PART I

Fundamental Clinical Concepts
Airway management is the cornerstone of resuscitation and is a defining skill for the specialty of emergency medicine. The emergency physician has primary responsibility for management of the airway. All techniques of airway management lie within the domain of emergency medicine. Rapid sequence intubation (RSI) with direct laryngoscopy is the most commonly used method for emergency intubation, but emergency airway management includes various intubation maneuvers, use of ancillary devices, approaches to the difficult airway, and rescue techniques when intubation fails.

Since the first reported use of neuromuscular blocking agents (NMBAs) in the emergency department (ED) by emergency personnel in 1971, there has been progressive sophistication of emergency airway techniques, pharmacologic agents, and special devices used to facilitate intubation. In the 1990s, RSI was widely adopted as the method of choice for most emergency intubations in the ED, and increasing attention has focused on identification and management of anticipated difficult intubation.

Decision to Intubate
A decision to intubate should be based on careful assessment of the patient with respect to three essential criteria: (1) failure to maintain or protect the airway, (2) failure of ventilation or oxygenation, and (3) the patient’s anticipated clinical course and likelihood of deterioration.

Failure to Maintain or Protect the Airway
A patent airway is essential for adequate ventilation and oxygenation. If the patient is unable to maintain the airway, patency must be established by artificial means, such as repositioning, chin lift, jaw thrust, or insertion of an oral or nasal airway. Likewise, the patient must be able to protect against aspiration of gastric contents, which carries significant morbidity and mortality. Traditionally, the presence or absence of a gag reflex has been advocated as a reliable indicator of the patient’s ability to protect the airway, but the gag reflex is absent in 12 to 25% of normal adults, and there is no evidence that its presence or absence corresponds to airway protective reflexes or the need for intubation. Testing the gag reflex in an obtunded, supine patient is unlikely to yield useful information with respect to the need to intubate and may precipitate vomiting. The patient’s ability to swallow or handle secretions is a more reliable indicator of airway protection. The recommended approach is to evaluate the patient’s ability to phonate in response to voice command or query (which provides information about level of consciousness and voice quality), level of consciousness, and ability to manage his or her own secretions (e.g., pooling of secretions in the oropharynx, absence of swallowing spontaneously or to command.) In general, a patient who requires a maneuver to establish a patent airway or who easily tolerates an oral airway probably requires intubation for protection of that airway, unless a temporary or readily reversible condition, such as opioid overdose, is present.

Failure of Ventilation or Oxygenation
Ventilatory failure that is not reversible by clinical means or increasing hypoxemia that is not adequately responsive to supplemental oxygen is a primary indication for intubation. This assessment is clinical and includes evaluation of the patient’s general status, oxygenation by pulse oximetry, and changes in the ventilatory pattern. Continuous capnography also can be helpful, but is not essential if oximetry readings are reliable. Arterial blood gases (ABGs) generally are not required to determine the patient’s need for intubation. In most circumstances, clinical assessment, including pulse oximetry with or without capnography, and observation of improvement or deterioration lead to a correct decision. ABG results are rarely helpful, may cause delay in intubating a deteriorating patient, and may be misleading, so, if obtained, they must be interpreted carefully in the context of the patient’s clinical status. Patients who are clinically improving despite severe or worsening ABG alterations may not require intubation, whereas a rapidly tiring patient may require intubation when ABG values are only modestly disturbed or even improving.

Regardless of the underlying cause, the need for mechanical ventilation generally mandates intubation. External mask devices increasingly have been used to provide assisted mechanical ventilation without intubation (see Chapter 2), but despite these advances, most patients who need assisted ventilation or positive pressure to improve oxygenation require intubation.
**Anticipated Clinical Course**

Certain conditions indicate the need for intubation even in the absence of frank airway, ventilatory, or oxygenation failure. These conditions are characterized by a moderate to high likelihood of predictable deterioration that would require airway intervention. Intubation may be indicated relatively early in the course of severe cyclic antidepressant overdose. Although the patient is awake, protecting the airway, and exchanging gas well, intubation is advisable to guard against the strong likelihood of clinical deterioration, which can occur relatively abruptly and includes coma, seizure, cardiac dysrhythmia or arrest, and possible aspiration of activated charcoal or gastric contents.

Significant multiple trauma, with or without head injury, may be an indication for intubation. Many of these patients are ventilating normally through a patent airway, and oxygen levels frequently are normal or supernormal with supplemental oxygen. Despite this, anticipated deterioration, loss of the ability to protect the airway, the need for invasive and painful procedures, or the need for studies outside the ED (e.g., computed tomography, angiography) may mandate intubation. A patient with penetrating neck trauma may present with a patent airway and adequate gas exchange. Nevertheless, early intubation is advisable with any evidence of vascular or direct airway injury because these patients tend to deteriorate and because increasing hemorrhage or swelling in the neck tends to both compromise the airway and confound later attempts at intubation.

Although these indications for intubation may seem quite different and individualized, the common thread is the anticipated clinical course over time. In each circumstance, it can be anticipated that future events will compromise either the patient’s ability to maintain and protect the airway or the patient’s ability to oxygenate and ventilate. A similar thought process is applied to any patient who will be leaving the ED for diagnostic studies (e.g., angiography) or who may be transported to another facility. If it seems clinically likely that the patient may deteriorate, then “preemptive” intubation is the prudent course.

**Identification of the Difficult Airway**

The emergency nature of the patient’s presentation often precludes postponement of the intubation, even for a short time, but knowledge of the difficulties presented by the patient’s airway permits thoughtful planning and preparation for possible intubation failure. Preintubation assessment should evaluate the patient for difficult intubation, difficult BMV, difficult ventilation using an extraglottic device (EGD, such as a laryngeal mask airway, see later discussion) and difficult cricothyrotomy. Knowledge of all four domains is crucial to successful planning.

Neuromuscular paralysis should be avoided in patients for whom a high degree of intubation difficulty is predicted, unless the administration of the NMBA is part of a planned approach to the difficult airway. This approach may include use of a double setup, in which an alternative approach, such as cricothyrotomy, is simultaneously prepared.

Preintubation evaluation should be as comprehensive as clinical circumstances permit. A systematic approach to the patient is required.

**Difficult Direct Laryngoscopy: LEMON**

Most of the difficult airway markers discussed in the anesthesia and emergency medicine literature have not been scientifically validated. Nevertheless, a methodical approach can be used to evaluate the patient, based on the accepted markers of difficult intubation by direct laryngoscopy. One such approach uses the mnemonic LEMON (Box 1-1). 

1. **L**ook **E**xternally. The patient first should be examined for external markers of difficult intubation, which are determined based simply on the intubator’s clinical impression. For example, the severely bruised and bloodied face of a combative trauma patient, immobilized in a cervical collar on a spine board, might (correctly) invoke an immediate appreciation of anticipated difficult intubation. Subjective clinical judgment can be highly specific (>90%), but insensitive and so must be augmented by other evaluations.

2. **E**valuate **3**-**3**-**2**. The second step in the evaluation of the difficult airway is to assess the patient’s anatomy to determine his or her suitability for direct laryngoscopy. Direct laryngoscopy requires the ability to visualize the glottis by direct vision through the mouth, using alignment of the oral, pharyngeal, and laryngeal axes. Visualization requires that the mouth open adequately, that the submandibular space be adequate to accommodate the tongue, and that the larynx be positioned low enough in the neck to be accessible. These relationships have been explored in various studies by external measurement of mouth opening, oropharyngeal size, neck movement, and thyromental distance. The “3-3-2 rule” is an effective summary of these geometric evaluations. The 3-3-2 rule requires that the patient be able to place 3 of his or her own fingers between the open incisors, 3 of his or her own fingers along the floor of the mandible beginning at the mentum, and 2 fingers from the laryngeal prominence to the floor of the

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**Box 1-1**

**“LEMON” Approach for Evaluation of Difficult Direct Laryngoscopy**

- Look externally for signs of difficult intubation (by gestalt)
- Evaluate the “3-3-2 rule”
- Mallampati
- Obstruction/Obesity
- Neck mobility

mandible (Fig. 1-1). A patient with a receding mandible and high-riding larynx can be impossible to intubate using direct laryngoscopy. Most patients are not sufficiently cooperative for such an evaluation, and the operator compares his or her fingers with the patient’s fingers to estimate the sizes for the three tests.

**M—Mallampati Scale.** Oral access is assessed using the Mallampati scale (Fig. 1-2). Visibility of the oral pharynx ranges from complete visualization, including the tonsillar pillars (class I), to no visualization at all, with the tongue pressed against the hard palate (class IV). Class I and class II predict adequate oral access, class III predicts moderate difficulty, and class IV predicts a high degree of difficulty.22,23 A recent meta-analysis confirmed that the four-class Mallampati score performs well as a predictor of difficult laryngoscopy (and, less so, difficult intubation), but that the Mallampati score, alone, is not a sufficient assessment tool.24

**O—Obstruction or Obesity.** Upper airway (supraglottic) obstruction may make visualization of the glottis, or intubation itself, mechanically impossible. Conditions such as epiglottitis, laryngeal tumor, Ludwig’s angina, neck hematoma, or glottic polyps can compromise laryngoscopy, passage of the endotracheal tube (ETT), BMV, or all three. Physical examination for airway obstruction is combined with assessment of the patient’s voice to satisfy this evaluation step. There is conflicting evidence regarding whether obesity is itself an independent marker of difficult intubation or whether patients with obesity simply are more likely to have other markers of difficult intubation.25,26 Regardless, obese patients generally are more difficult to intubate than their non-obese counterparts, and preparations must account both for this, and for the more rapid oxyhemoglobin desaturation and increased difficulty with ventilation using bag and mask or an EGD (see below) that will occur.

**N—Neck Mobility.** Neck mobility is essential for the repositioning of the angled axes of the upper airway in order to permit direct visualization of the glottis. Neck mobility is assessed by having the patient flex and extend the head and neck through a full range of motion. Neck extension is the most important motion, and simple extension may be as effective as the “sniffing” position in achieving an optimal laryngeal view.27 A recent study also found that the “extension-extension” position, in which the neck is extended on the body (opposite of the sniffing position) with the head extended on the neck, provides superior laryngeal views to the sniffing position.28 Modest limitations of motion do not seriously impair laryngoscopy, but severe loss of motion, as can occur in ankylosing spondylitis or rheumatoid arthritis, for example, may render laryngoscopy impossible. Cervical spine immobilization in trauma artificially reduces cervical spine mobility and predicts a more difficult laryngoscopy, but direct laryngoscopy is still highly successful in this group of patients.9
Identification of a difficult intubation does not preclude use of an RSI technique (see Fig. 1-7). The crucial determination is whether the clinician judges that the patient has a reasonable likelihood of intubation success, despite the difficulties identified, and that ventilation with a bag and mask or an EGD will be successful in the event that intubation fails (hence the value of the BMV and EGD assessments; see Boxes 1-2 and 1-3).

**Difficult Bag-mask Ventilation: MOANS**

Attributes of difficult BMV have largely been validated and can be summarized with the mnemonic MOANS (see Box 1-2). \(^{3,17,18}\)

- Difficulty with mask seal; obstruction (particularly supra-glottic obstruction, but can be present anywhere in the airway) or obesity (because of redundant upper airway tissues, chest wall weight, and resistance of abdominal mass); advanced age (best judged by the physiologic appearance of the patient, but age older than 55 years increases risk); edentulousness (“no teeth”), which independently interferes with mask seal; and stiffness or resistance to ventilation (e.g., asthma, chronic obstructive pulmonary disease, pulmonary edema, restrictive lung disease, term pregnancy) all cause or contribute to increased difficulty with BMV. The difficulty with BMV of the edentulous patient is the basis of the adage: “Remove dentures to intubate, leave them in to bag-mask ventilate.” The wisdom of this approach recently was validated yet again.\(^{29}\)

**Difficult Extraglottic Device Placement: RODS**

Placement of an EGD, such as a laryngeal mask airway, a Combitube, or a similar upper airway device often can facilitate ventilation, and convert a “can’t intubate, can’t oxygenate” situation to a “can’t intubate, can oxygenate” situation, which allows time for more careful planning of the rescue of a failed airway (see following section.) Difficulty achieving placement or ventilation using an EGD is predicted by the mnemonic “RODS.” Fortunately, if the clinician has already performed the LEMON and MOANS assessments, only the “D” for distorted anatomy remains to be evaluated (see Box 1-3).

**Difficult Cricothyrotomy**

Difficult cricothyrotomy can be anticipated whenever there is disturbance of the ability to locate and access the landmarks of the anterior airway via the neck. Prior surgery; the presence of hematoma, anatomic disruption, tumor, or abscess; scarring (as from radiation therapy or prior injury); or obesity, edema, or subcutaneous air each has the potential to make cricothyrotomy more difficult. The landmarks for cricothyrotomy are sought and identified as part of the preintubation assessment of the patient.

**Measurement of Intubation Difficulty**

The actual degree to which an intubation is “difficult” is highly subjective, and quantification is challenging. Research has relied on laryngoscopic view to characterize the intubation difficulty, and the most widely used system is that of Cormack and Lehane, which grades laryngoscopy according to the extent to which laryngeal and glottic structures can be seen.

- Grade 1 laryngoscopy, the entire glottic aperture is seen.
- Grade 2 laryngoscopy visualizes only a portion of the glottis (arytenoid cartilages alone or arytenoid cartilages plus part of the vocal cords). Grade 3 laryngoscopy visualizes only the epiglottis. In grade 4 laryngoscopy, not even the epiglottis is visible.

Research conducted on elective anesthesia patients suggests that true grade 4 laryngoscopy, which is associated with impossible intubation, occurs in less than 1% of patients. Grade 3 laryngoscopy, which represents extreme intubation difficulty, is found in less than 5% of patients. Grade 2 laryngoscopy, which occurs in 10 to 30% of patients, can be subdivided further into grade 2a, in which arytenoids and a portion of the vocal cords are seen, and grade 2b, in which only the arytenoids are seen. Intubation failure occurs in 67% of grade 2b cases but in only 4% of grade 2a cases.\(^{30}\) Approximately 80% of all grade 2 laryngoscopies are grade 2a; the rest are grade 2b. A grade 1 view is associated with virtually 100% intubation success. An alternative system, the POGO (percentage of glottic opening) also has been proposed and validated, but is not widely used or studied.\(^{31}\)

**Confirmation of Endotracheal Tube Placement**

The most serious complication of endotracheal intubation is unrecognized esophageal intubation with resultant hypoxic brain injury. Although direct visualization of the ETT passing through the vocal cords generally is a reliable indicator of tracheal intubation, such clinical anatomic observations are fallible, and additional means are required to ensure correct placement of the tube within the trachea. Traditional methods, such as chest auscultation, gastric auscultation, bag resistance, exhaled volume, visualization of condensation within the ETT, and chest radiography, all are prone to failure as means of confirming tracheal intubation.\(^{32}\) Other clinical techniques are readily available for detecting tracheal or esophageal intubation.

Immediately after intubation, the intubator should apply an end-tidal carbon dioxide (ETCO\(_2\)) detection device to the ETT and assess it through six manual ventilations. Disposable, colorimetric ETCO\(_2\) detectors are highly reliable, convenient, and easy to interpret, indicating adequate CO\(_2\) detection by color change (Figs. 1-3 and 1-4) (see Chapter 3). ETCO\(_2\) detection is highly reliable in determining tracheal and esophageal intubation in patients with spontaneous circulation.\(^{33}\) These devices indicate the carbon dioxide content in exhaled
In patients with cardiopulmonary arrest, a CO₂ level greater than 2%, which is the threshold for color change on colorimetric devices, should be considered definitive evidence of esophageal intubation. This circumstance arises in approximately 25 to 40% of intubated cardiac arrest patients. Aspiration technique, which is based on the anatomic differences between the trachea and the esophagus, is easy and rapid. Bulb or syringe aspiration devices may be used in patients with cardiac arrest who have no detectable CO₂, but although such devices are highly reliable at detecting esophageal intubation (sensitivity > 95%), false-positives, in which a correctly placed tracheal tube is incorrectly identified as esophageal, can occur in up to 25% of cardiac arrest patients.

Pulse oximetry is indicated as a monitoring technique in all critically ill patients, not just those who require intubation. Oximetry is useful in detecting esophageal intubation, but devices may be useful in the out-of-hospital setting when poor lighting hampers colorimetric ETCO₂ determination. They also are good backup devices when cardiac arrest confounds attempts to assess placement using ETCO₂. Detection of expired CO₂ is more reliable and should be considered the standard for confirmation of tracheal placement of an ETT and for early detection of accidental esophageal intubation. Aspiration devices have a valuable, but secondary role.

Repeat laryngoscopy generally is insufficient to “confirm” that the tube is through the glottis because error and misinterpretation can occur, especially if the clinician confirming the intubation is the same person who intubated in the first place. The objective instrument (ETCO₂) should be considered correct. Complete obstruction of the trachea or both mainstem bronchi, which prevents ventilation of the patient with even small tidal volumes, can lead to failure to detect CO₂ even when the tube is in the trachea. In the absence of known or suggested complete large airway obstruction, however, failure to detect CO₂ should not be ascribed to other causes, such as severe asthma, in which the physician might postulate that adequate CO₂ exchange is not occurring for physiologic reasons. Absent equipment failure, this generally does not occur, and detection failure should be equated with intubation failure.

Accordingly, ETCO₂ detection, with aspiration as backup, should be considered the primary means of ETT placement confirmation. Secondary means include physical examination findings, oximetry, and radiography. The examiner should auscultate both lung fields and the epigastic area. Auscultation of typical hollow, gurgling, gastric sounds in the epigastrium is highly suggestive of esophageal intubation and should prompt consideration of immediate reintubation. Diminished or absent breath sounds on one side (usually the left side) indicate main stem bronchus intubation, in the absence of pneumothorax or an alternative cause of unilateral loss of breath sounds. Persistent, obvious leak despite positive ETCO₂ detection indicates cuff malfunction or supraglottic placement of the ETT, such that the tube is in the airway, detecting CO₂, but above the vocal cords. In either case (main stem bronchus intubation or supraglottic intubation), tube malpositioning can be confirmed by inspection of the depth of insertion of the tube, supplemented by chest radiography when needed. If malpositioning is detected, repositioning is indicated.

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**Figure 1-3.** End-tidal CO₂ detector before application. The indicator is purple, which indicates failure to detect CO₂. This also is the appearance when the esophagus is intubated.

**Figure 1-4.** Positive detection of CO₂ turns the indicator yellow, indicating tracheal placement of the endotracheal tube.
may not show a decreasing oxygen saturation for several minutes after a failed intubation because of the oxygen reservoir (preoxygenation) created in the patient before intubation.\textsuperscript{35} Oximetry may be particularly misleading in a spontaneously breathing patient who has had an inadvertent nasoesophageal intubation and did not have the ET\textsubscript{CO}_2 measured. In this case, oxygen saturation may be preserved because of spontaneous respirations, but catastrophe can ensue if the patient is later paralyzed or heavily sedated in the mistaken belief that the tube is in the trachea.

Although chest radiography is universally recommended after ETT placement, its primary purpose is to ensure that the tube is well positioned below the cords and above the carina. A single anteroposterior chest radiograph is not sufficient to detect esophageal intubation, although esophageal intubation may be detected if the ETT is clearly outside the air shadow of the trachea. In cases where doubt persists, a fiberoptic scope can be passed through the ETT to identify tracheal rings, a “gold standard” for confirmation of tracheal placement.

\section*{MANAGEMENT}

\subsection*{Approach to Intubation}

After it is determined that the patient requires intubation, an approach must be planned. Algorithms for emergency airway management have been developed and provide a useful guide, both for planning intubation and for rescue in the event of intubation failure.\textsuperscript{4} The algorithm in Figure 1-5 assumes that a decision to intubate has been made and outlines such an approach. The approach is predicated on two key determinations that must be made before active airway management is begun (see Fig. 1-5). The first determination is whether the patient is in cardiopulmonary arrest or a state near to arrest and is predicted to be unresponsive to direct laryngoscopy. Such a patient (agonal, near death, circulatory collapse) is called a “crash airway” patient for the purposes of emergency airway management and is treated using the crash airway algorithm by immediate intubation without use of drugs, supplemented by a single dose of succinylcholine if the attempt to intubate fails and the patient is felt not to be sufficiently relaxed (Fig. 1-6). Next, it must be determined whether the patient represents a difficult intubation as determined by the LEMON, MOANS, and RODS evaluations. If so, the difficult airway algorithm is used (Fig. 1-7).

For all other cases, that is, for all patients who require emergency intubation but who have neither a crash airway nor a difficult airway, RSI is recommended. RSI provides the safest and quickest method of achieving intubation in such

![Figure 1-5. Main emergency airway management algorithm. OTI, orotracheal intubation; RSI, rapid sequence intubation. (Adapted from Walls RM, Murphy MF [eds]: Manual of Emergency Airway Management, 3rd ed. Philadelphia, Lippincott Williams & Wilkins, p. 11, 2008. Copyright © 2008 The Difficult Airway Course: Emergency and Lippincott Williams & Wilkins.)](image1)

![Figure 1-6. Crash airway algorithm. IVP, intravenous push. (Adapted from Walls RM, Murphy MF [eds]: Manual of Emergency Airway Management, 3rd ed. Philadelphia, Lippincott Williams & Wilkins, p. 14, 2008. Copyright © 2008 The Difficult Airway Course: Emergency and Lippincott Williams & Wilkins.)](image2)
After administration of the RSI drugs, intubation attempts are repeated until the patient is intubated or a failed intubation is identified. If more than one intubation attempt is required, oxygen saturation is monitored continuously, and if saturation falls to 90% or less, BMV is performed until saturation is recovered for another attempt. If the clinician cannot maintain oxygen saturation with BMV, despite optimal use of a two-person, two-handed technique with an oral airway in place, a failed airway exists. This is referred to as a “can't intubate, can't oxygenate” situation. In addition, if three attempts at direct laryngoscopy have been unsuccessful, a failed airway exists because subsequent attempts at laryngoscopy by the same clinician are unlikely to succeed. The three failed laryngoscopy attempts are defined as attempts at an experienced clinician, using best possible patient positioning and technique. A further attempt at direct laryngoscopy by the same clinician or one of equivalent experience is advisable, unless the clinician identifies a specific situation on the third laryngoscopy that is amenable to correction, justifying a fourth attempt. Also, if the clinician ascertains after even a single attempt that intubation will be impossible (e.g., grade IV laryngoscopic view despite optimal patient positioning), a failed airway is present. The failed airway is managed according to the failed airway algorithm (Fig. 1-8).

**Difficult Airway**

When preintubation evaluation has identified a potentially difficult airway, a different approach is used (see Fig. 1-7). After administration of the RSI drugs, intubation attempts are repeated until the patient is intubated or a failed intubation is identified. If more than one intubation attempt is required, oxygen saturation is monitored continuously, and if saturation falls to 90% or less, BMV is performed until saturation is recovered for another attempt. If the clinician cannot maintain oxygen saturation with BMV, despite optimal use of a two-person, two-handed technique with an oral airway in place, a failed airway exists. This is referred to as a “can't intubate, can't oxygenate” situation. In addition, if three attempts at direct laryngoscopy have been unsuccessful, a failed airway exists because subsequent attempts at laryngoscopy by the same clinician are unlikely to succeed. The three failed laryngoscopy attempts are defined as attempts at an experienced clinician, using best possible patient positioning and technique. A further attempt at direct laryngoscopy by the same clinician or one of equivalent experience is advisable, unless the clinician identifies a specific situation on the third laryngoscopy that is amenable to correction, justifying a fourth attempt. Also, if the clinician ascertains after even a single attempt that intubation will be impossible (e.g., grade IV laryngoscopic view despite optimal patient positioning), a failed airway is present. The failed airway is managed according to the failed airway algorithm (Fig. 1-8).
The awake technique often is direct laryngoscopy, assisted by topical anesthesia and sedation (comparable to that for a painful procedure), with the purpose of ascertaining whether intubation using direct laryngoscopy is possible. If the glottis is adequately visualized, the patient can be intubated at that time, or, in a stable difficult airway situation, the clinician may proceed with planned RSI, now assured of intubation success. Awake laryngoscopy can be performed using a direct laryngoscope, a flexible fiberoptic scope, a videolaryngoscope, or a rigid fiberoptic scope. If the awake laryngoscopy determines that oral intubation using a standard laryngoscope would likely be unsuccessful, the patient is intubated using any of numerous techniques shown in the last box in Figure 1-7. For each of these methods, the patient is kept breathing but variably sedated and anesthetized and each of the methods results in placement of a cuffed ETT in the trachea. The choice among these methods depends on clinician experience and preference, device availability, and patient attributes.

**Failed Airway**

Management of the failed airway is dictated by an assessment of whether the patient can be oxygenated. If adequate oxygenation cannot be maintained, the rescue technique of first resort is cricothyrotomy (see Fig. 1-8). Multiple attempts at other methods in the context of failed oxygenation delay cricothyrotomy and place the patient at increased risk for hypoxic brain injury. If an alternative device (i.e., an EGD such as a laryngeal mask airway or Combitube) is readily at hand, however, an attempt can be made to use it simultaneously with preparations for immediate cricothyrotomy, as long as initiation of cricothyrotomy is not delayed. Only a single attempt with the EGD is recommended in this circumstance.

If adequate oxygenation is possible, several options are available for the failed airway. In almost all cases, cricothyrotomy is the definitive rescue technique for the failed airway if time (i.e., preservation of oxygenation) does not allow for other approaches or if they fail. The fundamental difference in philosophy between the difficult airway and the failed airway is that the difficult airway is planned for, and the standard is to place a cuffed ETT in the trachea. The failed airway is **not** planned for, and the standard is to achieve an airway that provides adequate oxygenation to avert the immediate problem of hypoxic brain injury. Some of the devices used in the failed airway (e.g., EGDs) are temporary and do not provide airway protection.

**THERAPEUTIC MODALITIES**

**Methods of Intubation**

Although many techniques are available for intubation of the emergency patient, four methods are most common, with RSI being the most frequently used in nonarrested patients. The central concept of RSI is to take the patient from the starting point (e.g., conscious, breathing spontaneously) to a state of unconsciousness with complete neuromuscular paralysis, then to achieve intubation without interposed assisted ventilation. The risk of aspiration of gastric contents is felt to be significantly higher for patients who have not fasted before induction. Application of positive-pressure ventilation can cause air to pass into the stomach, resulting in gastric distention and likely increasing the risk of regurgitation and aspiration. The purpose of RSI is to avoid positive-pressure ventilation until the ETT is placed correctly in the trachea with the cuff inflated. This requires a preoxygenation phase, during which the nitrogen reservoir in the functional residual capacity in the lungs is replaced with oxygen, permitting at least several minutes of apnea (see later discussion) in the normal adult before oxygen desaturation to 90% ensues (Fig. 1-9).

Use of RSI also facilitates successful endotracheal intubation by causing complete relaxation of the patient’s musculature, allowing better access to the airway. Finally, RSI permits pharmacologic control of the physiologic responses to laryngoscopy and intubation, mitigating potential adverse effects. These effects include further intracranial pressure (ICP) increase in response to the procedure and to the sympathetic discharge resulting from laryngoscopy (Box 1-4). RSI is a series of discrete steps, and every step should be planned (see Box 1-5).**

**Preparation.** In the initial phase, the patient is assessed for intubation difficulty (unless this has already been done), and the intubation is planned, including determining dosages and

![Figure 1-9. Desaturation time for apneic, fully preoxygenated patients. Children, patients with comorbidity, and obese patients desaturate much more rapidly than healthy, normal adults. The box on the lower right-hand side of the graph depicts time to recovery from succinylcholine, which in almost all cases exceeds safe apnea time. Note also the precipitous decline of oxygen saturation from 90% to 0% for all groups. Modified from Benumof J, et al: Critical hemoglobin desaturation will occur before return to unparalyzed state following 1 mg/kg intravenous succinylcholine. Anesthesiology 87:979, 1997.](image-url)
sequence of drugs, tube size, and laryngoscope type, blade and size. Drugs are drawn up and labeled. All necessary equipment is assembled. All such patients require continuous cardiac monitoring and pulse oximetry. At least one and preferably two good-quality intravenous (IV) lines should be established. Redundancy is always desirable in case of equipment or IV access failure.

**Preoxygenation.** Administration of 100% oxygen for 3 minutes of normal, tidal volume breathing in a normal, healthy adult establishes an adequate oxygen reservoir to permit 8 minutes of apnea before oxygen desaturation to less than 90% occurs (see Fig. 1-9). The time to desaturation to less than 90% in children, obese adults, late-term pregnant women, and patients with significant comorbidity is considerably less. Desaturation time also is reduced if the patient does not inspire 100% oxygen. Nevertheless, adequate preoxygenation usually can be obtained, even in ED patients, to permit several minutes of apnea before oxygen desaturation to less than 90% occurs. In children and adults, preoxygenation is essential to the “no bagging” approach of RSI. If time is insufficient for a full 3-minute preoxygenation phase, eight vital capacity breaths using high-flow oxygen can achieve oxygen saturations and apnea times that match or exceed those obtained with traditional preoxygenation. Preoxygenation of obese patients in the head up position results in significantly longer (approximately 45 seconds) apnea time before critical saturation. Preoxygenation should be done in parallel with the preparation phase and can be started in the field for high risk patients. Oxygen saturation monitors permit earlier detection of desaturation during laryngoscopy, but preoxygenation remains an essential step in RSI.

**Pretreatment.** During this phase, drugs are administered 3 minutes before administration of the succinylcholine and induction agent to mitigate the effects of laryngoscopy and intubation on the patient’s presenting or comorbid conditions. Intubation is intensely stimulating and results in sympathetic discharge (the reflex sympathetic response to laryngoscopy), elevation of ICP in patients with ICP disturbance, and reactive bronchospasm. Bradycardia often occurs in children, particularly young children, but appears multifactorial, likely involving both parasympathetic discharge in response to airway instrumentation and perhaps some contributory effect of succinylcholine.

Pretreatment focuses on three main objectives, in certain at-risk patients. The three groups of patients at risk are those with reactive airways disease, elevated ICP, or a cardiovascular or neurovascular condition or acute event for which an acute elevation in blood pressure and heart rate might be hazardous. Patients with reactive airways disease often experience a worsening of their bronchospasm when intubated. Controversy exists regarding whether albuterol alone, lidocaine alone, or both drugs together are effective in reducing this intubation-related bronchospasm. Asthmatic patients being intubated in the ED for status asthmaticus will have received albuterol before intubation, and, pending larger studies, it is reasonable also to administer lidocaine (1.5 mg/kg) as a pretreatment drug in these cases. When an asthmatic patient is being intubated for a condition (e.g., trauma) other than acute asthma, nebulized albuterol and IV lidocaine should be given before intubation, if possible. Patients with significant cardiovascular disease (e.g., ischemic coronary disease) who are being intubated in the ED may benefit from the administration of the synthetic opioid, fentanyl, in a dose of 3 µg/kg to mitigate the release of catecholamines in response to airway manipulation. Similarly, patients with intracranial hemorrhage, elevated ICP, or marked hypertension may benefit from pretreatment with fentanyl. Finally, there is some evidence that patients with elevated ICP may experience less exacerbation of the ICP during intubation if they are pretreated with lidocaine (1.5 mg/kg). These patients, unless hypotensive, should also receive fentanyl (3 µg/kg) to mitigate blood pressure surges that might translate to further increases in ICP. There is evidence supporting the physiologic effects of these agents, but outcome data are lacking. Individualization is necessary, and critical time should not be lost administering pretreatment drugs if the patient requires immediate intubation. Despite the lack of outcome studies, considerable inferential evidence supports this approach, and these agents probably provide protection for vulnerable patients against the adverse hemodynamic and intracranial effects of laryngoscopy and intubation.

Although many variations are possible for pretreatment regimens in various conditions, pretreatment can be simplified to these three basic indications (see Box 1-4).

When possible, 3 minutes should elapse between the administration of the pretreatment drug and the administration of the induction drug and NMBA. If time is insufficient to wait 3 minutes, even a reduced time may provide some benefit.

**Paralysis with Induction.** In this phase, a potent sedative agent is administered by rapid IV push in a dose capable of rapidly producing unconsciousness. This is immediately followed by rapid administration of an intubating dose of an NMBA, usually succinylcholine. It is usual to wait 45 seconds from the time the succinylcholine is given to allow sufficient paralysis to occur. (See later discussion of drugs and doses.)

**Positioning.** The patient should be positioned for intubation as consciousness is lost. Usually, positioning involves head extension, often with flexion of the neck on the body, but there is evidence that simple extension of the head alone, or extension of both the head and neck (the extension-extension position) are equivalent or superior. (See earlier discussion.) Sellick’s maneuver (application of firm backward-directed pressure over the cricoid cartilage) has long been recommended to minimize the risk of passive regurgitation and, hence, aspiration, but two recent reviews have challenged this premise. In addition, there is evidence that Sellick’s maneuver may make laryngoscopy or intubation more difficult.

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**BOX 1-4**

**Pretreatment Agents for Rapid Sequence Intubation**

<table>
<thead>
<tr>
<th>Disease Type</th>
<th>Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactive airways disease</td>
<td>Lidocaine: 1.5 mg/kg IV, to mitigate bronchospasm. Albuterol 2.5 mg by nebulizer (if time permits and not already given).</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>Fentanyl: 3 µg/kg to mitigate sympathetic discharge.</td>
</tr>
<tr>
<td>Elevated ICP</td>
<td>Lidocaine: 1.5 mg/kg IV to mitigate ICP increase in response to airway manipulation. Fentanyl 3 µg/kg to mitigate sympathetic discharge and attendant rise in ICP.</td>
</tr>
</tbody>
</table>

*Given 3 minutes before induction and paralysis. 
ICP, intracranial pressure.

**BOX 1-5**

The Seven “Ps” Of RSI

1. Preparation
2. Preoxygenation
3. Pretreatment
4. Paralysis with induction
5. Positioning
6. Placement of tube
7. Postintubation management

---

45-46 Prebronchospasm. Bradycardia often occurs in children, particu-
in some patients.\textsuperscript{31} Accordingly, Sellick’s maneuver should be considered optional, applied selectively, and released or modified to improve laryngeal view or tube passage, as indicated. During this phase after administration of the induction agent and NMBA, although the patient becomes unconscious and apneic, BMV should not be initiated unless the oxygen saturation falls to 90%.

**Placement of Tube.** Approximately 45 seconds after the administration of succinylcholine, the patient is relaxed sufficiently to permit laryngoscopy; this is assessed most easily by moving the mandible to test for absence of muscle tone. The ETT is placed under direct visualization of the glottis. If the first attempt is unsuccessful, but oxygen saturation remains high, it is not necessary to ventilate the patient with a bag and mask between intubation attempts. If the oxygen saturation is approaching 90%, the patient may be ventilated briefly with a bag and mask between attempts to reestablish the oxygen reservoir. When BMV is performed, Sellick’s maneuver is advisable to minimize passage of air into the stomach.\textsuperscript{41} Sellick’s maneuver may be continued or released during repeat laryngoscopy, according to the judgment of the clinician and the glottic view obtained. As soon as the ETT is placed, the cuff should be inflated and its position confirmed as described earlier.

**Postintubation Management.** A chest radiograph should be obtained to confirm that main stem intubation has not occurred and to assess the lungs. There is a trend away from the use of long-acting NMBA (e.g., pancuronium, vecuronium) toward optimal management using opioid analgesics and sedative agents to facilitate mechanical ventilation.\textsuperscript{50} (See Chapter 3.) An adequate dose of a benzodiazepine (e.g., midazolam 0.1–0.2 mg/kg, IV) and an opioid analgesic (e.g., fentanyl, 3–5 µg/kg, IV, or morphine, 0.2–0.3 mg/kg, IV) is given to improve patient comfort and decrease sympathetic response to the ETT. Appropriate use of sedation and analgesia often obviates the need for an NMBA. Table 1-1 presents a sample RSI protocol using etomidate and succinylcholine. “Zero” refers to the time at which the induction agent and succinylcholine are pushed.

**Table 1-1 Sample Rapid Sequence Intubation Using Etomidate and Succinylcholine**

<table>
<thead>
<tr>
<th>TIME</th>
<th>STEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero minus 10 min</td>
<td>Preparation</td>
</tr>
<tr>
<td>Zero minus 5 min</td>
<td>Preoxygenation</td>
</tr>
<tr>
<td></td>
<td>100% oxygen for 3 min or eight vital capacity breaths</td>
</tr>
<tr>
<td>Zero minus 3 min</td>
<td>Pretreatment</td>
</tr>
<tr>
<td></td>
<td>as indicated</td>
</tr>
<tr>
<td>Zero</td>
<td>Paralysis with induction</td>
</tr>
<tr>
<td></td>
<td>Etomidate, 0.3 mg/kg</td>
</tr>
<tr>
<td></td>
<td>Succinylcholine, 1.5 mg/kg</td>
</tr>
<tr>
<td>Zero plus 30 sec</td>
<td>Positioning</td>
</tr>
<tr>
<td></td>
<td>Sellick’s maneuver optional</td>
</tr>
<tr>
<td>Zero plus 45 sec</td>
<td>Placement</td>
</tr>
<tr>
<td></td>
<td>Laryngoscopy and intubation</td>
</tr>
<tr>
<td></td>
<td>End-tidal carbon dioxide confirmation</td>
</tr>
<tr>
<td>Zero plus 2 min</td>
<td>Postintubation management</td>
</tr>
<tr>
<td></td>
<td>Sedation and analgesia as indicated</td>
</tr>
<tr>
<td></td>
<td>Initiate mechanical ventilation</td>
</tr>
<tr>
<td></td>
<td>NMBA only if needed after adequate sedation/analgesia</td>
</tr>
</tbody>
</table>

**Blind Nasotracheal Intubation**

Historically, blind nasotracheal intubation (BNTI) was used extensively in the ED and out-of-hospital setting, but has fallen out of favor largely because of the superiority of RSI.\textsuperscript{11,53} Success rates have been about 80 to 90%, and high complication rates are reported, most often epistaxis or delayed or incorrect tube placement.\textsuperscript{53} Long-term complications (e.g., sinusitis, turbinate destruction, laryngeal perforation) are uncommon and related to multiple attempts or prolonged intubation. Basilar skull fracture and facial trauma have been considered contraindications to nasotracheal intubation because of the risk of entering the cranial vault or increasing the incidence of intracranial infection. These contraindications are not based on scientific study, however, and two small studies failed to detect a difference in complications between orally and nasally intubated facial trauma patients.\textsuperscript{54,55} Two other studies compared the success rates of RSI and BNTI performed by physicians or paramedics on helicopter services. Results differed, with one study showing essentially equivalent success rates and the other showing a significant advantage for neuromuscular blockade over BNTI.\textsuperscript{56,57} ED studies have shown superiority of RSI over BNTI.\textsuperscript{11,39} Also, the incidence and severity of oxygen desaturation are greater in BNTI than with RSI.\textsuperscript{58}

BNTI is a valid and useful method of intubation in the out-of-hospital setting and is still widely used by paramedics and other out-of-hospital first responders. In the ED, where NMBA and RSI are available, BNTI should be considered a second-line approach and reserved for patients in whom the presence of a difficult airway makes RSI undesirable or contraindicated and alternatives (e.g., fiberoptics) are not available. Interestingly, the old recommendation that refrigeration of the tube before use increases success of nasotracheal intubation probably is not true. To the contrary, warming the tube to 40° before use appears to facilitate easy tube passage and reduce the incidence of epistaxis.\textsuperscript{59} Similarly, maintaining the head in a neutral position and inflating the ETT cuff to 15 mL in the oropharynx or hypopharynx before attempting to traverse the glottis also improves the success rate.\textsuperscript{60} Use of BNTI in the ED has declined sufficiently, and it is doubtful that emergency medicine residents will be adequately trained in the technique.\textsuperscript{53}

**Awake Oral Intubation**

Awake oral intubation is a technique in which sedative and topical anesthetic agents are administered to permit management of a difficult airway. Sedation and analgesia are achieved in a manner analogous to that for painful procedures in the ED. Topical anesthesia may be achieved by spray, nebulization, or local anesthetic nerve block. After the patient is sedated and topical anesthesia has been achieved, gentle direct, video, or fiberoptic laryngoscopy is performed to determine whether the glottis is visible and intubation possible. The patient may be intubated during the laryngoscopy, or the laryngoscopy may show that oral intubation is possible, permitting safe use of RSI (see earlier discussion).

Awake oral intubation is distinct from the practice of oral intubation using a sedative or opioid agent to obtund the patient for intubation without neuromuscular blockade, which had been a typical ED practice. This latter technique can be referred to as “intubation with sedation alone” or, paradoxically, “nonparalytic RSI.” Proponents of intubation with sedation alone argue that administration of a benzodiazepine, opioid, or both provides improved access to the airway, decreases patient resistance, and avoids the risks inherent
in neuromuscular blockade. This technique actually is more hazardous than RSI, however. Intubating conditions achieved even with deep anesthesia are significantly inferior to the conditions achieved when neuromuscular blockade is used. The same superiority of neuromuscular blockade-assisted intubation over intubation with sedation alone has been observed in pediatric emergency medicine and in EMS care. In general, the technique of administering a potent sedative agent to obtund the patient's responses and permit intubation in the absence of neuromuscular blockade is ill-advised and inappropriate for ETI in the ED, unless it is performed as part of an “awake” intubation as described earlier.

**Oral Intubation without Pharmacologic Agents**

The unconscious, unresponsive, near death patient may not require pharmacologic agents for intubation. If the patient is essentially dead, administration of any pharmacologic agent, including an NMBA, may needlessly delay intubation. Even an unconscious patient may retain sufficient muscle tone to render intubation difficult, however. If the glottis is not adequately visualized, administration of a single dose of succinylcholine alone may facilitate laryngoscopy. Success rates for intubating unconscious, unresponsive patients are comparable to those achieved with RSI, presumably because the patient is in a similar physiologic state (i.e., muscle relaxation, no ability to react to laryngoscopy or tube insertion).

**Pharmacologic Agents**

**Neuromuscular Blocking Agents**

Muscle contraction is the result of membrane depolarization, which causes massive intracellular release of calcium ions from the sarcoplasmic reticulum, leading to active contraction of myofibrils. The inciting incident is the depolarization of portions of the myocyte membrane, called the motor endplates, which are adjacent to the innervating axons. Action potentials conducted down the innervating axons cause release of the neurotransmitter acetylcholine (ACh) from the terminal axon. The ACh traverses the synaptic cleft, binds reversibly to receptors on the motor endplate, and opens channels in the membrane to initiate depolarization.

NMBA are highly water-soluble, quaternary ammonium compounds that mimic the quaternary ammonium group on the ACh molecule. Their water solubility explains why these agents do not readily cross the blood-brain barrier or placenta. The NMBA are divided into two main classes. The depolarizing agent, succinylcholine, exerts its effects by binding noncompetitively with ACh receptors on the motor endplate and causing sustained depolarization of the myocyte. The other major class of NMBA comprises the competitive, or nondepolarizing, agents, which bind competitively to ACh receptors, preventing access by ACh and preventing muscular activity. The competitive agents are of two pharmacologically distinct types, steroid-based agents (aminosteroid compounds) and benzylisoquinolines. Each of these basic chemical types has distinct properties, but only the aminosteroid compounds are used in the ED.

**Succinylcholine.** Succinylcholine is a combination of two molecules of ACh. Succinylcholine is rapidly hydrolyzed by plasma pseudocholinesterase to succinylmonocholine, which is a weak NMBA, then to succinic acid and choline, which have no NMBA activity. Pseudocholinesterase is not present at the motor endplate and exerts its effects systematically before the succinylcholine reaches the ACh receptor. Only a small amount of the succinylcholine that is administered survives to reach the motor endplate. When attached to the ACh receptor, succinylcholine is active until it diffuses away. Decreased plasma pseudocholinesterase activity can increase the amount of succinylcholine reaching the motor endplate, prolonging succinylcholine block, but this is of little significance in the emergency setting because the prolongation of action is rarely significant, reaching only 23 minutes at the extreme. Use. Succinylcholine is rapidly active, typically producing intubating conditions within 60 seconds of administration by rapid IV bolus injection. The clinical duration of action before spontaneous respiration is 6 to 10 minutes (see Fig. 1-9). Full recovery of normal neuromuscular function occurs within 15 minutes. The combination of rapid onset, complete reliability, short duration of action, and absence of serious side effects maintains succinylcholine as the drug of choice for most ED intubations. The use of a competitive, or nondepolarizing, NMBA for RSI may be desirable when succinylcholine is contraindicated and in certain other settings.

**Cardiovascular Effects.** As an ACh analogue, succinylcholine binds to ACh receptors throughout the body, not just at the motor endplate. It is difficult to separate the effects of succinylcholine on the heart that are caused by direct cardiac muscarinic stimulation from those caused by stimulation of autonomic ganglia by succinylcholine and from the effects induced by the autonomic responses to laryngoscopy and intubation. Succinylcholine can be a negative chronotrope, especially in children, and sinus bradycardia may ensue after succinylcholine administration. Sinus bradycardia is treated with atropine, if necessary, but is often self-limiting. Some pediatric practitioners recommend pretreatment with atropine for children younger than 1 year old, but there is no evidence for benefit. Other cardiac dysrhythmias, including ventricular fibrillation and asystole, have been reported with succinylcholine, but it is impossible to distinguish the effects of the drug itself from those caused by the intense vagal stimulation and catecholamine release that accompany laryngoscopy and intubation. In addition, many of these catastrophic complications occur in critically ill patients, further confounding attempts to identify whether the illness or any particular drug or procedure is the cause.

**Fasciculations.** The depolarizing action of succinylcholine results in fine, chaotic contractions of the muscles throughout the body for several seconds at the onset of paralysis in over 90% of patients. Muscle pain occurs in approximately 50% of patients who receive succinylcholine. Although it is widely believed that muscle pains are reduced or abolished by prior administration of a defasciculating dose of a competitive NMBA, the evidence is not conclusive. Use of 1.5 mg/kg of succinylcholine results in less fasciculation and less myalgia than occur with 1 mg/kg.

**Hyperkalemia.** Succinylcholine has been associated with severe, fatal hyperkalemia when administered in specific clinical circumstances (Table 1-2). Although the hyperkalemia occurs within minutes after administration of succinylcholine and may be severe or fatal, the patient’s vulnerability to succinylcholine-induced hyperkalemia does not become significant until at least 5 days after the inciting injury or burn. Succinylcholine remains the agent of choice for RSI in acute burn, trauma, stroke, spinal cord injury, and intra-abdominal sepsis if intubation occurs less than 5 days after onset of the condition. If doubt exists regarding the onset time, succinylcholine should be replaced with a competitive NMBA, usually rocuronium. Denervation syndromes (e.g., multiple sclerosis, amyotrophic lateral sclerosis) can be particularly troubling, however, because the risk begins with the onset of the disease and continues indefinitely, regardless of the apparent stability of the symptoms. Patients who have denervation caused by
stroke or spinal cord injury are stabilized after 6 months, and thereafter can receive succinylcholine safely.65 Potassium release does not occur to any significant extent in the general population. Succinylcholine is not contraindicated in renal failure but probably should not be used in patients with known or presumed hyperkalemia sufficient to manifest on the electrocardiogram. The only published series of patients with hyperkalemia, many of whom had renal failure, failed to show a single adverse event related to succinylcholine administration.70

Increased Intraocular Pressure. Succinylcholine may cause a modest increase in intraocular pressure and historically has been considered relatively or absolutely contraindicated in penetrating globe injury. There is no published evidence to support this view, however, and several large series show safety when succinylcholine is used in patients with open globes. The admonition to avoid succinylcholine in open globe injuries is unjustified and should be abandoned.71

Masseter Spasm. Succinylcholine has been reported rarely to cause masseter spasm, primarily in children.64 The clinical significance of this phenomenon is unclear, but administration of a competitive NMBA terminates the spasm. Severe, persistent spasm should raise suspicion of malignant hyperthermia.

Malignant Hyperthermia. Succinylcholine has been associated with malignant hyperthermia, a perplexing syndrome of rapid temperature rise and aggressive rhabdomyolysis. Malignant hyperthermia occurs in genetically predisposed individuals who receive certain volatile anesthetic agents or succinylcholine. The condition is extremely rare and has not been reported in the context of ED intubation. Treatment consists of cessation of any potential offending agents, administration of dantrolene (2 mg/kg IV every 5 min to a maximum dose of 10 mg/kg), and attempts to reduce body temperature by external means.72 A national malignant hyperthermia hotline is available for emergency consultation at 1-800-644-9737 (then dial zero).

Refrigeration. The standard recommendation to keep succinylcholine refrigerated creates problems related to its storage, timely retrieval, and ready availability on intubation carts or kits in the ED. Succinylcholine undergoes degradation beginning at the time of manufacture, and the rate of this degradation is much lower when the drug is refrigerated. Succinylcholine retains more than 90% of its original activity when stored at room temperature for 3 months; it retains even more if protected from light.73 Succinylcholine may be kept at room temperature in the ED or EMS setting, provided that a proper inventory control system ensures that all supplies are replaced not more than 3 months after introduction.

Competitive Agents. Competitive NMBA are classified according to their chemical structure. The aminosteroid agents include pancuronium, vecuronium, and rocuronium. Vecuronium neither releases histamine nor exhibits cardiac muscarinic blockade and is an excellent agent for maintenance of neuromuscular blockade when this is desirable. Rocuronium is the best agent for use in RSI when succinylcholine is contraindicated.

Rapid Sequence Intubation with a Competitive Agent. Competitive agents, especially vecuronium and rocuronium, have been studied extensively for RSI. Although vecuronium was the first competitive NMBA to establish a role in RSI, it works best when given as a split dose. First, 0.01 mg/kg is administered as a “priming” dose. Three minutes later, 0.15 mg/kg is given for paralysis, which is achieved in about 75 to 90 seconds. Rocuronium bromide (1 mg/kg IV) achieves intubating conditions closely approaching those of succinylcholine, lasts approximately 50 minutes, and has been used in the ED with success (Table 1-3).61,74

Paralysis after Intubation. After intubation, prolonged paralysis may be desired to optimize mechanical ventilation; however, current management trends are away from the use of prolonged paralysis in favor of deep sedation with analgesia. If neuromuscular blockade is desired, vecuronium (0.1 mg/kg IV) can be given. Longer term neuromuscular blockade must not be undertaken without attention to appropriate sedation and analgesia of the patient.50 An adequate dose of a benzodiazepine, such as midazolam (0.1–0.2 mg/kg IV), and an opioid analgesic, such as fentanyl (3–5 µg/kg IV) or morphine (0.2–0.3 mg/kg IV), is required to improve patient comfort and decrease sympathetic response to the ETT. Appropriate use

### Table 1-2 Conditions Associated with Hyperkalemia after Succinylcholine Administration

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>PERIOD OF CONCERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burns &gt;10% BSA</td>
<td>&gt;5 days until healed</td>
</tr>
<tr>
<td>Crush injury</td>
<td>&gt;5 days until healed</td>
</tr>
<tr>
<td>Denervation (stroke, spinal cord injury)</td>
<td>&gt;5 days until 6 months postinjury</td>
</tr>
<tr>
<td>Neuromuscular disease (ALS, MS)</td>
<td>Indefinitely</td>
</tr>
<tr>
<td>Intra-abdominal sepsis</td>
<td>&gt;5 days until resolution</td>
</tr>
</tbody>
</table>

ALS, amyotrophic lateral sclerosis; BSA, body surface area; MS, multiple sclerosis.

### Table 1-3 Sample Rapid Sequence Intubation Using Etomidate and Rocuronium

<table>
<thead>
<tr>
<th>TIME</th>
<th>STEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero minus 10 min</td>
<td>Preparation</td>
</tr>
<tr>
<td>Zero minus 5 min</td>
<td>Preoxygenation</td>
</tr>
<tr>
<td>100% oxygen for 3 min or eight vital capacity breaths</td>
<td></td>
</tr>
<tr>
<td>Zero minus 3 min</td>
<td>Pretreatment</td>
</tr>
<tr>
<td>As indicated</td>
<td></td>
</tr>
<tr>
<td>Zero</td>
<td>Paralysis with induction</td>
</tr>
<tr>
<td>Etomidate, 0.3 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Rocuronium, 1.0 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Zero plus 30 sec</td>
<td>Positioning</td>
</tr>
<tr>
<td>Zero plus 60 sec</td>
<td>Placement</td>
</tr>
<tr>
<td>Laryngoscopy and intubation</td>
<td></td>
</tr>
<tr>
<td>End-tidal carbon dioxide confirmation</td>
<td></td>
</tr>
<tr>
<td>Zero plus 2 min</td>
<td>Postintubation management</td>
</tr>
<tr>
<td>Sedation and analgesia mandatory because of prolonged (45 min) duration of paralysis with rocuronium</td>
<td></td>
</tr>
</tbody>
</table>
of sedation and analgesia often obviates the need for an NMBA. Additional medication may be required if the patient’s blood pressure and heart rate indicate excessive sympathetic tone.

Induction Agents

A patient who presents with any degree of clinical responsiveness, including reactivity to noxious stimuli, requires a sedative or induction agent at the time of administration of any NMBA. Patients who already are deeply unconscious and unresponsive may not require a full dose of an induction agent if the unconscious state is caused by drugs or alcohol (themselves general anesthetic agents.) Patients who are unconscious because of a central nervous system insult should receive an induction agent to attenuate adverse responses to airway manipulation. Induction agents also enhance the effect of the NMBA and improve intubation conditions because the intubation is done at the earliest phase of neuromuscular blockade, and the relaxation effects of the induction agent are additive to those of the NMBA.75

Etomidate. Etomidate is an imidazole derivative that has been in use since 1972. Its activity profile is similar to that for thiopental, with rapid onset, rapid peak activity, and brief duration, but it is remarkably hemodynamically stable.76,77 Etomidate has emerged as the agent of choice for ED RSI, and numerous reports attest to its effectiveness and safety.1,14 The induction dose is 0.3 mg/kg IV. Because etomidate is able to decrease ICP, cerebral blood flow, and cerebral metabolic rate without adversely affecting systemic mean arterial blood pressure and cerebral perfusion pressure, it is an excellent induction agent for patients with elevated ICP, even in cases of hemodynamic instability.77,78 Etomidate may cause brief myoclonus, but this is of no clinical significance. Etomidate by continuous infusion has been reported to cause suppression of endogenous cortisol production. Recently, controversy has emerged regarding the role of etomidate for intubation of patients with septic shock.79,81 Several retrospective studies have claimed to demonstrate that etomidate, used in a single dose for intubation, causes suppression of the adrenal response to exogenously administered adrenocorticotropic hormone, and have attempted to link this to increased mortality.82,83 Other retrospective studies have shown the opposite.84,85 Ironically, much of the original criticism of etomidate arose from the belief that adrenocortical response to exogenous corticotropin predicts outcome in patients with septic shock, a belief that has since been abandoned.86. Also, the most recent and comprehensive study of the role of corticosteroids in septic shock failed to show any benefit, casting further doubt about any possible mortality effect of a single dose of etomidate.87 Pending a properly constructed, prospective, randomized clinical trial, there is not sufficient evidence to support a recommendation that etomidate not be used in patients with septic shock.91,92 In fact, etomidate’s superior hemodynamic profile makes it an excellent choice in these generally unstable patients.

Barbiturates. Although both the thiobarbiturate, sodium thiopental, and the methylated oxybarbiturate, methohexital, have been used as induction agents for RSI, thiopental has been used more widely. The use of these agents has declined significantly, however, with the adoption of newer agents, particularly etomidate and propofol. The rapidly acting barbiturates are highly lipid-soluble and readily cross the blood-brain barrier, acting on the γ-aminobutyric acid receptor neuroinhibitory complex to rapidly depress central nervous system activity. A single dose of 5 mg/kg of thiopental produces loss of consciousness in less than 30 seconds, has a peak effect at 1 minute, and has a clinical duration of 5 to 8 minutes. Methohexital may have a slightly shorter duration of action but is more prone to cause central nervous system excitatory side effects, such as myoclonus. Thiopental is a negative inotrope and a potent venodilator and should be used with caution in patients whose cardiovascular reserve is diminished. For the same reason, thiopental should be avoided in a hypotensive patient who would not tolerate further compromise of circulation. Thiopental can release histamine and probably should not be used in asthmatic patients.

Benzodiazepines. Of the benzodiazepines, only midazolam is suited to use as an induction agent, with a normal induction dose of 0.2 to 0.3 mg/kg IV.77 In a dose of 0.3 mg/kg IV, midazolam produces loss of consciousness in about 30 seconds and has a clinical duration of 15 to 20 minutes.79 Midazolam is a negative inotrope comparable to thiopental and should be used with caution in hemodynamically compromised and elderly patients, for whom the dose can be reduced to 0.1 mg/kg or 0.05 mg/kg. Onset is slower at these reduced doses. Much lower doses than indicated are often used in ED intubations, perhaps because practitioners are familiar with the sedation doses, but not the anesthetic induction doses, of midazolam.90 These inadequate doses reduce the effectiveness of laryngoscopy, do not provide optimal blunting of adverse physiologic effects of laryngoscopy and intubation, and may compromise the patient’s amnesia for the intubation. Midazolam may be cerebroprotective, but less so than etomidate or thiopental.

Ketamine. Ketamine, a phencyclidine derivative, has been widely used as a general anesthetic agent since 1970. After an IV dose of 1 to 2 mg/kg, ketamine produces loss of awareness within 30 seconds, peaks in approximately 1 minute, and has a clinical duration of 10 to 15 minutes. As a dissociative anesthetic agent, ketamine induces a cataleptic state rather than a true unconscious state. The patient has profound analgesia but may have open eyes. Many protective reflexes, including airway reflexes, are preserved.

The principal uses of ketamine in emergency airway management are for the induction of patients with acute, severe asthma and for hemodynamically unstable trauma patients. Ketamine is exceptionally hemodynamically stable, more so than etomidate, so although either drug is a good choice in the trauma patient, ketamine is probably superior in terms of preserving precarious cardiovascular stability.93 In patients with status asthmaticus, etomidate or any of most of the other induction agents is acceptable, with the notable exception of sodium thiopental, which releases histamine. Ketamine is a direct bronchodilator and releases catecholamines, so may be useful both for intubation and for intermittent administration as part of sedation for mechanical ventilation in patients with severe asthma, although no outcome studies clearly demonstrate its superiority.

Controversy exists regarding the use of ketamine in patients with elevated ICP because ketamine has been believed to increase cerebral metabolic rate, ICP, and cerebral blood flow.91 The evidence that ketamine can produce harm in this way is conflicting, however, and its role as an induction agent in trauma is significant because of its superior hemodynamic stability.94 Because of its tendency to release catecholamines and increase blood pressure, ketamine should probably be avoided in head trauma patients with normal or elevated blood pressure. However, in the hypotensive head trauma patient, ketamine is a reasonable choice for induction.77 Ketamine tends to produce unpleasant emergence phenomena, especially disturbing or frightening dreams in the first 3 hours after awakening. These reactions, which are more prominent in
adults than in children, in women than in men, in patients receiving larger doses, and in certain personality types, are mitigated by benzodiazepine administration. Patients (e.g., with asthma) who undergo RSI with ketamine should receive a sufficient dose of a benzodiazepine (e.g., 0.05 mg/kg of lorazepam) as part of postintubation management.

### Special Clinical Circumstances

#### Status Asthmaticus
Status asthmaticus with supervening respiratory failure is a preterminal event. Respiratory failure in the asthmatic patient is not caused primarily by progressive worsening of the bronchospasm, but rather by eventual exhaustion and fatigue secondary to the effort of breathing against severe airway resistance. All patients who are intubated for status asthmatics are heavily sedated and receive mechanical ventilation. RSI permits the most rapid attainment of intubation, protects against aspiration, and induces the unconsciousness and motor paralysis necessary for optimal initiation of mechanical ventilation; it is the recommended technique for intubation of a patient in status asthmaticus. Difficult airway considerations are complex in an asthmatic patient because of impending respiratory arrest and the patient’s inability to tolerate attempts at awake intubation. Even when a difficult airway is identified in an asthmatic patient, RSI is usually the intubation method of choice, with a double setup for rescue cricothyrotomy when indicated.

The asthmatic patient has highly reactive airways, and steps should be taken to minimize any additional bronchospasm that may occur during intubation. Lidocaine has been shown to suppress the coughing that occurs in response to airway manipulation and may improve ETT tolerance and reduce reactive bronchospasm in asthmatic patients. The balance of evidence suggests that lidocaine (1.5 mg/kg) is indicated as a pretreatment drug before intubation in status asthmatics and in asthmatic patients being intubated for reasons other than their asthma. High-dose, inhaled beta-agonists may provide maximal protection against reactive bronchospasm during intubation in asthmatics without active bronchospasm, and lidocaine may provide little additional benefit in this setting. This approach has not been tested in patients in status asthmaticus, however. Ketamine has been shown to produce bronchodilation in humans and animal models and may be the ideal induction agent in asthma. Although reports to date have been limited, there is a growing body of experience with ketamine as an induction agent for the emergency intubation of patients with status asthmatics. Ketamine also has been reported to mitigate bronchospasm in patients who are not intubated and in patients who are already intubated and who are not improving with mechanical ventilation (Table 1-4).

### Hemodynamic Consequences of Intubation
Laryngoscopy and intubation are potent stimuli for the reflex release of catecholamines. This reflex sympathetic response to laryngoscopy (RSRL) produces only modest increases in blood pressure and heart rate and is of little consequence in otherwise healthy patients. The RSRL is of potential clinical significance in two settings: acute elevation of ICP and certain cardiovascular diseases (e.g., intracerebral hemorrhage, subarachnoid hemorrhage, aortic dissection or aneurysm, and ischemic heart disease). In these settings, the reflex release of catecholamines, increased myocardial oxygen demand, and attendant rise in mean arterial blood pressure and heart rate may produce deleterious effects. The synthetic opioids (e.g., fentanyl) and beta-adrenergic blocking agents (e.g., esmolol) are capable of blunting the RSRL and stabilizing heart rate and blood pressure during intubation. Lidocaine also has been studied, but the results are contradictory and inconclusive. In patients at risk from acute blood pressure elevation, administration of fentanyl (3 µg/kg) during the pretreatment phase of RSI attenuates the heart rate and blood pressure increase. The full sympatholytic dose of fentanyl is 5 to 9 µg/kg, but if this dose is administered as a single pretreatment bolus, hypoventilation or apnea can occur. The administration of 3 µg/kg is safer and can be supplemented with an additional 3 µg/kg immediately after intubation if full sympathetic blockade is desired or if hypertension and tachycardia ensue, providing evidence of excessive sympathetic activity. Fentanyl should be given as the last pretreatment drug over 60 seconds to prevent hypoventilation or apnea.

### Elevated Intracranial Pressure
When ICP is elevated as a result of head injury or acute intracranial catastrophe, maintenance of cerebral perfusion pressure and avoidance of further increases in ICP are desirable. Significant reductions in mean arterial blood pressure decrease cerebral perfusion pressure by reducing the driving gradient between arterial pressure and ICP, leading to increased cerebral ischemia. Maintenance of the systemic mean arterial blood pressure at 100 mm Hg or greater supports the cerebral perfusion pressure and reduces the likelihood of secondary injury. In addition, cerebral autoregulation may be lost, and increases in systemic blood pressure may lead to corresponding increases in cerebral blood flow and ICP. With elevated ICP, control of the reflex hemodynamic stimulation resulting from intubation is desirable to avoid further elevation of ICP. Fentanyl (3 µg/kg) given as a pretreatment drug is the best choice for this purpose in the emergency setting.

Evidence suggests a separate reflex that increases ICP in response to laryngoscopy and intubation, although the precise mechanism is not understood. IV lidocaine reduces ICP and
blunts the ICP response to laryngoscopy and intubation. Lido-
caine (1.5 mg/kg IV), administered during the pretreatment
phase of RSI, is desirable to blunt the ICP response to laryn-
goscopy and intubation. Similarly, RSRL and ICP response
to laryngoscopy and intubation relatively contraindicate BNTI,
which should be undertaken only if RSI is impossible and
fiberoptic intubation is not an option.

The physician should choose an induction agent that bal-
ances a favorable effect on cerebral dynamics and ICP with a
stable systemic hemodynamic profile. At present, etomidate
(0.3 mg/kg) probably is the best choice for patients with el-
evated ICP, although thiopental also is an excellent choice
when hypotension is not present (Table 1-5).

### Potential Cervical Spine Injury

Historically, it was believed that oral endotracheal intubation
carried an unacceptably high risk of injury to the cervical
spinal cord in patients with blunt cervical spine injury and was
relatively contraindicated, but this assertion was never sub-
jected to scientific scrutiny. Numerous studies and reports
have asserted the safety and effectiveness of controlled, oral
intubation with in-line cervical spine immobilization, whether
done as an awake procedure or with neuromuscular block-
ade.55,56 The evidence favors RSI with in-line stabilization,
which provides maximal control of the patient, the ability to
mitigate adverse effects of the intubation, and the best condi-
tions for laryngoscopy. In-line stabilization also seems to
improve the laryngoscopic view of the larynx compared with
conventional tape/collar/sandbag immobilization. The intu-
bating laryngeal mask airway (ILMA) also has been compared
with conventional laryngoscopy and may result in less move-
ment of the cervical spine during intubation than that caused
by direct laryngoscopy.57 A comparison of methods on a cadaver
model of unstable injury of the third cervical vertebra rein-
fors the potential role for fiberoptic intubation and raised
questions about the safety of the Combitube because of sig-
nificant cervical spine movement during its placement.58
Newer devices have also shown promise for safe intubation
of patients with cervical spine injury. A fluoroscopic study com-
paring intubation using the Shikani optical stylet (SOS) to that
done with direct laryngoscopy showed significantly less cervi-
cal spine movement with the SOS, but a slightly longer time
(28 sec vs. 17 sec) to achieve intubation.59 The Airtraq, a
single-use intubation device, resulted in better glottic views
and more rapid intubation of patients with cervical spine
immobilization than direct laryngoscopy using a Macintosh
blade.100 The GlideScope, a video laryngoscope, provides
superior glottic views with reduced or comparable cervical
spine movement when compared with conventional direct
laryngoscopy using the Macintosh blade.101,102

Cervical spine immobilization of patients with penetrating
head and neck trauma is poorly addressed in the literature. It
is not proven whether patients with gunshot or shotgun inju-
ries to the head or neck are at risk of exacerbation of cervical
cord injury during intubation, but there is no report of such a
patient, with or without clinical evidence of spinal cord injury,
who was injured by intubation. If the path of the missile is felt
to not involve the bony spinal column and there is no evidence
of spinal cord injury, prudence would dictate immobilization
of patients with gunshot wounds to the head or neck with a
secondary injury mechanism (e.g., fall from height) or with
neurologic deficit suggesting spinal involvement.103 Immobili-
ation for intubation of patients with penetrating injury else-
where in the body should be directed by the likelihood of
secondary injury to the spine from a fall or other event distinct
from the wounding.

### Pediatric Intubation

Although many considerations in pediatric intubation are the
same as for adults, a few differences exist in regard to airway
management. The larynx is higher in the child’s neck, causing
a more acute angle between the oral pharynx and the larynx.
Visualization is aided by gentle posterior pressure on the ante-
rior aspect of the thyroid cartilage. The epiglottis is high and
soft, making visualization of the cords more difficult. If the
child is very small, the prominent occiput brings the mouth to
a position far anterior to the larynx; an assistant can lift the
chest gently by grasping both shoulders, immobilizing the
head at the same time. The airway in the small child is short,
and care must be taken not to intubate either bronchus.57

A straight laryngoscope blade is desirable to displace the
floppy epiglottis, especially in young children, and positioning
for intubation may be different. BNTI is relatively contrain-
dicated in children younger than 12 years old. Although the
product insert for succinylcholine now advises against its
routine use in pediatric anesthesia because of the risk of
hyperkalemia in children with undiagnosed congenital neu-
romuscular disorders (e.g., muscular dystrophy), it remains the
drug of choice for emergency RSI of infants and children.62
Rocuronium has been used in children, but experience is too
limited to recommend that it replace succinylcholine for pedi-
atrie RSI in the ED. RSI may be used in children in a similar
manner to adults, with two important differences. Excessive
bradycardia may be seen with succinylcholine in children
younger than 1 year old, but it is not known whether admin-
istration of atropine (0.02 mg/kg) during the pretreatment
phase prevents any possible adverse outcome. The dose of
succinylcholine in infants is 2 mg/kg. Induction agents may be
selected using similar criteria as for adults. The major diffi-
culty in intubating children and infants is choosing the correct
size of equipment and the correct drug doses for age or size.
These obstacles can be overcome by use of a length-based
system (Broselow-Luten Color Coding Kids; Vital Signs, Inc.,
Totowa, NJ), which provides dosing and equipment sizes
based on the length of the child. Cricothyrotomy is impossible

<table>
<thead>
<tr>
<th>TIME</th>
<th>STEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero minus 10 min</td>
<td>Preparation</td>
</tr>
<tr>
<td>Zero minus 5 min</td>
<td>Preoxygenation (as possible)</td>
</tr>
<tr>
<td>Zero minus 3 min</td>
<td>Pretreatment</td>
</tr>
<tr>
<td>Zero</td>
<td>Paralysis with induction</td>
</tr>
<tr>
<td>Zero plus 30 sec</td>
<td>Positioning</td>
</tr>
<tr>
<td>Zero plus 45 sec</td>
<td>Placement</td>
</tr>
<tr>
<td>Zero plus 2 min</td>
<td>Postintubation management</td>
</tr>
</tbody>
</table>

*May substitute rocuronium, 1 mg/kg, for succinylcholine.
in small children, and alternative rescue airway devices (e.g., percutaneous oxygenation via the cricothyroid membrane) are required.

Other Airway Devices and Techniques

Regardless of the care taken by the intubator and the detailed assessment of the patient before intubation, some intubations are simply unsuccessful or impossible. In most circumstances when intubation is not possible, BMV or ventilation using an EGD provides adequate ventilation and oxygenation until a rescue airway can be established. This underscores the importance of evaluating the patient for ease of intubation, ventilation, and EGD use before deciding on the best approach and initiating the intubation sequence. Over the past 10 years, there has been a revolution in airway management, based primarily on the incorporation of video and fiberoptic technology into laryngoscopes and stylets. In addition, increasing experience with extraglottic devices and other approaches has proved useful both for routine and difficult or failed airways.

Extraglottic Devices

Laryngeal Mask Airway. The laryngeal mask airway (LMA) is an irregular, ovoid, silicone mask with an inflatable rim, connected to a tube that allows ventilation (Fig. 1-10). It is available in both reusable and single-use configurations; single-use models are offered by several manufacturers and are probably equivalent. The mask is inserted blindly into the pharynx, then inflated, providing a seal that permits ventilation of the trachea with minimal gastric insufflation. In elective anesthesia, the LMA has an extremely high insertion success rate and low complication rate, including a low incidence of tracheal aspiration. Studies to date have focused on use during resuscitation from cardiopulmonary arrest, although data are beginning to emerge for use of the LMA as a rescue device in the event of failed intubation and as an alternative to direct laryngoscopy for intubation or a bag-valve-mask for ventilation. Evaluations of LMA insertion by experienced and inexperienced personnel consistently have shown ease of insertion, high insertion success rates, and successful ventilation. Novice users appear to be able to both ventilate and intubate more easily and successfully with the intubating LMA (ILMA) than by bag-mask ventilation and direct laryngoscopy. The LMA may be a viable alternative to endotracheal intubation for in-hospital or out-of-hospital treatment of cardiac arrest, particularly when responders are inexperienced airway managers. At a minimum, the device may serve a temporizing role equal or superior to BMV until definitive airway management can be achieved. A new form of LMA, the iGel, has a viscous gel within the cuff, so does not require inflation. Initial experience with the device, even with minimally trained novice users, is promising, with high insertion success rates and short insertion times.

The ILMA is designed to facilitate intubation through the mask after correct placement (Fig. 1-11). It differs from the LMA in two main ways: The mask is attached to a rigid, stainless steel ventilation tube that is bent almost to a right angle, and the mask incorporates an epiglottic elevator at its distal end. Placement of the ILMA results in successful ventilation in almost 100% of cases and successful subsequent intubation in 95%. The ILMA can also be used for both ventilation and intubation in obese patients with similarly high success rates. The ILMA has a special ETT and a stabilizer rod to remove the mask over the ETT after intubation is accomplished, but intubation can be comparably successful with a conventional polyvinylchloride (PVC) endotracheal tube.

The ILMA is a better device than the standard LMA for use in the ED because it facilitates both rescue ventilation and intubation. Intubation through the ILMA has compared favorably in terms of success with direct laryngoscopy and is superior in the hands of relatively novice intubators. When the ILMA is placed, intubation can be performed blindly or guided by a lighted stylet or a fiberoptic scope. The ILMA comes only in sizes 3, 4, and 5 and so is not suitable for use in patients weighing less than about 30 kg. For smaller patients, the standard LMA, which has sizes down to size 1 (infant), should be used. Intubation can be achieved through the standard LMA,
but the success rate is significantly less than with the ILMA. As experience with both the LMA and ILMA grows, it is likely that there will be increasing adoption of the LMA as a primary airway management technique by nonhospital first-responders, and the ILMA is gaining attention as a primary rescue device in the ED.

A new version of the ILMA, the CTACH incorporates fiberoptic bundles and a detachable viewing screen to provide a view of the glottis during intubation. The device performs better than the standard ILMA for first attempt intubation, where it achieves almost 95% success versus approximately 80% for the ILMA in one well-conducted study. Ultimately, though, the ILMA’s intubation success rate is so high (on three or fewer attempts) that it is not clear that the CTACH provides additional benefit overall. The view can uncommonly be obscured by secretions, but this is easily solved by removing and reinserting the device, or cleaning it with a swab through the airway lumen. The greatest issue is cost, with the CTACH priced almost five times higher than the corresponding set of standard ILMAs. Whether the additional cost provides additional benefit for application in the ED remains to be seen.

In the ED, the primary use of the LMA or ILMA is as a rescue technique to provide a temporary airway when intubation has failed, bag ventilation is satisfactory, and the patient has been paralyzed or is otherwise in need of immediate airway management. In such cases, the LMA is one of numerous acceptable devices. In the “can’t intubate, can’t ventilate” situation, cricothyrotomy is indicated, but an ILMA may be placed rapidly in an attempt to achieve ventilation (converting the situation to “can’t intubate, can ventilate”) as long as this is done in parallel with preparations for cricothyrotomy and does not delay the initiation of a surgical airway. Availability of the LMA and adequate prior training of the clinician offer a legitimate option for the management of the failed airway, and the ILMA compares well with fiberoptic intubation in terms of successful intubation of difficult airways. The standard LMA may also offer advantages for providing ventilation in unconventional positions, such as when the patient is lying on his or her side. In the out-of-hospital setting, where concerns about esophageal placement of ETTs have focused interest on methods used for airway management, the LMA and Combitube offer excellent placement and ventilation characteristics and may be preferable to endotracheal intubation in this setting, especially when intubation is relatively infrequently performed. If the patient is in a difficult position in terms of intubation access, the LMA may facilitate more rapid ventilation. New LMA devices, from a number of manufacturers, are now available.

**Esophagotracheal Combitube.** The Combitube is a plastic double-lumen tube with one lumen functioning as an airway after esophageal insertion and the other lumen functioning as a tracheal airway (Fig. 1-12). The tube is placed blindly into the esophagus, and proximal and distal balloons are inflated to prevent escape of ventilatory gases through the pharynx to the mouth or nose or down the esophagus. The tube is placed into the esophagus, as designed, almost 100% of the time, but both lumens are patent, so ventilation is still possible if the tube has been placed inadvertently into the trachea.

The Combitube is primarily a substitute for endotracheal intubation for non-ETT-trained personnel, but it also has a role as a primary airway device in place of endotracheal intubation in the out-of-hospital setting. It has been used as a rescue device or as a primary intubating device in difficult airways that have precluded endotracheal intubation or successful LMA placement, both in patients with and those without cardiac arrest. Serious complications attributable to Combitube use are uncommon. The tube may be difficult to insert blindly when the patient is in cervical spine precautions, raising concerns about first-responder use in trauma patients, but results have been conflicting. Standard methods for confirming tube placement, using ETCO₂, seem to be reliable in identifying whether the tube has been passed into the esophagus or trachea and in confirming the correct ventilation port.

Although the Combitube has provided successful ventilation for several hours, it should be considered a temporizing measure only. Current use in the ED should be restricted to rescue placement after failed oral intubation with adequate BMV or a quick maneuver in the “can’t intubate, can’t oxygenate” patient simultaneous with preparation for a cricothyrotomy (analogous to the use of the ILMA in this situation). The Combitube has virtually no role in the ED as a primary airway management device except in cases of cardiopulmonary arrest when expertise for endotracheal intubation is not available.

**Video Laryngoscopes.** New devices incorporate video imaging into modified laryngoscopes to allow superior visualization of the glottis without the need to create a straight-line visual axis through the mouth. The Glidescope uses an extended Macintosh blade with a sharply angulated tip to direct the video camera at the glottis, even in patients with difficult airways (Fig. 1-13). When compared with direct laryngoscopy, the Glidescope provides an equivalent or superior glottic view, and has a very high intubation success rate. The Glidescope appears to cause less cervical spine movement than conventional direct laryngoscopy with a Macintosh blade. The C-MAC video laryngoscope (Fig. 1-14) incorporates a complementary-metal-oxide-semiconductor (CMOS) video chip into otherwise conventional laryngoscope blades, to enhance glottic view. Other videolaryngoscopes are available or under development. Overall, videolaryngoscopy offers the promise of transforming laryngoscopy and has the potential to render conventional, direct laryngoscopy obsolete.

**Fiberoptic Intubating Stylets.** Several rigid fiberoptic intubating stylets have also been approved and adopted into clinical use. The Shikani Optical Stylet (SOS—Clarus Medical, Minneapolis, Minn.) is the most studied of these. The endotracheal tube is placed over the
The GlideScope (Verathon, Inc.) is a video laryngoscope that uses a 50° deflection of the distal tip of the blade (which is otherwise similar to an extended MAC-3 blade) to direct the video camera and light source directly at the glottis without repositioning the head. The endotracheal tube insertion is done under direct vision via the video screen. (From Walls RM, Murphy MF [eds]: Manual of Emergency Airway Management, 3rd ed. Philadelphia, Lippincott Williams & Wilkins, p. 171, 2008, with permission.)

The C-MAC video laryngoscopy (Karl Storz Endoscopy) uses an integrated CMOS video chip to capture a video image from near the distal tip of an otherwise conventional laryngoscope blade. The image is conveyed to a video screen where it is viewed by the intubator. (From Walls RM, Murphy MF [eds]: Manual of Emergency Airway Management, 3rd ed. Philadelphia, Lippincott Williams & Wilkins, p. 173, 2008, with permission.)

Flexible Fiberoptic Scopes

Intubation using a flexible fiberoptic scope is increasingly applied to difficult airways in the ED, after many years of use for similar applications in the operating room. The intubating fiberoptic bronchoscope can be passed through the vocal cords under fiberoptic visualization, then can serve as an introducer over which the ETT is passed. Fiberoptic examination facilitates airway assessment for the need for intubation, without definitely committing the patient to intubation, as is the case when an NMBA is administered for RSI. For example, in a patient with smoke inhalation, examination with the fiberoptic scope might identify that intubation is not required, but will also facilitate intubation when it is indicated. Intubation of morbidly obese patients, those with distorted airway anatomy (e.g., penetrating or blunt anterior neck injury), or those with fixed cervical spine deformity, can be achieved using the fiberoptic scope, topical anesthesia, and moderate (procedural level) sedation, thus preserving the patient’s ability to breathe until intubation is achieved. The fiberoptic scope also has been used successfully in concert with the ILMA to achieve intubation in difficult cases, including when the cervical spine is immobilized, where it significantly outperforms conventional laryngoscopy.

There is a significant learning curve for flexible fiberoptic intubation, and fiberoptic examination of the upper airway in
patients with pharyngitis or odynophagia, for example, is helpful, as it requires the same “navigation skills” as are required for intubation. Use of a video attachment for instruction, so that the instructor and learner can simultaneously see the same image appears to enhance learning. Models have been created to allow learners to navigate through a series of openings and around barriers, which also increases subsequent intubation performance.

The role of flexible fiberoptic intubation in the ED is greatly expanding, as obesity increases in the population, and, increasingly, difficult airways are handled in the ED without backup. The transition from fiberoptic to CMOS video technology should make these flexible scopes more prone, less prone to fogging, and less expensive—all desirable attributes for emergency intubation. Emergency physicians should have immediate access to fiberoptic scopes and should endeavor to acquire training and practice in their use. Fiberoptic scopes are of great value in the patient with predicted difficulty in direct laryngoscopy, EGD use, and BMV. The expanding use of video laryngoscopy will redefine the role of flexible fiberoptic scopes, as video laryngoscopy solves many of the difficulties that occur with direct laryngoscopy.

Other Intubation Techniques

Retrograde Intubation. In retrograde intubation, a flexible wire is passed in retrograde fashion through a cricothyroid membrane puncture. The wire is retrieved through the mouth, then used to facilitate intubation by serving as a guide over which the ETT is passed. Purported advantages of retrograde intubation include ease of learning and application to the difficult airway. Although retrograde intubation theoretically may be useful when the upper airway is disrupted by trauma, rendering oral intubation difficult or impossible, it is unlikely to be used in the ED except in circumstances in which alternative devices, such as fiberoptic intubation, Trachlight, Combitube, and cricothyrotomy, are unavailable. Published reports of its use in emergency circumstances have been limited to case reports, very small series, and review articles. It is doubtful whether retrograde intubation would ever be the airway maneuver of first choice in the ED, but it may be a useful consideration in rare, unique difficult airway cases.

Lighted Stylet. The lighted stylet is a device that incorporates a handle, a fitting for mounting an ETT, and an intubating stylet with a fiberoptic light mounted on the end (Fig. 1-17). The ETT is mounted as on a conventional intubating stylet, but transillumination of the soft tissues from within the neck permits identification of tracheal entry by the stylet and ETT. The lighted stylet has been used for oral and nasal intubation and has an excellent success rate. The lighted stylet is less stimulating to the heart rate and blood pressure than conventional laryngoscopy and may be useful when sympathetic stimulation is not desirable. Although overall success rates with the Trachlight lighted stylet have been high, it may be more difficult for novice intubators to learn than conventional laryngoscopy, if only minimal manikin training is used. The Trachlight can be used as a primary intubating device or as a rescue device in the “can’t intubate, can ventilate” failed airway. It is not appropriate for the “can’t intubate, can’t ventilate” failed airway, when cricothyrotomy is indicated. As a device for a difficult airway, the lighted stylet can be used as the intubating stylet for a standard oral intubation. The direct illumination by the stylet can aid in visualization during intubation. If direct laryngoscopy is unsuccessful, the first rescue procedure could be an immediate attempt at blind, oral intubation using the lighted stylet, as long as ventilation is possible. There is also some evidence that the Trachlight produces less cervical spine motion than does direct laryngoscopy.

Surgical Airway Management

Needle Cricothyrotomy with Transtracheal Jet Ventilation

Needle cricothyrotomy involves the insertion of a large needle (ideally 10-gauge) through the cricothyroid membrane into the airway. When inserted, the needle is used to ventilate the patient with a standard wall oxygen source. Because of the high-velocity ventilation that ensues through the narrow catheter, this procedure is called transtracheal jet ventilation. Transtracheal jet ventilation has been used successfully in humans and has been subjected to various animal experiments to determine its uses and limitations. It rarely has been used in patients in EDs, however, where its role as a rescue device in the “can’t intubate, can’t ventilate” situation is vastly inferior to cricothyrotomy.

The jet ventilator should include a regulator and gauge so that pressures can be monitored and reduced, especially in children (Fig. 1-18). Upper airway obstruction has been considered a contraindication to transtracheal jet ventilation, but ventilation still can be successful, although at the cost of higher intrapleural pressure and possibly pulmonary barotrauma. In general, when upper airway obstruction is present in adults, percutaneous or surgical cricothyrotomy is preferred.

The primary indication for transtracheal ventilation in the ED is the initiation of emergency oxygenation for a pediatric patient who is apneic (either because of the presenting condition or because of administration of an NMBA) and in whom intubation and BMV are impossible. Cricothyrotomy is extremely difficult or impossible in children younger than 10 years old, and transtracheal ventilation should be considered the surgical rescue modality of choice in this age group. For children younger than 5 years old, bag ventilation is used with the percutaneous catheter, and pressurized devices are avoided.

Cricothyrotomy

Cricothyrotomy is the creation of an opening in the cricothyroid membrane through which a cannula, usually a cuffed tracheostomy tube, is inserted to permit ventilation. The techniques, and variations thereof, are well described elsewhere. When surgical airway management is required, cricothyrotomy is the procedure of choice in the emergency setting, where it is faster, more straightforward, and more likely to be successful than tracheotomy. Cricothyrotomy is indicated when oral or nasal intubation is impossible or fails and when BMV cannot maintain adequate oxygen saturation (the “can’t intubate, can’t ventilate” situation). Several large series have established that the incidence of cricothyrotomy is approximately 1% of all ED intubations.
Cricothyrotomy is relatively contraindicated by distorted neck anatomy, preexisting infection, and coagulopathy; these contraindications are relative, however, and the establishment of the airway takes precedence over all other considerations. Successful cricothyrotomy after systemic fibrinolytic therapy has been reported. The procedure should be avoided in children younger than 10 years old, in whom anatomic considerations make it exceedingly difficult. Studies suggest that approximately five “practice” cricothyrotomies on a simulator or animal model are sufficient to achieve at least baseline capability with the procedure.

Cricothyrotomes are devices used to perform percutaneous cricothyroidotomy. Percutaneous cricothyrotomy using the Seldinger technique appears comparable to formal open cricothyrotomy in terms of ease of learning and success rates. The safety and effectiveness of other cricothyrotomes are not clearly established. A recently released kit by Portex offers a small red flag indicator to warn when the posterior tracheal wall is touched, but a cadaver study showed that, although the device resulted in somewhat faster placement of an airway than did a Seldinger technique, the incidences of both failure and major complications (posterior airway wall laceration) were unacceptably high, so the device cannot be recommended. Only two percutaneous cricothyrotomy sets on the market currently have the ability to place auffed tracheostomy tube. One is a dedicated Seldinger cricothyrotomy set; the other is a combination set that has all necessary equipment for either a Seldinger percutaneous cricothyrotomy or a standard surgical cricothyrotomy (Melker universal cricothyrotomy kit; Cook Critical Care, Bloomington, Ind.) (Fig. 1-19).

OUTCOMES

Few studies of emergency airway management have characterized complications and outcomes. The largest single-institution series reported a success rate for ED RSI of 99% and a complication rate of 9.5%; most complications were minor. Phase II of the large National Emergency Airway Registry Study (NEAR II) of almost 9000 ED intubations reported success rates of approximately 97% for RSI. The NEAR classification system characterizes potentially adverse occurrences during intubation as “adverse events.” In the NEAR study, the observed rate of adverse events was approximately 9% in medical patients and 8% in trauma patients, and most of these were minor. No studies have evaluated the long-term outcome of intubated ED patients.