at the smallest effective dose, and carefully monitoring clinical and arterial blood gas parameters.

Exposing the lung to excessive concentrations of O₂ can lead to toxicity and, in severe cases, can cause acute respiratory distress syndrome. Injury to the pulmonary parenchyma occurs as a result of the formation of reactive oxygen species. No data describe what concentration or duration of exposure to O₂ leads to toxicity but presumably both of these factors, as well as individual patient characteristics, determine the likelihood of toxicity. The benefits of O₂ therapy in the ED usually outweigh the risks of O₂ toxicity. Fear of toxicity should not prevent the use of O₂ when there is an indication but should encourage the clinician to use the minimum concentration of O₂ necessary to achieve therapeutic goals. High concentrations of O₂ are well tolerated over short periods and may be life saving.

In patients receiving high concentrations of supplemental O₂, nitrogen in the alveoli is largely replaced by O₂. If this O₂ is then absorbed into the blood faster than it can be replaced, the volume of the alveoli will decrease and absorptive atelectasis will occur. Airway obstruction potentiates this problem by preventing the rapid replacement of absorbed gases.

**NPPV**

NPPV provides patients the benefits of positive-pressure ventilation without endotracheal intubation and its associated risks. Once limited to the treatment of obstructive sleep apnea and chronic respiratory failure, NPPV is now commonly used for acute respiratory failure.

NPPV decreases intubation rates and mortality in the setting of acute pulmonary edema and acute exacerbations of COPD. [63][64][65][66] NPPV has fewer infectious complications and is often a good alternative to endotracheal intubation. [68][69]

CPAP describes a constant level of positive airway pressure maintained throughout the respiratory cycle without the provision of greater support during inspiration. The addition of increased pressure during the inspiratory phase is known as pressure support (PS). The combination of CPAP and PS is bilevel positive airway pressure, commonly referred to as BiPAP. The focus of this chapter is the use of BiPAP in the setting of acute respiratory failure (ARF).

BiPAP (Respironics, Inc., Murrysville, PA; www.respironics.com) is a trade name for noninvasive ventilators manufactured by Respironics and should not be confused with the term BiPAP as described previously.

CPAP was first used to treat congestive heart failure in 1936 when Poulton[70] described using a vacuum cleaner to generate positive pressure. Neuromuscular disorders were first treated with NPPV in 1987 and it was first used in the setting of ARF in 1989.[71][72] The past decade has seen extensive investigation into noninvasive ventilation and its use in ARF.

**Indications and Contraindications**

Strong evidence exists for the use of NPPV in acute exacerbations of COPD. Evidence-based guidelines recommend its use in patients who, despite maximal medical therapy, exhibit persistent respiratory distress and
respiratory acidosis (pH ≤ 7.35). When used in addition to standard medical therapy, NPPV decreases the need for intubation, decreases complications, and improves outcomes in this population. NPPV also decreases the need for endotracheal intubation and decreases mortality in patients with respiratory failure secondary to cardiogenic pulmonary edema. The exact benefits of CPAP versus BiPAP are uncertain, and either is acceptable when NPPV is required. Some studies suggest that CPAP is preferable to BiPAP for acute pulmonary edema; however, no definite consensus has been reached.

NPPV has been used successfully in the setting of ARF secondary to pneumonia. However, the benefit is not as great in this group as in others and intubation rates are still high. Some evidence supports a trial of NPPV in respiratory failure secondary to asthma. However, large-scale randomized trials are lacking and it is not certain that the treatment is beneficial in this setting. An attempt to reverse respiratory failure using NPPV is reasonable in selected asthmatics but provisions for more aggressive intervention should be immediately available.

NPPV is especially useful in patients with ARF who have do-not-resuscitate (DNR) status and do not want endotracheal intubation. Most patients who refuse intubation will allow NPPV. Several clinical scenarios exist in which NPPV is likely to fail (Table 3–1). Patients who are in extremis are not candidates for NPPV. When the combination of mental status, respiratory function, and hemodynamics indicate this threshold has been reached, the airway should be managed using traditional endotracheal intubation. Altered mental status is generally considered a contraindication to the use of NPPV. Despite this, there are reports of NPPV success in patients with severely altered mental status. In select patients who are able to maintain airway patency, NPPV can be attempted provided the equipment and personnel for endotracheal intubation are immediately available. Patient-ventilator synchrony is crucial to the success of NPPV, and therefore, patients who are agitated or combative are unlikely to be successfully managed with this technique.

**TABLE 3–1 -- Patient Characteristics Associated with Noninvasive Positive-Pressure Ventilation Failure**

<table>
<thead>
<tr>
<th>Characteristics</th>
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</thead>
<tbody>
<tr>
<td>Pneumonia, ARDS</td>
</tr>
<tr>
<td>Decreased level of consciousness (GCS ≤ 13)</td>
</tr>
<tr>
<td>Respiratory rate ≥ 30</td>
</tr>
<tr>
<td>Severe disease (Apache II ≥ 29, SAPS II ≥ 35)</td>
</tr>
<tr>
<td>pH &lt; 7.25</td>
</tr>
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ARDS, adult respiratory distress syndrome; GCS, Glasgow Coma Score; SAPS, Simplified Acute Physiology Score.

In hemodynamically stable patients, NPPV appears to have no significant adverse effects and may actually improve hemodynamics. However, in decompensated patients or those with a low pulmonary capillary wedge pressure, hemodynamics may be adversely affected by NPPV. The adverse hemodynamic effects of NPPV will be no greater than those of conventional mechanical ventilation in the same patient and a trial can be considered for a patient who is otherwise a good candidate.

Patients with facial features or deformities that preclude effective mask fitting are not appropriate candidates for NPPV. The presence of facial hair may also create difficulties with mask fitting but is not a contraindication. Positive pressure applied after recent sinus or upper airway surgery may have adverse results; these conditions are contraindications to its use. Positive pressure alone will not provide a lasting remedy for a fixed obstruction of the upper airway; such patients should be managed with traditional airway techniques. Because significant aerophagia can occur with NPPV, bowel obstruction and recent upper gastrointestinal surgery are relative contraindications. The technique may be employed safely if the mental status is normal and the inspiratory pressures are kept below 20 cm H₂O.
Excessive respiratory secretions predict failure of NPPV and are better managed in the intubated patient. Persistent vomiting is considered a contraindication to NPPV. Suctioning and clearance of vomitus from the airway is difficult during noninvasive ventilation.

**Equipment**

NPPV can be safely and adequately delivered using standard critical care ventilators or machines specifically designed to deliver BiPAP (i.e., BiPAP Vision, Respironics).

Dedicated BiPAP devices have been extensively studied in the setting of ARF, and this is the strongest argument for using them instead of standard ventilators. These devices are tolerant of the leaks that are inevitable in NPPV and do not sound unnecessary alarms. They are portable, simple to operate, and less expensive than standard ventilators. However, they have fewer monitoring capabilities than standard ventilators and most lack an O₂ blender, which precludes precise determination of \[ \text{FI}_\text{O}_2 \] . Delivery of \[ \text{FI}_\text{O}_2 \] greater than 50% is difficult to achieve with typical BiPAP settings.\(^{[97]}\) O₂ blenders and advanced monitoring capabilities are being incorporated into newer devices.

Traditional critical care ventilators can also deliver NPPV. They allow delivery of a precise and sophisticated monitoring but do not tolerate leaks as well as machines designed specifically for noninvasive ventilation. Some ventilators now include a dedicated NPPV mode, which may overcome this problem. Regardless of the ventilator chosen, it is critical that it be capable of maintaining airway pressure in the presence of leakage around the mask interface.

Perhaps no piece of equipment is more important to the success of NPPV than the interface between the patient and the ventilator. The oronasal mask eliminates the problem of leakage through the mouth and augments respiratory mechanics more effectively than nasal masks (see Fig. 3–4B ).\(^{[98]}\)\(^{[99]}\)\(^{[100]}\) It has the disadvantage of being quite claustrophobic and precluding eating, oral suctioning, and effective verbal communication. The volume of the oronasal mask is greater than that of the nasal mask. This increased dead space leads to some degree of CO₂ rebreathing, the effects of which are probably insignificant. Masks containing an exhalation port are optimal for preventing rebreathing and efficiently lowering arterial carbon dioxide pressure \((P_a \text{CO}_2)\) . The oronasal mask is recommended for patients with ARF and is the most widely used interface in this setting.\(^{[101]}\)

Nasal masks are the predominant interface used in chronic respiratory failure but can also be used in the acute setting. They are well tolerated owing the ability to eat and communicate verbally. They do permit significant leakage from the mouth, which can be somewhat uncomfortable. Significant mouth breathing markedly decreases their effectiveness.

**Application of NPPV**

When using a conventional critical care ventilator, one must decide between pressure- and volume-limited modes of ventilation. Whereas both modes will provide adequate support for most patients, pressure-limited modes tend to be better tolerated and are the most widely used. Pressure-supported ventilation (PSV) is the mode most commonly used for NPPV in ARF. PSV refers only to the provision of ventilatory support during inspiration. CPAP in addition to PSV provides greater support and is preferred.\(^{[102]}\) CPAP should initially be set at 4 to 5 cm H₂O. Initial pressure support should be set at 8 to 10 cm H₂O to prevent patient discomfort and intolerance due to high inspiratory pressures. Leakage around the mask is inevitable during NPPV. This can create problems with cycling and is a major cause of patient intolerance of NPPV. For this reason, triggers should be set to their most sensitive levels. If the ventilator has a dedicated NPPV mode, be certain it is selected.
When using a dedicated NPPV machine such as the BiPAP Vision, the spontaneous mode is analogous to PSV and cycles to inspiration only when it is triggered by the patient. This mode is appropriate for most patients. If the respiratory drive is diminished or the inspiratory effort is insufficient to trigger the ventilator, then the spontaneous/time mode should be selected. This mode will function identically to the spontaneous mode unless the patient fails to trigger the ventilator at or above the set respiratory rate, in which case it will cycle automatically to provide the set number of breaths per minute.

Expiratory positive airway pressure (EPAP) is the minimum level of positive pressure supplied during the respiratory cycle and is present during the expiratory phase. It is analogous to CPAP and should be set at 4 to 5 cm H₂O initially. Lower levels may lead to accumulation of expired gases in the circuit and CO₂ rebreathing. Inspiratory positive airway pressure (IPAP) refers to the additional support provided during the inspiratory phase and should be initially set at 8 to 10 cm H₂O initially. An O₂ line should be attached to the designated inlet site in the circuit or a T-piece inserted in the tubing. An initial flow of 4 L/min is reasonable but higher levels (≤15 L/min) are appropriate in the presence of significant hypoxemia. If the machine has an O₂ blender, the desired \( \text{FiO}_2 \) should be set.

Before establishing NPPV, consideration should be given to patient criteria associated with failure of NPPV (see Table 3–1). Whereas the technique can be used in a wide variety of patients, selecting patients based on these criteria will ensure a reasonable chance for success. Before starting NPPV, establish standard vital sign monitoring (including SpO₂) and obtain intravenous access. Preparations for endotracheal intubation should be made and a skilled operator immediately available. Although noninvasive ventilation can be done in any position, place the patient in the upright or semi-upright position to optimize respiratory mechanics and lessen the risk of aspiration.

Select a proper-sized mask and attach head straps. Configure the ventilator and turn it on with the initial settings determined as described previously. With the patient properly positioned, hold the mask loosely against the face with constant reassurance and coaching. As the patient becomes accustomed to positive pressure, secure the mask and adjust it to minimize leaks. Do not overtighten the straps because this can lead to patient intolerance and pressure necrosis on the bridge of the nose (see Fig. 3–4C).

Once the patient is tolerating the mask, titrate the pressures to achieve the desired effect of decreasing the respiratory rate and work of breathing. Avoid inspiratory pressures above 20 cm H₂O because they will increase the risk of aerophagia and patient intolerance. Adjust O₂ flow or \( \text{FiO}_2 \) to achieve the desired SpO₂. One should keep in mind that when using a single-limb ventilator circuit and O₂ bleed in (as with the BiPAP Vision), the delivered \( \text{FiO}_2 \) will decrease for a given O₂ flow as the IPAP is increased; therefore, it may be necessary to increase O₂ flow as the IPAP is increased to avoid desaturation.

Monitor the patient minute-to-minute using clinical parameters. A significant deterioration in the patient's condition may indicate the need for endotracheal intubation. Measure arterial blood gases prior to instituting NPPV and again 1 hour later. Further measurement of arterial blood gases is dictated by the response to therapy and clinical situation.

Patient-ventilator synchrony is crucial to the success of NPPV. Patient tolerance may be increased by allowing the patient to hold the mask on her or his own face. This approach allows her or him to get used to the feeling of the NPPV mask while avoiding the sensation of being smothered by the device. The patient should be constantly reassured and coached during the initiation of NPPV. Low-dose neuroleptics or anxiolytics may also be useful in achieving maximal patient compliance and ventilator synchrony.

Cycling from inspiration to expiration is determined differently depending on the mode of ventilation. In PSV, inspiration ends when the flow in the circuit decelerates to a predetermined level. Owing to the inevitable presence
of leaks during NPPV, it is possible that the ventilator will not sense a deceleration of flow sufficient to cycle to expiration, leading to persistent inspiratory pressures being delivered to the patient. Achieving a good mask fit with minimal leaks is the best prevention for this complication. Many ventilators also incorporate a backup time-cycling mechanism, which sets a maximum duration of the inspiratory phase.

Patient-ventilator asynchrony may result from failure to sense a spontaneous breath. Once again, minimize leakage around the mask to help remedy this problem. If the ventilator allows manipulation of triggering parameters, flow triggering should be used and set at its most sensitive level.

Although aerosol delivery is less efficient during NPPV than during spontaneous breathing, the efficacy of aerosolized bronchodilators appears to be maintained. Deliver aerosols distally in the circuit, ideally between the tubing and the patient interface.

Complications

The most common complications of NPPV are typically minor and easily remedied. Discomfort or ulceration over the bridge of the nose can be minimized by avoiding overtightening straps or by using a skin barrier in this location. Sinus and middle ear discomfort may occur in the presence of high inspiratory pressures. This is best managed with a temporary decrease in pressure followed by gradual increase as the patient tolerates. Claustrophobia can occur with the use of the oronasal mask and may lead to patient intolerance of the procedure. If the patient’s clinical condition permits, consider loosening the straps and letting the patient hold the mask to his or her face. Low-dose anxiolytics may also be appropriate in some patients.

Major complications of NPPV are rare and include pneumothorax, hypotension, gastric overdistention, and esophageal perforation. Appropriate patient selection and use of proper settings will minimize the occurrence of these conditions. Constant monitoring of the NPPV patient is necessary to immediately detect their occurrence.

BAG-MASK VENTILATION

Bag-mask ventilation is the single most important technique for emergency airway management. Bag-mask devices are widely available and are standard equipment in all patient care settings. Although the bag-mask method of ventilation appears to be simple, it can be difficult to perform correctly. Having good bag-mask ventilation skills is a prerequisite to more advanced methods of emergency airway management. Manually opening the airway, properly positioning the head and neck, placing an oropharyngeal airway device, and achieving a tight face mask seal are the keys to good bag-mask ventilation.

Indications and Contraindications

Bag-mask ventilation is the most common initial technique for ventilation of apneic patients and for rescue ventilation after failed intubation. Many authors note that bag-mask ventilation is relatively contraindicated in patients with a full stomach, those who are in cardiac arrest, and those who are undergoing RSI. These patients have a high risk of stomach inflation and subsequent aspiration. Unfortunately, these are the patients for whom ED providers most commonly use bag-mask ventilation. In ED situations, the need for ventilation and oxygenation always takes priority over potential aspiration.

The only contraindication to attempting bag-mask ventilation is when application of a face mask is impossible. It is often impossible to achieve an effective face mask seal on patients with significant deforming facial trauma and those with thick beards. An intermediate ventilation device, such as a laryngeal mask airway (LMA), is a better choice for initial ventilation in such patients.

Bag-Mask Ventilation Technique

Achieving adequate tidal volumes with bag-mask ventilation requires a tight mask seal and appropriate compression of the bag. However, overaggressive bag-mask ventilation causes stomach inflation and increases the risk of aspiration. The goal is to achieve adequate gas exchange while keeping the peak airway pressures low. Squeezing the bag forcefully and abruptly creates a high peak airway pressure and is more likely to inflate the stomach. Several studies show that increased tidal volume is associated with higher peak airway pressures and increased gastric
Data also show that decreased inspiratory time increases peak airway pressure and increases gastric inflation. Therefore, it appears that the best method of bag-mask ventilation is to provide a tidal volume of about 500 mL delivered over 1 to 1.5 seconds. Effective ventilation and oxygenation should be judged by chest rise, breath sounds, SpO₂, and exhaled CO₂ monitoring.

A variety of mask configurations are available to facilitate a tight seal. The most common mask used in ED situations is a transparent disposable plastic mask with a high-volume, low-pressure cuff. This type of mask eliminates the need for an anatomically formed mask and can be used for a wide variety of patients with differing facial features. Various mask sizes are available.

For the single rescuer, only one hand can be used to achieve the seal because the other must squeeze the bag. The rescuer must apply pressure anteriorly while simultaneously lifting the jaw forward. The thumb and index finger provide anterior pressure while the fifth and fourth fingers lift the jaw. The E-C clamp technique is often the most effective: The thumb and index finger form a “C” providing anterior pressure over the mask; while the third, fourth, and fifth fingers form an “E” to lift the jaw (Fig. 3–5). Generally, well-fitting intact dentures should be left in place to help ensure a better seal with the mask.

**Figure 3–5** One-handed bag-mask ventilation technique can be difficult to perform efficiently. The thumb and index finger control the mask, while the third to fifth fingers lift the mandible up into the mask. It may be possible to place the little finger behind the angle of the mandible to perform a jaw-thrust maneuver. (From Thomsen T, Setnik G [eds]: Procedures Consult—Emergency Medicine Module. Copyright 2008 Elsevier Inc. All rights reserved.)

It has been suggested that effective bag-mask ventilation during CPR requires two hands and, therefore, two rescuers. We suggest using the two-rescuer technique whenever it is practical (Fig. 3–6).

**Figure 3–6** With the easier two-handed bag-mask ventilation technique, the mask is controlled by the thenar eminences and thumbs (A), while the second through fifth fingers perform a jaw thrust and lift the mandible up into the mask (B). One operator controls the mask, the other the bag. (A and B, From Thomsen T, Setnik G [eds] Procedures Consult—Emergency Medicine Module. Copyright 2008 Elsevier Inc. All rights reserved.)

All bag-mask devices should be attached to a supplemental O₂ source (with a flow rate of 15 L/min) to avoid hypoxia. A significant problem with the bag-mask method is the low percentage of O₂ achieved with some reservoirs. The amount of delivered O₂ is dependent on the ventilatory rate, the volumes delivered during each breath, the O₂ flow rate into the ventilating bag, the filling time for reservoir bags, and the type of reservoir used. A 2500-mL bag reservoir and a demand valve are preferred for O₂ supplementation during bag-mask ventilation.

Pediatric bag-mask devices should have a minimum volume of 450 mL. Pediatric and larger bags may be used for ventilation of infants with the proper mask size, but be careful to administer only the volume necessary to effectively ventilate the infant. Avoid pop-off valves because airway pressure under emergency conditions may often exceed the pressure of the valve. [116]
Bag-mask ventilation may be the best method of prehospital airway support in trauma patients and in children. Murray and coworkers performed a large retrospective study suggesting that patients with severe head injury had a higher risk of mortality if they were intubated in the prehospital setting. In the same year, Gausche and associates reported that neurologic outcome and ultimate survival rates of prehospital pediatric resuscitations by emergency medical service (EMS) providers with bag-mask ventilation were as good as with tracheal intubation.

Complications

The main complications of the bag-mask technique are inability to ventilate and gastric inflation. Several factors may lead to difficult bag-mask ventilation. Langeron and colleagues performed a large prospective study of adults undergoing general anesthesia and reported a 5% incidence of difficult mask ventilation. They also identified five independent risk factors for difficult mask ventilation (Table 3–2). When mask ventilation is technically difficult, higher peak airway pressure is often required in order to provide an adequate tidal volume. In these situations, gastric inflation is more likely and aspiration may occur.

TABLE 3–2 -- Risk Factors for Difficult Mask Ventilation

<table>
<thead>
<tr>
<th>Risk Factor</th>
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<tbody>
<tr>
<td>Presence of a beard</td>
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<tr>
<td>Body mass index &gt; 26 kg/m²</td>
</tr>
<tr>
<td>Lack of teeth</td>
</tr>
<tr>
<td>Age &gt; 55 yr</td>
</tr>
<tr>
<td>History of snoring</td>
</tr>
</tbody>
</table>


Be vigilant to recognize complications early and take corrective action. Even when bag-mask ventilation is easy and good technique is used, some gastric dilatation will usually occur. Minor gastric distention should not be considered substandard in the setting of prolonged bag-mask ventilation.

Cricoid Pressure (Sellick's Maneuver)

Consider applying cricoid pressure during bag-mask ventilation. Cricoid pressure is often referred to as Sellick's maneuver, because of Sellick's classic article in 1961. The purpose of the technique is to apply external force to the anterior cricoid ring to push the trachea posteriorly, compressing the esophagus against the cervical vertebrae. In theory, cricoid pressure compresses the distensible upper esophagus but not the airway, because the cricoid ring is fairly rigid. Some data suggest that cricoid pressure prevents gastric inflation and subsequent vomiting/regurgitation during bag-mask ventilation and intubation. However, there are also conflicting reports and some controversy about whether cricoid pressure is really effective. Nevertheless, cricoid pressure is currently recommended and should be performed when possible during resuscitation and all RSIs.

Be aware that excessive or incorrectly applied cricoid pressure can interfere with bag-mask ventilation, direct laryngoscopy, and insertion of the LMAs. When faced with difficult or failed ventilation or intubation, or when using LMAs, consider relaxation of cricoid pressure. Also, be very careful when applying cricoid pressure in infants and young children, whose airways are more pliable and subject to obstruction with excessive cricoid pressure.

The proper technique for applying cricoid pressure (Sellick's maneuver) is to place the thumb and middle finger on either side of the cricoid cartilage with the index finger in the center anteriorly. Apply about 30 N of force to the cricoid cartilage in the posterior direction. As a reference, about 40 N of digital force on the bridge of the nose will usually cause pain.

INTERMEDIATE AIRWAY DEVICES
In an emergency airway situation, use these devices for temporary rescue ventilation until tracheal intubation or a surgical airway can be performed.

The LMAs

The laryngeal mask airway (LMA™, LMA North America, Inc., San Diego, CA; www.lmana.com) devices are essential adjuncts for rescue ventilation and difficult intubation. LMA devices have been used more than 200 million times worldwide and researched extensively. LMA devices are primary rescue adjuncts in the difficult airway guidelines put forth by the American Society of Anesthesiologists and the Difficult Airway Society. Advanced Cardiac Life Support guidelines suggest that the LMA provides a more secure and reliable means of ventilation than face-mask ventilation. Pediatric Advanced Life Support guidelines acknowledge the LMA as a potential backup device for difficult pediatric airways.

All of the LMA devices consist of an airway tube attached to an oval mask, rimmed by an inflatable cuff. The cuffed mask is designed to form a seal around the glottis when the device is properly placed. In fasted patients undergoing general anesthesia, an LMA can often be used instead of a tracheal tube. The LMA-glottic seal allows positive-pressure ventilation and protection of the airway from oral and nasal secretions. LMA devices do not necessarily protect the airway from aspiration of gastric contents. In emergency airway management, LMA devices are used as temporizing airways to allow rescue ventilation and provide a conduit for tracheal intubation.

Several different types of LMA devices are available. For emergency airway management, the original LMA and the intubating laryngeal mask airway (ILMA) are the most practical. Therefore, we describe these devices in detail and do not discuss other LMA devices. Emergency airway providers should be aware that the procedure for placing the ILMA is much different from the procedure for placing the LMA. It is prudent to learn how to use both devices, because many EDs use the ILMA in adults and the LMA in children. Many prehospital providers use the LMA.

The original LMA is now called the LMA Classic. A disposable version of the original LMA, called the LMA Unique, is available. The ILMA is called the LMA Fastrach, and it is specially designed to facilitate tracheal intubation. A disposable version of the intubating LMA, called the LMA Fastrach Single Use, is available.

Both versions of the original LMA (LMA Classic and LMA Unique) have the same design and functional characteristics, so in this chapter both devices are referred to as the LMA. Both versions of the ILMA (LMA Fastrach and LMA Fastrach Single Use) have the same design and function characteristics, so they are referred to as the ILMA in this chapter. Several other LMA devices are not as practical for emergency airway management and are not discussed in this chapter.

The LMA and the ILMA can be used as rescue devices in cases of failed bag-mask ventilation. Both devices can be inserted in less than 30 seconds and provide effective ventilation in 98% to 99% of patients. The ILMA is more useful in the ED, because it is easier for inexperienced personnel to place and facilitates tracheal intubation. Also, when the head is in the neutral position, during in-line stabilization of the cervical spine, the ILMA is more likely to allow successful ventilation and intubation.

Patients who are difficult to intubate by direct laryngoscopy are often easy to intubate with the ILMA because many anatomic factors that cause difficult direct laryngoscopy do not affect placement or function of the LMA devices. The ILMA is more successful for ventilation and intubation of difficult airways than the LMA, and the failure rate of ILMA intubation of difficult airways is very low (see Chapter 4 for intubation through LMA devices).

The ILMA (ILMA or LMA Fastrach)

The ILMA is an essential rescue ventilation device for the “cannot-intubate/cannot-ventilate” situation. It is also an excellent primary ventilation and intubation device for patients with known difficult airways, especially in cases of severe facial trauma. The ILMA has several advantages over the LMA (see earlier). The ILMA mask is attached to a metal tube and handle. The handle allows one-handed insertion and manipulation. The metal tube has an anatomic curve to fit into the upper airway and is large enough to accept an 8.0-mm cuffed endotracheal tube. The ILMA can be used up to 40 times before being replaced. The disposable ILMA has a hard plastic handle and tube and can be used only once. The ILMA is available only in sizes suitable for adults and children heavier than 30 kg, so the LMA should be used for smaller children and infants.
Indications and Contraindications

The ILMA is indicated as an alternative to bag-mask ventilation or as a conduit for intubation of difficult airways. Its primary use in emergency airway management has been as a rescue device in the cannot-intubate/cannot-ventilate situation. In this situation, adequate ventilation with the ILMA is possible in almost all cases. Ventilation with the ILMA is probably superior to face mask ventilation with inexperienced providers. The ILMA can also be used as a primary ventilation and intubation device for patients with difficult airways. Tracheal intubation through the ILMA can be accomplished using a blind technique, or with light-wand or fiberoptic guidance. The ILMA is especially useful in patients with difficult face mask ventilation owing to a beard, severe facial trauma, or obesity because none of these factors inhibits ILMA placement. When brisk bleeding above the glottis makes ventilation and intubation difficult, the ILMA can prevent aspiration of blood and facilitate blind or fiberoptic intubation. In patients requiring an urgent cricothyotomy or percutaneous needle insertion into the trachea, the ILMA can be used to counteract anterior neck pressure. In this capacity, the ILMA provides temporary ventilation and stabilizes the cervical spine during the surgical airway procedure.

The ILMA is contraindicated in patients with less than 2 cm of mouth opening. The ILMA requires 2 cm of space between the upper and the lower incisors in order to be inserted. The ILMA is relatively contraindicated in awake patients, especially those with a full stomach. Insertion of the ILMA in an awake patient will cause coughing, gagging, or vomiting. If the ILMA is inserted when the patient is awake and the stomach is full, there is a high likelihood of vomiting and aspiration. In the ED, the ILMA should be used only if the patient is unconscious or after a paralytic agent has been given. Once the ILMA is inserted and ventilation is established, the patient should not be allowed to wake up or gag. Consider giving a long-acting paralytic agent or multiple doses of succinylcholine after the ILMA is placed and ventilation is adequate.

Although several studies show that the ILMA is safe and effective for ventilation and intubation during in-line cervical spine stabilization, some evidence shows that the ILMA causes posterior pressure on the midportion of the cervical spine. The clinical importance of cervical spine pressure caused by the ILMA is unknown and the device is generally considered safe in patients with an unstable cervical spine injury. Nevertheless, providers should be aware of this concern and make every effort to stabilize the ILMA in these situations. Ventilation with the ILMA may be difficult or impossible in patients with severely distorted upper airway anatomy, especially those with scarring secondary to cervical radiation therapy.

Placement of the ILMA

The first step is to select the appropriate-sized ILMA. The ILMA is available in three sizes: size 3 for children weighing 30 to 50 kg, size 4 for small adults weighing 50 to 70 kg, and size 5 for adults weighing 70 to 100 kg. When there is doubt about which size is appropriate, it is probably better to use the larger size.

After choosing the correct ILMA, completely deflate the cuff while pushing it posteriorly so that it assumes a smooth wedge shape without any wrinkles. Place a small amount of water-based lubricant onto the posterior surface of the ILMA mask just before insertion. Open the patient's mouth and position the posterior mask tip so that it is flat against the hard palate immediately posterior to the upper incisors. Advance the airway straight into the mouth along the hard palate without rotation until the curved part of the airway tube is in contact with the patient's chin. Then rotate the ILMA completely into the hypopharynx by advancing it along its curved axis, keeping the posterior mask firmly applied to the soft palate and posterior pharynx, until firm resistance is felt. Cricoid pressure impedes proper placement of the ILMA, so consider briefly releasing cricoid pressure while the device is rotated into its final position, wedged into the proximal esophagus. After insertion, the airway tube should emerge from the mouth directed somewhat caudally. Without holding the tube or handle, inflate the mask cuff. The entire device will normally slide backward a bit when the cuff is inflated. Frequently, only half of the maximum cuff volume is sufficient to obtain a good mask seal. Do not overinflate the cuff; this may make the seal worse. See the instruction manual for maximum cuff volumes. Attach a bag and ventilate the patient, using chest rise, breath sounds, and capnography to confirm adequate gas exchange. If bagging is easy and ventilation is good, the aperture of the ILMA is probably aligned correctly over the vocal cords.
If optimal ILMA placement is not initially accomplished, adjusting maneuvers can be attempted. The purpose of adjusting maneuvers is to align the aperture of the ILMA with the glottic opening. Proper positioning of the ILMA aperture with the glottic opening allows optimal ventilation and facilitates tracheal intubation. Before adjusting the ILMA, consider the patient's position and degree of relaxation; both may affect ILMA function. The ILMA works best in the neutral or sniffing position; cervical extension may interfere with proper placement. The patient should not react to ILMA placement with coughing or gagging because this may interfere with proper placement. Have a single operator perform the adjustment maneuvers by gripping the ILMA handle with one hand, in a “frying pan” grip, and providing bag ventilation with the other hand (Fig. 3–11). After each adjustment maneuver, assess the quality of bag ventilation and mask seal. Easy bag ventilation, good chest rise, and the absence of an audible mask leak are indications of good ILMA alignment with the glottis.

To adjust the position of the ILMA, first gently pull the handle toward you without rotation along the ILMA’s curvature. Next, gently push the handle toward the patient's feet without rotating it. Finally, try the “Chandy maneuver,” gently rotating the ILMA farther into the hypopharynx and then lifting the handle toward the ceiling above the patient's feet.
If these simple maneuvers do not result in adequate ventilation, then consider the “up-down maneuver” (Fig. 3–12). This technique is used to correct down-folding of the epiglottis, which is common with insertion of the ILMA and may interfere with ventilation or intubation. The up-down maneuver is accomplished by rotating the ILMA out of the hypopharynx along its curvature about 5 to 6 cm, while the cuff remains inflated, then sliding it back into position while pressing it against the posterior pharynx. Do not use excessive force when placing or adjusting the ILMA.

If adjusting maneuvers do not result in adequate ventilation, it is likely that the wrong size of ILMA has been used. Incorrect ILMA size is more likely to be a problem if the device is too small, so try a larger ILMA as a reasonable first approach. If another ILMA size is not available, external anterior neck manipulation/pressure may bring the glottis and ILMA cuff into proper alignment. If the size of the ILMA is not in question, consider completely removing and carefully reinserting the device (see Chapter 4 for intubation through the ILMA and ILMA removal).

Complications

Complications of ventilation and intubation using the ILMA are rare. Episodes of hypoxia are rare after adequate ventilation is established with the ILMA. The risk of aspiration when using the ILMA in the ED is difficult to assess. There are no reports of significant aspiration in descriptive studies of the ILMA. However, most studies have been performed in the controlled environment of the operating room. The risk of aspiration is likely to be much higher in the ED. The ILMA does provide some protection against gastric inflation and passive regurgitation. However, active vomiting while the ILMA is in place would probably lead to aspiration.

Pressure injury to the pharynx may be caused by prolonged use of the ILMA. This complication is very unlikely in the ED. The potential for pressure injury can be prevented by deflating the ILMA as soon as possible after tracheal intubation is achieved.

The LMA (LMA Classic and LMA Unique)

Insertion and tracheal intubation through the LMA are more complicated. The LMA Classic can be used up to 40 times before being replaced. The LMA Unique is a single-use version of the LMA Classic. The LMA Unique has the same dimensions as LMA Classic but is made out of plastic instead of silicone and is very inexpensive. The LMA Classic and LMA Unique are available in all sizes, including pediatric and neonatal sizes. Because the design and functional characteristics of both devices are the same, we use the term LMA to refer to both devices.

Indications and Contraindications

The LMA should be considered as a primary rescue device for pediatric emergency airway management, because an ILMA is not available for patients who weigh less than 30 kg. The LMA is also a good rescue device for adult emergency airway management, when an ILMA is not available. In addition, a very large adult LMA, size 6, is available for patients who weigh more than 100 kg. The largest available ILMA is a size 5. The LMA is a successful rescue device for rescue ventilation in the cannot-intubate/cannot-ventilate situation. The LMA may provide a more secure and reliable means of ventilation than a face mask. The LMA allows adequate ventilation in 98% of adults with known difficult airways and in 90% to 95% of those with unexpectedly difficult airways. The LMA is useful in patients with brisk bleeding above the glottis or with difficult face mask ventilation owing to a beard, severe facial trauma, or obesity.

Intubation through the LMA is possible, but it requires a smaller endotracheal tube and is more difficult than intubation through the ILMA (see Chapter 4 for intubation through the LMA). Blind intubation through the LMA is not
recommended. Most adults with difficult airways can be successfully intubated through the LMA using a flexible fiberoptic scope; however, there is a higher rate of technical problems, hypoxia, and failed intubation compared with the ILMA. [127]

The LMA is particularly useful as a rescue device in difficult pediatric airways. [127] Two descriptive studies and 86 case reports describe the use of the LMA for difficult pediatric airways. [127] [159] [161] [162] In these reports, ventilation was adequate with the LMA in nearly all pediatric patients. [127] [159] [161] [162] Intubation of pediatric patients through the LMA is usually possible with a small fiberoptic scope. [159] [161] Case series and case reports also suggest that the LMA can provide an effective rescue airway in neonatal resuscitation if bag-mask ventilation and endotracheal intubation fail. [163]

Placement of the LMA

The first step is to select the appropriate-sized LMA. The LMA is available in a wide range of sizes, from size 1 for neonates weighing less than 5 kg to size 6 for adults weighing more than 100 kg. The disposable version is available in sizes 1 through 5, but not size 6. After selecting the proper size, completely deflate the LMA cuff while pushing it posteriorly, so that it forms a smooth wedge shape without any wrinkles (see Fig. 3–7). Place a small amount of water-based lubricant onto the posterior surface of the LMA mask just before insertion. The best patient position for LMA insertion is the sniffing position, with the neck flexed and the head extended. The LMA may be inserted using two different techniques, depending on access to the patient. The most common method is the index finger insertion technique. This is accomplished by holding the LMA like a pen, with the index finger at the junction of the airway tube and the cuff (Fig. 3–13). Have an assistant open the patient's mouth and insert the LMA with the posterior tip pressed against the hard palate just behind the upper incisors. Under direct vision, use the index finger to slide the LMA along the hard palate and into the oropharynx (Fig. 3–14). As the LMA is inserted farther, extend the index finger and push the posterior cuff along the soft palate and the posterior pharynx. Exert counterpressure on the back of the patient's head during insertion. Continue to push the LMA into the hypopharynx until resistance is felt (Fig. 3–15). Use the other hand to hold the proximal end of the LMA airway tube while removing your index finger from the patient's mouth (Fig. 3–16).

**Figure 3–13** LMA insertion. Lubricate the posterior surface of the LMA cuff/mask. Hold the LMA like a pen and place the tip of the index finger at the junction of the airway tube and the cuff. Have an assistant hold the patient's mouth open. Place the posterior tip of cuff against the anterior hard palate just behind the upper incisors.

**Figure 3–14** LMA insertion. Using the index finger, slide the LMA along the hard palate and posterior pharynx. Use the other hand to apply countertraction on the back of the patient's head.
An alternative method is the thumb insertion technique. Use this technique when you have limited access to the patient from behind (see www.lmana.com for details). Hold the LMA with your thumb at the junction of the cuff and the airway tube. Place the mask against the hard palate under direct vision as with the index finger technique. Use the thumb to push the LMA into the mouth along the palate and posterior pharynx. Hold the end of the airway tube with the other hand while removing your thumb from the mouth.

After the LMA is fully inserted, let go of the proximal end of the airway tube and inflate the cuff enough to achieve a good seal with the glottis (Fig. 3–17). This may require only half of the maximum cuff volume. Be careful not to overinflate the LMA cuff (see the product packaging for maximal cuff volumes). Attach a bag and ventilate the patient, using chest rise, breath sounds, and capnography to confirm adequate gas exchange. If bagging is easy and ventilation is good, the aperture of the LMA is probably aligned correctly over the glottic opening. Proper positioning of the LMA aperture with the glottic opening allows optimal ventilation.

Several tips or techniques should be considered if LMA ventilation is inadequate. The best way to ensure proper ventilation is to optimize the insertion technique by carefully following the previously discussed directions. Position the patient's head and neck properly and ensure that the patient is deeply anesthetized or paralyzed. Listen for an audible cuff leak to make sure there is a good mask seal. Adjust the cuff volume if necessary to improve the mask seal and ensure optimal ventilation. Simply adding more air to the cuff will not necessarily improve the mask seal with the glottis. Cuff overinflation may cause a leak, whereas deflation and repositioning may improve the seal.

Sometimes adjusting the patient's head and neck position is easier than trying to change the position of the LMA. Move the patient into a better sniffing position or into the chin-to-chest position so see if this improves the LMA cuff seal. If these positions do not help, or are not possible, then try a jaw-thrust or a chin-lift maneuver. Also, apply anterior neck pressure to help push the glottis down into contact with the LMA mask. This technique can be used in combination with any of the maneuvers just discussed.

If mask seal and ventilation are still not optimal after simple repositioning maneuvers, withdraw, advance, or rotate the LMA cuff. Another alternative is to completely remove and reinsert the LMA, with careful attention to the details described earlier. If unsuccessful, change the LMA size. A larger size LMA will usually improve ventilation even if it is more difficult to insert. It is much more common to need to increase LMA size rather than to decrease LMA size. Finally, consider using the ILMA or the Combitube or performing a surgical airway when ventilation with the LMA is not adequate.

Complications
The most important complications associated with using the LMA are aspiration of gastric contents and hypoxia. Remember that the LMA does not protect against aspiration and may actually cause vomiting if the patient gags when the device is placed. In fasted anesthetized patients, the incidence of aspiration is very low, about 2 per 10,000 cases. There are many descriptive studies and case reports of LMA use for difficult airways with no mention of significant aspiration. Although the risk of aspiration is surely higher than 2 per 10,000 when using the LMA in the ED, there is evidence that it provides some protection from passive regurgitation and produces less gastric inflation than bag-mask ventilation.

The cannot-intubate/cannot-ventilate scenarios are the most common reasons for using the LMA in the ED. In this situation, failure to adequately ventilate and oxygenate with the LMA occurs in about 6% of cases. Another 6% of patients with difficult airways suffer episodes of hypoxia during attempts to intubate through the LMA. There is evidence that the ILMA performs better in the cannot-intubate/cannot-ventilate situation. Failure to ventilate with the ILMA occurs in only about 2% of cases and hypoxia after ILMA placement is very rare. Also, there are more technical difficulties when using the LMA, compared with the ILMA, for difficult airways. This is probably due to the fact that the LMA requires more skill for proper insertion and was not specifically designed to facilitate tracheal intubation.

The Esophageal-Tracheal Combitube

The esophageal-tracheal Combitube (Nellcor, Pleasanton, CA; www.nellcor.com) is an intermediate airway device that can be placed blindly and rapidly. It was designed as a rescue device for difficult and emergency airways. It provides adequate ventilation in up to 95% of patients when it is placed by prehospital providers. When the Combitube is placed by physicians, the success rate approaches 100%. The Combitube has two parallel lumens, a small distal cuff, and a large proximal cuff. When it is placed blindly, the tip will end up in the esophagus in about 90% of cases and in the trachea in about 10% of cases (Fig. 3–18). The longer lumen/tube is used for ventilation when the tip is in the esophagus. It is perforated at the level of the pharynx and occluded at the distal end. The shorter lumen/tube is used for ventilation when the tip is in the trachea. It is open at the distal end, like a standard endotracheal tube. The large proximal cuff/balloon is designed to occlude the pharynx by filling the space between the base of the tongue and the soft palate. The small distal cuff serves as a seal in either the esophagus or the trachea. The Combitube compares favorably with the endotracheal tube with respect to ventilation and oxygenation in cardiac arrest situations. In the unconscious patient, the Combitube may provide adequate protection from aspiration.

**Figure 3–18** Esophageal-tracheal Combitube. The distal tube and cuff can be placed into either the esophagus (solid lines) or the trachea (dotted lines). The operator must quickly determine where the tip of the device is located, in order to ventilate the correct airway tube.

**Indications and Contraindications**

The Combitube is a good choice as a primary airway in patients who are unresponsive or in cardiac arrest, especially in the uncontrolled prehospital environment. The Combitube can also be used in any emergency airway setting for rescue ventilation after failed bag-mask ventilation or failed intubation. In cases of failed intubation, with an unexpectedly difficult airway, the Combitube may be used to provide adequate ventilation and allow time for other methods of intubation or a controlled surgical airway. The Combitube should not be used in patients with an intact gag reflex and is not recommended in patients shorter than 4 feet tall. It is contraindicated in suspected caustic poisonings or proximal esophageal disorders.

**Placement of the Combitube**
The Combitube is available in two sizes. The manufacturer recommends the smaller 37 French device for patients 4 feet to 5 feet 6 inches tall, and the larger 41-French device for patients over 5 feet tall. However, studies suggest that the smaller 37-French Combitube can be safely used in patients up to about 6 feet tall. The larger 41-French device is appropriate for patients over 6 feet tall.

To insert the Combitube, hold the device in the dominant hand and gently advance it caudally into the pharynx while grasping the tongue and jaw between the thumb and the index finger of the nondominant hand. Pass the tube blindly along the tongue to a depth that places the printed rings on the proximal end of the tube between the patient’s teeth and the alveolar ridge. If resistance is met in the hypopharynx, remove the tube and bend it between the balloons for several seconds to facilitate insertion. After insertion, fill the pharyngeal balloon with 100 mL of air, and fill the distal cuff with 10 to 15 mL of air. The large pharyngeal balloon serves to securely seat the Combitube in the oropharynx and to create a closed system in the case of esophageal placement. Because about 90% of placements are esophageal, begin ventilation through the longer (blue) airway tube.

Look for chest rise, good breath sounds, and capnography, without gastric inflation, to confirm proper ventilation. Alternatively, use a Wee-type aspirator device on the shorter (clear) lumen to confirm that the tip is in the esophagus, prior to ventilation through the longer (blue) lumen. The inability to easily aspirate air confirms esophageal placement. Easy aspiration with the Wee-type device indicates a tracheal positioning of the tube and requires changing the ventilation to the shorter (clear) tracheal lumen.

If there is confusion about the location of the Combitube tip, use capnography to ensure that the correct airway tube is being ventilated. However, capnography may be confusing in cases of cardiac arrest.

If the Combitube is in the esophageal position, suction the stomach by passing a catheter through the shorter (clear) lumen into the stomach while the patient is being ventilated via the longer (blue) lumen.

Complications

Inappropriate balloon inflation and incorrect Combitube placement can lead to air leaks during ventilation. The most common placement error is an improper insertion angle. Use a more caudal, longitudinal direction of insertion as opposed to an anteroposterior direction of insertion. The Combitube must also be maintained in the true midline position during insertion to avoid blind pockets in the supraglottic area, which can prevent the passage of the tube. Attention to aligning the ring markings on the tube at the level of the incisors ensures proper positioning of the tube.

The Laryngeal Tube

The laryngeal tube (King LT, King Systems Corporation, Noblesville, IN; www.kingsystems.com) is a relatively new supraglottic airway somewhat similar to the Combitube. Like the Combitube, the King LT is designed to isolate the glottic opening between an oropharyngeal cuff and an esophageal cuff (Fig. 3–19). Unlike the Combitube, the King LT has only one airway lumen and a simplified cuff system, so that both cuffs can be inflated with a single airway port. Multiple versions of the King LT have been clinically tested and the latest version is promising.

Like the Combitube, the King LT is designed for blind placement and has a large proximal cuff and small distal cuff. Unlike the Combitube, the tip of the King LT is designed to be placed into the esophagus only. The shape of the King LT and the size of the tip make it unlikely to be placed into the trachea.
When the King LT is properly placed, positive-pressure ventilation is unlikely to cause a gas leak or gastric inflation. Some data show that the King LT may provide a better seal in the oropharynx than the LMA. The King LT-D is a disposable version of the King LT. The King LT-D is designed with the same specifications as the reusable King LT. The King LTS-D is a disposable device exactly like the King LT-D, except for the addition of a distal suction port. There are limited but positive data about the use of the King LT in the emergency and difficult airway settings. The King LT-D is becoming popular in the prehospital setting and is replacing the Combitube in some EMS systems.

Indications and Contraindications

In the ED, indications for using the King LT are the same as those for the Combitube. It appears to be a good rescue ventilation device for failed bag-mask ventilation or failed intubation. Because the King LT is a supraglottic airway and is designed to be placed blindly, it is relatively contraindicated in patients with foreign body upper airway obstruction.

Placement of the King LT

The first step is to choose the proper size King LT. It is available only in adolescent and adult sizes in the United States. The size 3 is yellow and designed for patients 4 to 5 feet in height, the size 4 is red and designed for patients 5 to 6 feet in height, and the size 5 is purple and designed for patients over 6 feet in height. Several pediatric sizes are available in Europe, but not in the United States.

After determining the appropriate-sized King LT, check the cuffs and then completely deflate them prior to placement. Lubricate the device with a water-based lubricant. The best patient position for insertion of the King LT is the sniffing position, but it can be placed with the head in the neutral position if necessary. Hold the LT at the connector with the dominant hand and hold the mouth open by grasping the chin with the nondominant hand. Introduce the tip of the device into the corner of the mouth while rotating the tube 45° to 90° so that the blue orientation line on the tube is touching the corner of the mouth. Pass the tip of the device into the mouth and under the tongue. As the tip passes under the base of the tongue, rotate the tube back to the midline so that the blue orientation line faces the ceiling. Without exerting force, advance the King LT until the connector is aligned with the teeth. Inflate the cuffs with the minimum volume necessary to create a good seal (see product brochure for maximum cuff volumes). Ventilate with a bag-valve system and confirm placement with chest rise, breath sounds, and capnography.

Complications

Because the King LT is a relatively new device, complications are not extensively documented. The most serious potential complication is tracheal placement. Unlike the Combitube, the tip of the King LT should never go into the trachea. Tracheal placement of the King LT would result in complete airway obstruction and no ventilation of the lungs. Improper placement may result in poor ventilation and injury to the upper airway, especially if the device is not kept in the midline during insertion.

DECISION-MAKING IN EMERGENCY AIRWAY MANAGEMENT

The airway provider must have many tools readily available to deal with the acutely compromised airway. It is important to be proficient in a number of different techniques and to tailor their use to the needs of the individual patient. Rescuers should practice potential scenarios before facing patients with a compromised airway. Failure to do so may lead to unnecessarily aggressive management in some situations or to irreversible hypoxic injury as a result of hesitation in others. Deciding who requires a definitive airway and who needs only supportive measures is a formidable task for even the most skilled clinician.

BOX 3–1

Decision-Making in Emergency Airway Management
Although it is common knowledge that airway management is the first priority in the management of any seriously ill or injured patient, its importance is sometimes underestimated. Failure to treat airway management as the top priority can lead to serious errors in patient care and often presages a cycle of patient deterioration and misguided therapeutic intervention.

The following parameters should be assessed before the decision is made to establish a definitive airway:

- Adequacy of current ventilation.
- Potential for hypoxia.
- Airway patency.
- Need for neuromuscular blockade (full stomach, teeth clenching).
- Cervical spine stability.
- Safety of the technique and skill of the operator.

Consideration of these factors should guide the clinician in selecting the optimal technique. Choosing the initial approach is often straightforward. Difficulty arises precipitously when the initial approach fails. Time becomes critical as the risk of irreversible hypoxic injury and cardiac arrest rises. Anxiety then increases and the potential for error increases. Forethought and practice are invaluable when managing these situations.

**Rapid Sequence Induction/Intubation (RSI)**

Rapid sequence induction of anesthesia has evolved since the introduction of succinylcholine in 1951. The term RSI was initially used as an abbreviation for rapid sequence induction, but is now synonymous with rapid sequence intubation. Initially, the main purpose of RSI was to avoid positive pressure ventilation and prevent gastric inflation in patients at risk of aspiration. RSI has become the most common method of emergency airway management because it provides optimal conditions for direct laryngoscopy. Providers using RSI must appreciate the importance of basic skills like preoxygenation, patient positioning and bag-mask ventilation.

Emergency providers should be very careful not to use RSI in a cavalier manner. When giving a paralytic agent, the provider takes complete responsibility for airway maintenance, ventilation, and oxygenation of the patient. Consider awake intubation in patients with known difficult airways. RSI is contraindicated in patients who cannot be orally intubated. RSI should be avoided in patients with laryngotracheal abnormalities caused by tumors, infection, edema or a history of cervical radiation therapy.

One of the most important concepts to understand when using RSI is the concept of optimal laryngoscopy, to maximize first pass success. Preparation, preoxygenation, proper patient positioning, anterior neck maneuvers, and good laryngoscopy skills are all important components of optimal laryngoscopy (see Chapter 4). Also, maximizing RSI success requires that providers understand when to avoid RSI. Patient safety during RSI depends on the provider's ability to maintain ventilation and oxygenation if the first attempt at laryngoscopy fails. In this situation, bag-mask ventilation restores oxygenation and allows multiple laryngoscopy attempts. The importance of bag-mask ventilation skills cannot be overstated. Good bag-mask skills allow the emergency airway provider to be less anxious about laryngoscopy and improve the chances of successful RSI.

**Difficult Airways and When to Avoid RSI**

The term difficult airway is popular, but there is no standard definition of this term. Many use it to describe patients who are difficult to intubate using direct laryngoscopy. Subsequently there is a significant amount of literature dedicated to predicting difficult laryngoscopy. However, even in the best circumstances only 50% of cases of difficult laryngoscopy can be predicted. Many factors such as Mallampati scoring and measurement of thyromental distance have not been found to accurately predict difficult laryngoscopy, especially in the emergency setting.
Only obvious anatomic and pathologic abnormalities, or a history of difficult intubation are accurate predictors of difficult laryngoscopy (see Chapter 4).

In the emergency setting it is more useful to think of difficult airways as situations where our usual methods of ventilation and intubation fail. Our goal should be to avoid RSI on patients who cannot be ventilated with a bag-mask device and cannot be intubated by direct laryngoscopy. Risk factors for difficult bag-mask ventilation have not been studied as thoroughly, but there is good evidence that the presence of a beard, obesity, lack of teeth, age over 55 years, and a history of snoring all make bag-mask ventilation more difficult (Table 3–3). The realization that we cannot predict all cases of difficult ventilation and difficult laryngoscopy mandates the need for reliable back-up devices like the ILMA/LMA and the Combitube. There is no doubt that use of the LMA and ILMA has decreased the frequency of failed airways (Fig. 3–20). Finally, if RSI is our usual method of intubation, we must be prepared to perform a surgical airway when laryngoscopy, bag-mask ventilation, and back-up devices fail.

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>LMA</th>
<th>Disposable LMA</th>
<th>ILMA</th>
</tr>
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<tbody>
<tr>
<td>&lt;5</td>
<td>1</td>
<td>—</td>
<td>—</td>
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<tr>
<td>5–10</td>
<td>1.5</td>
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<td>10–20</td>
<td>2</td>
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<tr>
<td>20–30</td>
<td>2.5</td>
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<td>30–50</td>
<td>3</td>
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<td>50–70</td>
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<td>70–100</td>
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<tr>
<td>&gt;100</td>
<td>6</td>
<td>—</td>
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ILMA, intubating laryngeal mask airway; LMA, laryngeal mask airway.

* Note that only standard LMA is available for patients <30 kg.
Emergency Airway Management Algorithm

The algorithm presented here summarizes the general approach used in the Department of Emergency Medicine at Hennepin County Medical Center (Fig. 3–21 and Table 3–4). This algorithm is presented as an example. Individual providers and institutions should determine their own algorithms based on the availability of skills and resources. There are many similarities between this algorithm and those put forth by the American Society of Anesthesiologists and the Difficult Airway Society. However, ours is simple and more applicable to emergency airway management. Most published airway algorithms are not ideal for emergency airway management because they do not account for the conditions that we commonly face; patients with full stomachs who are critically ill and often uncooperative, and intubations that cannot be canceled if the airway is too difficult. Also, many algorithms resemble wish lists of equipment and skills that are simply not available to most emergency airway providers. We stress basic airway skills like preparation/preoxygenation, direct laryngoscopy, and bag-mask ventilation. We also stress the importance of the bougie and the ILMA or LMA as effective basic rescue devices (see Chapter 4 for a discussion of the bougie). Combes and coworkers validated this approach in a large prospective study.

Figure 3–21  Emergency airway management algorithm used at Hennepin County Medical Center. The end point of the algorithm is successful tracheal intubation. This algorithm is presented as an example. Individuals and institutions should formulate their own algorithms based on the availability of skills and resources.

TABLE 3–4  -- “Other” Intubation Methods for Emergency Airway Management

<table>
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<tr>
<th>Method</th>
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<tr>
<td>Flexible fiberoptics</td>
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<tr>
<td>Rigid/semirigid fiberoptics</td>
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<tr>
<td>Video laryngoscopy</td>
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<td>Lighted stylet</td>
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</tbody>
</table>
Conclusion

Good basic airway management skills, a clear preconceived plan and the availability of proven rescue devices are the keys to dealing with airway emergencies. There are many techniques and devices that can be used to manage emergency airways. However, in difficult situations providers will probably have the best success with techniques and devices with which they are the most familiar.

Acknowledgments

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