Emergency airway management

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Emergency airway management is one of the most crucial aspects in caring for critically ill patients. The patient’s rapidly evolving condition as well as the spectrum of acute airway disorders confronted in an emergency setting requires both knowledge and skill in all aspects of acute airway management. The need for intubation can be determined by assessing the integrity of the airway, the adequacy of oxygenation and ventilation, the ability to protect the airway, and the need for intubation based on the patient’s present condition or therapy required. This determination is dynamic; the emergency physician should consider the need for intubation not only at the time of presentation but also in the management of the patient’s condition. Endotracheal intubation is used to establish, maintain, or protect an airway that is compromised or has a potential for compromise. In addition, it is used to improve pulmonary toilet and to enhance oxygenation and ventilation. It is the first choice for invasive airway management when simple positioning or bag valve mask ventilation is inadequate. Consideration of the patient’s airway in this context allows the emergency physician to anticipate and prepare for the difficult airway, thus avoiding a potential forced and hurried intubation.

A standard definition for the difficult airway has not been identified. In this article, a difficult airway is defined as a clinical situation in which the practitioner experiences difficulty with ventilation, laryngoscopy, or tracheal intubation. There is strong evidence that specific strategies facilitate management of the difficult airway. Although the exact degree of benefit cannot be determined, there is strong agreement that a preformulated strategy will lead to improved outcomes [1–4]. The strategy will depend in part upon the patient’s condition and the physician’s skills and preferences.

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This article assumes the reader is knowledgeable and experienced in routine endotracheal intubation techniques. It focuses on identification and management of the difficult airway, including alternative noninvasive techniques such as tactile intubation, directional tubes, stylets, combination tubes, and the laryngeal mask airway. Invasive techniques discussed are retrograde intubation, needle cricothyrotomy, and surgical cricothyrotomy. Methods for intubation such as rapid sequence intubation and awake intubation techniques are also reviewed.

**Difficult intubations**

The experienced clinician can usually anticipate when intubation may be difficult (Box 1) [5]. This is determined by obtaining a directed airway history and thorough physical exam. In many cases history and physical examination may be abbreviated because of emergent circumstances, but they should not be omitted. This assessment is a reliable indicator of the patient’s overall state of health and is useful in predicting potential difficulties [3,5–7]. Occasionally, despite a thorough evaluation, a patient may present with an unexpected problem during intubation. At these times the practitioner should depend on a preformulated plan of action.

**History**

The historical data obtained should be brief and include information about previous intubations with delineation of any problems, the presence of dental appliances (bridges, fillings) or loose teeth, and the time of last meal, because this may influence the choice of pretreatment and paralysis medications.

Medical disease history should be directed to determine if there is congenital or acquired disease that may interfere with the mobility of the cervical spine, atlanto-occipital joint, mandible, or soft tissues of the oral cavity and neck; such diseases include arthritis (especially rheumatoid) and ankylosing spondylitis. If nasotracheal intubation is contemplated, inquiries about clotting disturbances, nasal polyps, and a history of epistaxis should be obtained.

**Physical exam**

A general assessment of the patient’s overall condition, especially the level of consciousness and the ability to breathe should be performed. Examination of the airway includes exam of the temporomandibular joint (TMJ), mandible, lips oral cavity, tongue, teeth, neck, and cervical spine. The nose, septum, and nasal pharynx should be included if nasotracheal intubation is being used or considered as a rescue technique in the breathing patient.
The function of the TMJ is complex and involves articulation and movement between the mandible and the cranium. There are two distinct movements involved in opening the mouth, and each contributes approximately 50% to the degree of opening of the mouth [8]. The first is a hinge-like movement of the condyle through the synovial cavity, and the second is the forward displacement of the condyle.

Assessment of the TMJ is performed by having the patient open their mouth widely (Fig. 1). The practitioner should listen and palpate for clicks and crepitus, both of which indicate joint dysfunction, and assess the width of the opening. Normal adults are capable of inserting three fingers, held

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**Box 1. Predisposing factors for difficult intubation**

**Anatomic variations**
- Short, thick mandible
- Thick/fat “bull” neck
- Narrow mouth opening
- Large tongue
- Dental anomalies/protruding teeth
- Limited range of motion of cervical spine

**Congenital abnormalities**
- Scoliosis
- Mandibular hypoplasia
- Maxillary hypoplasia
- Klipper-Feil syndrome (decreased number of cervical vertebrae)
- Cleft lip/palate

**Disease states**
- Temporomandibular joint disorder
- Degenerative cervical spine disease/arthritis
- Ankylosing spondylitis
- Infection (retropharyngeal abscess, Ludwig’s angina)
- Airway edema
- Foreign objects
- Malignancy
- Previous tracheostomy

**Trauma**
- Facial
- Mandibular
- Maxillary
- Cervical
vertically in the midline into their mouth, which corresponds to a maximum mandibular opening of 50 to 60 mm [9]. This width is important because the depth of the McIntosh #3 laryngoscope blade (Hospital Equipments Manufacturing Company, New Delhi, India) is 20 mm. If the mandibular opening is less than this, the McIntosh #3 laryngoscope blade cannot be inserted into the mouth, necessitating a technique different than orotracheal intubation.

Mandible hypoplasia is frequently associated with difficult intubation. In a normal adult, the distance from the hyoid bone to the mandibular symphysis is about three finger widths. If this measurement is two finger widths or less, the mandible is considered hypoplastic.

The patient’s oral hygiene should be assessed; if dentures are present, they should be removed. In the pediatric population, an occasional foreign object such as candy or chewing gum may be hidden in the recesses of the oral cavity. Cleft lip deformities may present problems during intubation because the laryngoscope blade tends to enter the cleft. Long, protruding teeth may limit the size of the mouth opening and may be damaged during intubation.

Two features of the tongue that may impede the clinician’s ability to see the airway are size and mobility. Occasionally, the tongue may be so large that it obstructs the view of the uvula, the pillars, and even the soft palate. The Mallampati classification is commonly used in anesthesia to describe the oral opening (Fig. 2) [6]. If the tongue is fixed in a position by tumor or other disease state, the view of the airway may be compromised.

The neck and cervical spine should be examined before intubation. In the traumatic patient, one should presume there is a cervical spine injury when attempting intubation. In the atraumatic patient, the general contour of the neck should be inspected. Obese patients with short, muscular, thick necks
typically have a limited range of motion and are more difficult to intubate. Skin pigmentation changes may be secondary to recent radiotherapy, which can cause acute inflammatory changes, scarring, and fibrosis in the neck region. Previous tracheostomy scars suggest tracheal stenosis and difficult intubation. All neck masses warrant concern, especially if related to a vascular injury, since the airway can be occluded without warning. Infections such as a retropharyngeal abscess, or Ludwig’s angina can distort the anatomy to such a degree that there is soft tissue displacement of the trachea.

Vocal quality and the presence of stridor also suggest airway compromise. Lesions that are predominantly supraglottic are typically associated with inspiratory stridor, whereas subglottic lesions tend to cause both inspiratory and expiratory stridor.

Mobility of the cervical spine is measured by flexion or extension. The optimal position for endotracheal intubation is flexion of the cervical spine and extension of the head at the atlanto-occipital joint. Flexion or extension deformities of the cervical spine associated with arthritides can make direct laryngoscopy more difficult, if not impossible.

Suboptimal standard technique can also make a routine intubation difficult [10]. The most common mistake made during intubation is “cranking back” on the laryngoscope handle to lever the top of the blade to provide better visibility. This maneuver may improve glottic visualization, however, it restricts the intubators’ ability to manipulate the tube by limiting the size of the oral opening and it jeopardizes the teeth. During direct laryngoscopy, damage to the teeth is usually caused by excessive pressure on the teeth. Lifting the laryngoscope and blade upward and forward both improves the glottic visibility and increases the oral opening, allowing more room for manipulating the endotracheal tube.

Alternative noninvasive techniques

Several modifications of the standard technique, as well as adjuncts and alternative techniques, have been reported to assist in difficult intubations (Box 2) [11,12]. Changing the laryngoscope blade from curved to straight or vice versa is a simple technique that may favorably affect the intubators’ ability to see the glottis or manipulate the tube successfully. Straight (Miller) blades (Hospital Equipments Manufacturing Company, New Delhi, India) are narrow blades with a curved central canal. A patient may be easier to intubate with a straight blade if they have overriding teeth, a very floppy epiglottis, or a thick neck that is difficult to maneuver. Straight blades are better for intubating small children. The curved (McIntosh) blade has a broad, flat surface and a tall flange to enhance movement of the tongue. For adults, a McIntosh #3 or #4 or a Miller #2 blade is most useful. Occasionally a patient with a thick neck will require a Miller #3.

Position of the patient is a simple maneuver that may aid visualization of the vocal cords. To establish this line of sight, there are three axis that must be obtained (Fig. 3) [13]. The first is the axis of the mouth to the posterior pharynx, the second is a line running parallel to the posterior pharynx, and third is the line of the larynx as it traverses into the trachea. At rest, none of these axes are completely aligned. To establish a clear line of sight, it is important to first flex the neck on the shoulders to align the posterior pharynx and the larynx. Approximately 30° of flexion is necessary to achieve this alignment. It is useful to place towels or folded sheets under the occiput of the patient to assist in holding this position. Next, it is important to extend the head on the neck to approximate a line of sight from the mouth, with the line of the pharynx and with the now aligned larynx. This requires approximately 20° of extension, although more may be necessary depending on the soft tissue of the posterior pharynx. This extension occurs at the
atlanto-occipital joint and thus, the cause of difficulty if there is arthritis or cervical spine abnormalities. This final alignment is conducive to direct visualization of the vocal cords and is called the “intubating” or “sniffing” position.

**Box 2. Invasive and noninvasive alternatives, modifications, and adjuncts**

**Invasive techniques**
- Translaryngeal guided or “retrograde” intubation
- Fiberoptic endotracheal intubation
- Percutaneous transtracheal ventilation or needle cricothyrotomy
- Surgical cricothyrotomy
- Percutaneous tracheostomy
- Surgical tracheostomy

**Noninvasive techniques**
- Changing laryngoscope blades
- Endotracheal tube stylet
- Magill forceps
- Directional tip control tubes
- Blind orotracheal passage based on landmarks
- Use of an assistant
- Special laryngoscope blades
- Guiding stylets
- Lighted stylets
- Tactile orotracheal intubation
- Pharyngeotracheal lumen airway
- Esophageal–tracheal combitube airway
- Laryngeal mask airway
- Standard nasotracheal intubation
- Tactile nasotracheal intubation

**Digital/tactile intubation**

During laryngoscopy, the only structure commonly seen is the epiglottis. A blind technique using anatomical landmarks is the digital or tactile technique. The endotracheal tube is passed blindly by sliding the end of the tube along the under surface of the epiglottis and through the glottic opening [13,14]. By palpating the epiglottis with the index and long fingers, the epiglottis can be picked up by the long finger and directed anteriorly. The tube is guided by the index finger under the epiglottis and into the
trachea. A stylet bent at a 90° angle 4 to 6 cm from the tip of the tube should be used to assist in placement.

Advantages of “tactile intubation” include rapidity (when experienced), no need for special equipment and no movement of the head and neck. The limitation to this technique is to be successful the patient must be deeply unconscious or there may be injury to the intubator’s hand.
Directional tubes

Endotracheal tubes (Endotrol tubes®, Mallinckrodt, Hazelwood, MD) with directional tip controls allow the intubator to alter the distal curve of the tube as needed during insertion [14]. This avoids intubation delays caused by having to readjust the tube curve. Magill forceps, while designed primarily for assisting with nasotracheal intubation, may also be useful for directing a tube during attempted orotracheal intubation. This is a two-person technique with an assistant used to retract the laryngoscope with the intubators’ guidance. After adequate glottic exposure is attained by the assistant, the intubators manipulate the tube into the glottic opening using the Magill forceps.

Stylets

Stylets are commonly used to ensure that the tube is rigid and to allow greater curvature of the tube for reaching the more “anteriorly” situated larynx. The rigid stylet should never extend beyond the tip of the tube because it may cause pharyngeal or laryngeal trauma. Passing a smaller guide through the glottis initially may facilitate tube insertion in cases where the glottic opening can be seen but endotracheal tube insertion is difficult (eg, glottic edema in a burn patient). Devices successfully used for this purpose include suction catheters or tracheal tube exchangers over stylet wires. In addition, there are specially designed stylets with distal directional control that assist in moving the tube into the tracheal opening.

Lighted stylets

A transillumination technique for blind orotracheal or nasotracheal intubation is the lighted stylet or “light wand” [15–18]. The light at the tip of the stylet is positioned within 0.5 cm of the end of the endotracheal tube. Using a 90° angle placed 4 to 6 cm from the end of the tube, the tube is guided by observing the anterior neck for transillumination through the soft tissue. A bright red glow in the midline at the level of the larynx indicates proper guidance of the tube. (Fig. 4) The tip of the tube is in the pyriform sinus if the bright red glow is off the midline. A dull diffuse glow represents passage of the

![Fig. 4. Lighted stylet tube placement.](image-url)
tube into the esophagus. An advantage of this technique is the lack of head and neck manipulation. This technique is limited by overhead lighting, which creates difficulty seeing the stylet light. Also, because it is a blind technique, it is not recommended in patients with anatomic abnormalities of the upper airway such as tumors, polyps and infections (epiglottitis).

Esophageal–tracheal tubes
Initially designed for prehospital care, these airways may provide adequate ventilation as a temporizing measure until a more secure airway can be obtained [19–21]. These combination tubes are currently part of the ASA recommendation for a patient that cannot be intubated or ventilated. Esophageal obturator airway (EOA) tubes had been widely used by prehospital emergency medical personnel before the development of combination tubes. The EOA’s major limitation was that ventilation was impossible if there was tracheal placement.

The Combitube (The Kendall Company, Mansfield, MA) is currently the more commonly used tube (Fig. 5). This airway device is a double lumen ventilation tube with two cuffs, a small distal cuff and a larger proximal cuff. One tube has a sealed distal end with perforations located on the sides between the cuffs. The other tube has an open distal end. If the tube passes blindly into the trachea, the tube with the open distal lumen is used for
ventilation as an endotracheal tube. If the tube passes into the esophagus, the shorter tube is used to ventilate the lungs similar to the EOA. The advantage of this device is that it avoids the problem of accidental tracheal intubation and no ability to ventilate that may occur with an EOA. It may be helpful if there is massive bleeding or regurgitation. It requires no head or neck movement and can be used on cervical spine injury patients. The disadvantage is a contraindication in patients under 16 years of age or less than 150 inches tall. The Combitube must be used in patients without an intact gag who are unconscious. Combination tubes are an accepted alternative for rescue airway but are most often seen in patients from the field. Familiarity with these devices is important to ensure proper use.

**Laryngeal mask airway**

The laryngeal mask airway (LMA) was approved for use in the United States in 1992. It was developed in the 1980s and was used in the United Kingdom in the latter portion of that decade. It serves as a bridge between endotracheal intubation and face mask ventilation [22]. This device consists of a tube resembling an endotracheal tube with a distal mask structure designed to form a seal around the glottic structures in the hypopharynx. It is placed in unconscious patients and traditionally has been used on patients under anesthesia. A blind technique is used to place the LMA using the thumb and index finger to advance the tube and mask horizontally over the hard palate until it reaches into the posterior pharynx. Here the mask moves vertically until resistance is met. The cuff is then inflated and breathing is assessed by normal excursion, breath sounds, and no evidence of extraneous
sounds. Slow, controlled breaths work best to avoid leakage around the cuff and the appearance of ineffective placement and unnecessary removal.

The LMA comes in multiple sizes ranging from 1 to 5. Sizes 1 and 2 (with half sizes) are recommended for children. Generally size 4 is used for normal-sized adults and size 5 is used for adults weighing more than 70 kg. Both a disposable and reusable LMA are available. In addition, an intubating LMA permits intubation through the device itself using a specifically designed endotracheal (ET) tube.

The LMA is an excellent replacement for face mask ventilation. It does not replace the endotracheal tube largely because of the risk of aspiration. In addition, laryngospasm and inability to ventilate can still occur [23]. Inability to ventilate can occur because of glottic rigidity or any soft tissue obstruction above the level of the glottis. Experience with this device in emergency airway situations is limited at present, but it may offer another temporary measure until a more secure airway can be obtained.

**Nasotracheal intubation**

Awake, blind nasotracheal intubation is different from endotracheal intubation because it requires a breathing patient. The nasal procedure is somewhat more difficult, is more time-consuming, and has a lower success rate than the orotracheal route [24,25].

Indications for nasotracheal intubation include dyspneic patients in whom the supine position is impossible or contraindicated and in whom the oral cavity is not accessible to orotracheal intubation. Examples of this are wired jaws, anatomical problems (eg, a small mouth), TMJ arthritis, trismus, tetanus, intraoral infections, active seizures, obstructing lesions of the anterior oropharynx (eg, tumors), Ludwig’s angina, lingual swelling/hematoma, or dental abscesses. Other indications are unsuccessful orotracheal intubation despite multiple attempts or patients in whom paralyzing agents are contraindicated.

The tube for nasotracheal intubation should be approximately 1 mm smaller in diameter than the tube used for orotracheal intubation. It should be made of clear polyvinylchloride to allow breath condensation to be seen on the inside walls of the tube. Directional tubes are preferred.

There are three anesthetic techniques that may be helpful in nasotracheal intubation: nasal, pharyngeal and translaryngeal. Nasal anesthesia is obtained using either topical viscous lidocaine (2% to 4%) and phenylephrine (1%) or cetacaine solution and phenylephrine (1%) or cocaine solution 2% to 10% [26]. One to two milliliters of solution in each nares should be sufficient and can be applied with cotton swabs, pledgets, or spray. These combinations allow both anesthesia and vasoconstriction. Cocaine is the only topical anesthetic agent that provides both vasoconstriction and anesthesia. Lidocaine and cetacaine anesthesia require approximately 60 seconds for onset, whereas cocaine takes 5 minutes [25]. Hypertension is a relative contraindication to the use of both cocaine and phenylephrine [27].
Pharyngeal anesthesia is performed by spraying lidocaine or cetacaine to the posterior pharynx. It is controversial whether pharyngeal anesthesia predisposes patients to aspiration [28]. Translaryngeal anesthesia is not generally used in emergency medicine because it is unnecessary, time-consuming, and has complications [28].

Blind nasotracheal intubation is performed with the patient supine or sitting in the “sniffing” position. The patient, if conscious, should receive step-by-step instructions before and during the procedure. Lack of proper psychological preparation will lead to fear, anxiety, movement, and lack of cooperation. The edge of the tube is placed against the nasal septum of the chosen nostril, to prevent abrasions and bleeding, and the tube is directed perpendicular to the facial plane with the curvature of the tube facing superiorly. The tube is then inserted through the nasal passage and into the pharynx by using a continuous forward pressure. If difficulty with passage occurs, one can try a smaller tube or use the other nostril. Once the tube is in the pharynx, it should be rotated 180° so that the curvature faces inferiorly. The tube now serves as a nasal airway and facilitates the remainder of the procedure. If the tube impedes on the posterior pharyngeal wall, redirection by traction on the ring of the directional tube will overcome this obstacle.

Upon advancing the tube forward approximately 2.5 to 5.0 cm, the operator will note air movement passing through the tube. As the intubator appreciates airflow, an assistant should apply gentle but firm pressure on the cricoid cartilage (the Selek maneuver). The patient should be instructed to breathe in and out, and during inspiration the tube is advanced beyond the vocal cords. Balloon inflation and tube confirmation is performed using standard techniques.

The nasotracheal tube can lie in only one of five locations outside the trachea: (1) the vocal cords outside the larynx, (2) the vallecula, (3) the left pyriform fossa, (4) the right pyriform fossa, or (5) the esophagus. A misdirected tube at the vocal cords outside the larynx results in obstruction to passage of the tube despite good detection of breath sounds and can be corrected by gentle rotation. A tube that impacts the vallecula will often cause a midline supralaryngeal bulge in the neck. Retracting the tube a few centimeters, followed by gentle pressure in the area just above the larynx, or by slight flexion of the head, will solve this problem. Misdirection of the tube into either the left or right pyriform fossae will often result in a corresponding lateral bulge in the neck. This problem is corrected by (1) displacing the patient’s larynx slightly in the direction of the bulge, (2) rotating the tube, (3) moving the head toward the side of the displacement, or (4) by any combination of these maneuvers.

There is debate concerning the desirability of oral versus nasotrachea intubation for patients in whom a prolonged intubation is expected. Nasal airways are better tolerated by patients, but they carry the risk of turbinate necrosis and sinusitis with prolonged use [24]. Relative
contraindications to performance of nasotracheal intubation include severe nasal or oral hematomas or hemorrhage, infections or hematomas of the upper neck, maxillary facial trauma, blood clotting abnormalities, nasopharyngeal obstruction (deviated septum, masses) and acute epiglottitis.

Apnea or near apnea is an absolute contraindication only in use of the standard blind technique. However, use of the lighted stylet fiberoptic endoscope, or tactile technique has been reported to aid in nasotracheal intubation in the apneic patient [26,29–31]. This technique has not been reported outside the anesthesia literature. Also, even with vasoconstriction and gentle tube manipulation, problematic epistaxis can occur [24,32,33].

Invasive airway management

Translaryngeal guided (‘‘retrograde’’) intubation

Retrograde tracheal intubation is an effective emergency technique for securing an airway should conventional means of endotracheal intubation fail. Nevertheless, this technique has not yet gained wide clinical acceptance. This may be because of its invasive nature and the potential difficulty associated with cricothyroid puncture; in addition, it is rarely taught in the clinical setting [34]. Retrottracheal intubation requires minimal operator experience and can be performed without head or neck movement [35,36].

Use of retrograde intubation is indicated in a clinical setting in which an alternative technique is desired because of bleeding, secretions, or vomitus in the upper airway that obscures glottic visualization and there is inability to orally or nasally intubate using standard techniques. It is an alternative to surgical cricothyrotomy [34,35,37]. Stable, cooperative patients, and comatose patients with free access to the posterior pharynx and spontaneous respiratory efforts are the most suitable candidates. Retrograde tracheal intubation may not be suitable for patients requiring immediate intubation and ventilation, since the procedure can be expected to take up to 5 minutes for completion [38].

Cases have been reported in which retrograde intubation has proved effective in patients with abnormal anatomical or pathologic conditions of the upper airway, including congenital orofacial lesions, tumors, and infections such as acute epiglottitis. Retrograde tracheal intubation has also been useful in patients with other conditions limiting visualization of the glottis such as cervical spondylosis, trauma, or severe kyphosis. Patients sustaining severe orofacial trauma, in whom distortion of normal anatomy and a blood field precludes convention endotracheal intubation, are considered candidates as well [39–42].

Preparation for retrograde intubation includes preoxygenation and local anesthesia. Oxygen should be provided through a face mask. Use of retrograde tracheal intubation allows unimpeded upper airway management up to the point of retrieval of the guide catheter/wire from the posterior
pharynx. Bag mask ventilation may also be added if spontaneous respirations are deemed inadequate.

After preoxygenation of the patient and equipment preparation, the posterior pharynx is sprayed with a topical anesthetic. A sterile technique is advisable if time permits. One milliliter of 1% lidocaine is injected into the skin overlying the cricothyroid membrane, and another 2 ml is injected into the glottic space and supraglottic lumen. In the conscious patient, care should be taken to remove the needle quickly after this maneuver to avoid injury from subsequent coughing.

Retrograde intubation is performed using a 16- to 18-gauge needle placed in the cricothyroid membrane, directing the needle at 30° to 40° angle cephalad. When positioning the needle, it should be connected to a syringe filled with saline, and the bevel of the needle should be aligned with the scale marked on the barrel of the syringe. This allows direction of the bevel cephalad once inside the larynx. The syringe can then be aspirated as it is being inserted to ensure that the needle tip has entered the laryngotracheal lumen (Fig. 6). A small stab incision with a #11 surgical blade may facilitate entrance of the needle to the skin.

A through-the-needle catheter or, preferably, a soft-tipped guide wire is then passed retrograde from the larynx to the oral cavity where it is retrieved. The guide wire needs to be long enough to pass out of the mouth. A 100-cm wire is recommended to allow manipulation of the tube or use of adjunct equipment. The needle is removed and the guide wire is secured at the skin over the cricothyroid membrane with a hemostat.

The endotracheal tube is placed over the guide wire at the proximal end of the wire (near the oral cavity). The wire is threaded into the distal side hole (Murphy’s eye) and out the proximal end of the tube (Fig. 7) [43]. The tube is then passed along the guide wire into the larynx while the guide is held taut. Mild to moderate pressure must be held on the ET tube to advance it into the trachea. The wire is withdrawn from the mouth in a retrograde direction to prevent contamination of cervical soft tissues at the

Fig. 6. Confirmation of placement in the laryngotracheal lumen.
puncture site. It is important that the motion of pulling the wire and the advancement of the tube occur simultaneously; in addition, this maneuver requires both hands and pressure. This is to ensure that when the guide is released the tube will move down through the larynx and into the trachea and not fall back into the hypopharynx. The advancing beveled edge of the endotracheal tube may strike against the vocal cords; if this occurs, use of force to move the tube through the glottis must be avoided. Rather, use simple counterclockwise rotation of the endotracheal tube 90° to bring Murphy’s eye anterior and align the bevel perpendicular to the glottis slits, which allows the tube to pass [40].

Modifications of this technique have been described using a plastic sheath protector, a Cook exchange catheter, or a flexible stylet through the ET tube into the distal trachea just before releasing the guide wire [34]. This may help prevent the ET tube from falling back into the hypopharynx.

An absolute contraindication to this procedure is complete upper airway obstruction. Other relative contraindications include severe trauma to the larynx or laryngotracheal separation, the presence of an enlarged thyroid gland, soft tissue infection or abscess over the cricothyroid area, coagulopathy, and inability to open the mouth for catheter retrieval. The major limitation of this technique is that if the endotracheal tube falls into the hypopharynx at guide release, the procedure must be repeated.

Percutaneous transtracheal ventilation or needle cricothyrotomy

Percutaneous transtracheal ventilation or needle cricothyrotomy can be used as a temporizing measure when oral or nasal intubation is not possible. It is not recommended if there is complete airway obstruction, although this has been recently debated if a large catheter is used.

The technique is similar to the retrograde technique. The cricothyroid membrane is identified, and a 12- to 16-gauge over-the-needle catheter that
is attached to a saline-filled syringe is inserted at a 30° to 45° angle caudally. Unlike the retrograde technique, it is not directed toward the head because no wire has to be directed to the oral cavity. The catheter is threaded into the hub. The catheter tip is then connected to a pressurized oxygen apparatus capable of delivering approximately 50 psi of oxygen. One-second inflations are provided at a rate of approximately 12 per minute. If a high-pressure oxygen source is not available, another alternative is to attempt to use a bag-valve apparatus connected to the catheter. The proximal connector of an 8.0 ET tube will fit tightly inside a 3-cc syringe, which could be connected to the catheter. In addition, the proximal connector of a 3.0 ET tube will fit into a catheter hub.

An alternative to this technique is to use a Seldinger catheter introducer set, such as an 8.5-Fr introducer kit commonly used for pulmonary artery catheters. The needle can be used to make the initial puncture and the guidewire inserted securely into the distal trachea. The catheter is then inserted over the wire using the dilator. The 8.5-Fr catheters have been shown to provide some exhalation and have been used successfully in models of complete airway obstruction.

It is most important to remember that this is a temporary procedure until a more secure airway can be attained. In addition, its effect is limited because oxygenation can only be maintained for about 30 minutes because of the lack of adequate ventilation and progressive hypercapnia.

**Surgical cricothyrotomy**

There are few situations in emergency medicine that inspire more concern than an airway that needs to be managed surgically. The incidence is low and the acquisition of the necessary skill is difficult. Even when a clinical situation requires a surgical airway, there is often a psychological reluctance to attempt the procedure. This tends to make the procedure even more difficult because delay only places greater time constraints on the emergency physician to achieve a successful airway. The only mandatory indication for a surgical airway is total upper airway obstruction. The most common reason is failure to achieve intubation by nonsurgical means. The emergency physician is usually more familiar and comfortable with alternative forms of airway management, and often persists in attempts to achieve oral or nasal intubation, when in fact the patient needs a surgical airway.

Surgical cricothyrotomy is indicated in the setting of severe maxillofacial trauma preventing oral intubation, known unstable cervical spine fracture, laryngotracheal trauma except for tracheal transection, complete upper airway obstruction oropharyngeal obstruction or inability to secure the airway by other intubation techniques. It is contraindicated in pediatric patients less than 12 years old or if there is laryngotraheal separation or tracheal transection. The latter contraindication is because the transected airway may be tenuously held together by the cervical fascia. An incision dividing the fascia will cause the distal stump of the trachea to retract into
the mediastinum with disastrous consequences for the patient. If an endotracheal tube cannot be passed across the separation to act as a stent, a tracheostomy is the preferred surgical approach. Penetrating trauma to the neck in either high Zone 2 or Zone 3 associated with an expanding hematoma is also a contraindication.

Surgical cricothyroidotomy is performed by first locating the cricothyroid membrane. The easiest way to remember this technique is to break it into four steps: palpation, incision, insertion and intubation. The larynx is palpated and stabilized by bracing the laryngeal cartilage with the thumb and middle finger. The position of the cricothyroid membrane is maintained with the index finger (Fig. 8). A skin incision is then made and can be a midline, vertical incision (3–4 cm) or a horizontal incision over the cricothyroid membrane. An incision is then made through the cricothyroid membrane just above the cricoid cartilage. A Trousseau dilator, tracheal hook, hemostat, or blade handle should be immediately inserted in the opening. A tracheostomy tube (a #4 is appropriate for an average adult) or an endotracheal tube (6.0 mm is adequate for an average adult) should be inserted to secure the airway. It is very important not to lose control of the opening that has been made.

A rapid, four-step cricothyrotomy technique has been described in the literature [44]. In this technique, the skin incision is made horizontally at the same time the incision is made through the cricoid membrane. This technique, however, has been reported to have an increased incidence of cricoid cartilage fracture [45].

It is important to remember that cricothyrotomy is an emergency procedure, which is guided by palpation of the anatomy. When indicated, it must be performed rapidly and it can usually be completed in less than 30 seconds. It is a procedure guided by touch, not sight. The time required to dissect the neck tissues adequately to see the cricothyroid membrane would likely require several minutes; such a time delay would almost certainly be detrimental to the patient.
This technique has limitations in severe laryngotracheal trauma, cervical hematoma, or swelling of the neck, which can make performance of it very difficult. In addition, cricothyrotomy is useless in complete tracheal transection or tracheal foreign body.

**Rapid sequence intubation**

Rapid sequence intubation (RSI) involves the use of neuromuscular blocking agents and sedatives or hypnotic agents to facilitate intubation and limit the potential adverse effects of laryngoscopy and intubation [34,46,47]. It also allows the patient to be intubated without experiencing the physiological trauma of being intubated while conscious. Rapid sequence intubations are now considered routine in most emergency departments, accounting for 70% to 84% of all emergency department intubations [4,48]. The use of pharmacologic agents to assist intubations seems to decrease complications. Comparisons of paralytic assisted and nonparalytic assisted intubations, using historical controls, showed that non-RSI patients had 15% more aspirations, 25% more airway trauma, and 3% more deaths [49].

RSI is not a “one method fits all” technique. Drugs selected to be used for RSI should be tailored to the specific scenario and the individual patient. The clinician should be familiar with an array of pharmacological options for emergent endotracheal intubation, including barbiturates, nonbarbiturate hypnotics, benzodiazepines, opiates, associative agents, and neuromuscular blocking agents (Table 1). Each scenario should be evaluated to find out if there are any relative contraindications to RSI. The major risk of RSI is that the physician could potentially paralyze a nonapneic patient, making it impossible to intubate, ventilate, or create a surgical airway.

The emergency physician may choose to perform an awake intubation in certain circumstances. This option is easily employed in patients who are spontaneously breathing but have strong contraindications to paralysis. These include patients with any anatomical barriers that may obstruct the airway and prevent intubation. Patients who are candidates for awake intubation may receive nebulized 4% lidocaine to reduce their gag reflex, light sedation with midazolam, or other appropriate sedating/hypnotic agents [50,51].

**Approach to RSI**

RSI can be divided into five stages: preparation, preoxygenation, premedication with sedation and anesthesia, paralysis, and intubation.

**Preparation**

Preparation includes appropriate placement of intravenous lines, continuous cardiac and pulse oximetry monitoring, and preoxygenation. Cardiac monitoring is important because the procedure itself may cause cardiac
Table 1
Sedative agents

<table>
<thead>
<tr>
<th>Drug</th>
<th>Induction dose</th>
<th>Recommended dose for RSI</th>
<th>Induction time</th>
<th>Physiologic effect</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg/kg</td>
<td>mg/kg</td>
<td></td>
<td>BP</td>
<td>ICP</td>
</tr>
<tr>
<td>Etomidate</td>
<td>0.3</td>
<td>0.05–0.1</td>
<td>10–15 s</td>
<td>Neutral</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Possible epileptogenic/monoclonic jerks</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adrenal suppression</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>↑ incidence of N/V</td>
<td></td>
</tr>
<tr>
<td>Fentanyl</td>
<td>5–7</td>
<td>1–2</td>
<td>30–45 s</td>
<td>Neutral</td>
<td>↑†↑</td>
</tr>
<tr>
<td>Ketamine</td>
<td>1–2</td>
<td>0.5–1</td>
<td>30–45 s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midazolam</td>
<td>0.1–0.3</td>
<td>1–2</td>
<td>2–3 min</td>
<td>Neutral, ↓ with higher dose</td>
<td>Neutral</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propofol</td>
<td>1–2</td>
<td>0.5–1</td>
<td>10–15 s</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Thiopental</td>
<td>3–5</td>
<td>2–3 mg/kg if &lt;65</td>
<td>10–15 s</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1–2 mg/kg if &gt;65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Abbreviations: BP, blood pressure; ICP, intracranial pressure; RSI, rapid sequence intubation.*
dysrhythmias [52]. Pulse oximetry alerts the intubator if the patient is becoming hypoxic. Studies have shown that pulse oximetry can reduce the frequency and duration of hypoxemia associated with clinical intubation [53].

Preoxygenation

Preoxygenation begins with administration of high-flow oxygen to maximize arterial oxygenation. The goal is to avoid using positive pressure ventilation to prevent hyperinflation of the stomach, vomiting, and aspiration. Five minutes of 100% oxygen is best; however, one study showed that eight deep breaths over 60 seconds significantly slowed the hemoglobin desaturation that occurs with apnea [10]. This preoxygenation phase replaces the nitrogen reserves in the lungs with oxygen and allows 3 to 5 minutes of apnea without serious hypoxemia in a patient with normal hemodynamics.

Premedication

Premedication using pharmacological agents can be given to facilitate endotracheal intubation. These agents are given to prevent the patient from experiencing the physiologic consequences of intubation, such as increases in pulse, blood pressure, intracranial and intraocular pressure [34,54–56]. Sedative and hypnotic agents produce a continuum of physiological effects that range from sedation to induction of anesthesia, depending on the dose administered [51,57–61]. Numerous different agents can be successful in various scenarios (Table 2). The author recommends that the induction doses not be used, but that decreased doses be given and repeated to achieve desired effects.

Intravenous lidocaine may reduce the cardiovascular response to endotracheal tube placement. Studies on this topic are conflicting [46, 62,63]. Intravenous lidocaine administered 3 to 5 minutes before intubation may blunt the associated rise in intracranial pressure, though the evidence for this is limited [64–68]. There is no evidence that lidocaine should be given routinely for rapid sequence intubation in the emergency department. However, it is frequently administered to patients at risk for

Table 2
Sedative scenario table

<table>
<thead>
<tr>
<th>Condition</th>
<th>Sedatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normotensive + euvolemia</td>
<td>Propofol, etomidate, thiopental</td>
</tr>
<tr>
<td>↑ ICP and normal BP</td>
<td>Propofol, thiopental</td>
</tr>
<tr>
<td>↑ ICP and ↓ BP</td>
<td>Etomidate</td>
</tr>
<tr>
<td>Severe hypotension or hypovolemia</td>
<td>Etomidate, ketamine</td>
</tr>
<tr>
<td>Status asthmatic</td>
<td>Ketamine, etomidate, propofol</td>
</tr>
<tr>
<td>CHF</td>
<td>Etomidate</td>
</tr>
<tr>
<td>Status epileptic</td>
<td>Thiopental, propofol, midazolam</td>
</tr>
<tr>
<td>Combative patient</td>
<td>Propofol, etomidate, thiopental</td>
</tr>
</tbody>
</table>

Abbreviations: BP, blood pressure; CHF, congestive heart failure; ICP, intracranial pressure.
intracranial hypertension, including those with head trauma, presumed central nervous system bleeding, or intracranial mass lesions. No ill effects have been reported.

**Paralysis**

Neuromuscular blocking agents are used to induce complete paralysis; this relaxes the upper airway musculature and makes laryngoscopy easier. There are two classes of neuromuscular blocking agents: depolarizing and nondepolarizing (Table 3). Succinylcholine is the most commonly used depolarizing agent because of its rapid onset and short duration of action (usually less than 10 minutes). Nondepolarizing agents competitively block the acetylcholine receptor on the motor end plate preventing stimulation of the skeletal muscle. Nondepolarizing agents do not produce fasciculations; rather, they produce flaccid paralysis.

Administration of succinylcholine in patients with pseudocholinesterase deficiencies or underlying medical problems may prolong paralysis substantially [69]. Limitations to use of succinylcholine include elevation of intracranial pressure, elevated intragastric pressure, prolonged paralysis, hyperkalemia in the susceptible patient, and cardiac dysrhythmias (eg, bradycardia and asystole) [47,70–74]. Succinylcholine commonly induces musculoskeletal fasciculation. If the clinician wishes to avoid fasciculations associated with succinylcholine, a subparalytic dose of a nondepolarizing agent can be administered [70,75]. Occasionally, a subparalytic dose of a nondepolarizing agent may induce clinical paralysis with ventilatory compromise within 2 to 3 minutes; the clinician should always be prepared for this scenario. Increased intracranial pressure, concomitant ocular trauma, and patients whose oral intake status is not known are patients for which a subparalytic defasciculating dose of a nondepolarizing agent is recommended.

**Intubation**

Pressure on the cricoid cartilage (Selek’s maneuver) should be applied as spontaneous respirations begin to cease. Release should not occur until the patient is intubated and the cuff is inflated [62,71]. The Selek maneuver should be discontinued immediately if the patient vomits. Approximately 45 to 60 seconds after administration of succinylcholine, the patient should be

Table 3

<table>
<thead>
<tr>
<th>Paralytic agents</th>
<th>Time to intubation</th>
<th>Clinical duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Succinylcholine</td>
<td>40–60 s</td>
<td>6–12 min</td>
</tr>
<tr>
<td>Subparalytic dose + SCh</td>
<td>90–120 s</td>
<td>6–12 min</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>45–75 s</td>
<td>30–60 min</td>
</tr>
<tr>
<td>Vecuronium</td>
<td>2–3 min</td>
<td>30–90 min</td>
</tr>
<tr>
<td>Rapacuronium</td>
<td>45–75 s</td>
<td>15–25 min</td>
</tr>
</tbody>
</table>
totally apneic and the jaw should be completely relaxed. If these conditions are not met, the physician should wait an additional 15 seconds and reassess for optimal conditions. It is better to wait for optimal paralysis than to rush into a difficult intubation [75].

Once the patient has met optimal conditions, the clinician should intubate the patient under direct visualization of the glottis. The tube should be passed between the vocal cords, the stylet should be removed, the cuff should be inflated, and placement should be confirmed with auscultation as well as capnometry. Cricoid pressure should be released. Once there has been confirmation of proper placement of the endotracheal tube, post-intubation care should be undertaken (eg, sedation and paralysis, or, if needed, ventilatory management and appropriate diagnostic tests).

Summary

Airway control is one of the most critical interventions required for saving a life. It is essential that practitioners be as well trained as possible in the numerous techniques available to establish airway control. This article reviews some of the available techniques, though other techniques that are not discussed (such as fiberoptic-assisted endotracheal intubation) may also be useful. Perhaps the most important aspect of advanced airway management is the ability to anticipate and prepare for the difficult airway. This article gives numerous options for the difficult airway situation.

References


