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Airway Management in Trauma: An Update

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The past 10 years has seen a proliferation in the number of devices that are designed specifically for the difficult airway. The advantage of most of these devices is that the laryngeal opening can be visualized indirectly; they do not require the head and neck to be positioned so that the oral, pharyngeal, and laryngeal axes line up. This is particularly advantageous in the setting of trauma where movement of the neck can be dangerous. Another major advancement in the management of the airway in trauma has been the development and increasingly widespread use of the laryngeal mask airways, particularly the intubating laryngeal mask airway. These devices have become critical airway adjuncts in the management of patients who are difficult to ventilate or to intubate.

This article reviews the more recent theoretic and practical information that pertains to airway management in trauma. This includes newer airway devices, techniques, or maneuvers that are useful in the trauma setting, though potentially are underused. The algorithmic approach to the difficult airway, which aptly describes the trauma airway, is not discussed because several well-informed algorithms are readily available (www.asahq.org, www.das.uk.com). Each clinician needs to be knowledgeable about the various airway options and then, based on the physician's particular skills and resources, construct an algorithm that works best.

Intubation in the setting of potential cervical spine injury

The safety of inline immobilization of the cervical spine and emergency orotracheal intubation in multiple trauma is well established. Since the

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mid-1980s, when this became an accepted practice, there have been only a handful of reports of intubation causing spinal cord injury and, in each case, the head and neck were not immobilized [1–3].

Despite this exceptional safety record, during which time most intubations were performed using direct laryngoscopy, studies continue to be published comparing cervical spine movement during direct laryngoscopy with that observed using other airway interventions. There are two models: the patient with normal airway anatomy undergoing elective intubation in the operating room and cadavers in whom unstable cervical spines were created surgically. Spine movement is documented fluoroscopically or with radiographs. In the normal patients, in whom angulation of the cervical bodies is the sole measurement, most cervical spine movement during intubation occurs in the upper cervical spine, especially the occiput–C1 and atlantoaxial segments, regardless of which device is used [4–9]. Although these studies produce results that are statistically significant, their clinical significance is questionable. Specifically, a clinically significant degree of angulation has not been described (the largest reported angle was 15° at the occiput–C1 junction) [9]; displacement, not angulation, accounts for most spinal cord injuries and; several studies were conducted without immobilization. In the cadaveric model of the unstable cervical spine, there are data to suggest that the lighted stylet and fiber-optically guided nasotracheal intubation cause the least amount of subluxation, but, again, the differences were small and of unknown clinical significance [10–15]. Crosby [16], in a comprehensive review of airway management after cervical spine trauma, concluded that, as of 2006, there was no clearly superior modality for intubation in this setting.

Although the clinical relevance of much of the research on the movement of the C-spine during intubation is unclear, the cadaveric studies served to validate the practice of removing the C-collar and immobilizing the C-spine during intubation. Gerling and colleagues [14], using a C5–6 transection model, reported more subluxation during direct laryngoscopy with the collar than with inline immobilization. Laryngeal visualization also was improved after collar removal. Immediately following intubation, the collar is reapplied. Studies of unstable c-spines also demonstrated that there is as much subluxation with facemask ventilation, the chin lift, and the jaw thrust as with intubation itself [11,12], thus emphasizing the need for immobilization during all airway maneuvers.

Before leaving the topic of inline immobilization, a final comment should be made regarding the concept of "neutral" positioning of the head and neck in adult trauma. Although this term is used commonly, there is no accepted definition. Some studies defined it clinically [9,17], but most major trauma references do not address the subject [18–20]. Schriger and colleagues [17] defined neutral as the position that one assumes when standing and looking straight ahead; they found that a mean of 4 cm of occiput elevation was required to achieve this position. Data from De Lorenzo and colleagues [21], using MRI to determine the optimal elevation of the occiput for maximizing the spinal canal/spinal cord ratio at C5 and C6 (a common level of injury), suggested that at least 2 cm of elevation is desirable in normal individuals. Regardless of how neutral is defined, it is clear that the common practice of leaving the head immobilized on the backboard results in a position that may be far from neutral. This is especially evident in the profile of an obese patient whose thick back puts the cervical spine in hyperextension when the head rests on the backboard. Head elevation needs to be individualized in the morbidly obese and the elderly who may have preexistent lordotic deformities. Optimizing head and neck position, within the constraints of the trauma setting, will improve positioning for intubation while maintaining the integrity of the spinal cord.

Anterior neck maneuvers during intubation

There are two manipulations of the anterior neck that often improve laryngeal visualization during intubation. "BURP" (backward upward right pressure) is applied by an assistant over the lower thyroid cartilage to improve the glottic view when it is found to be suboptimal. The second maneuver, optimal external laryngeal manipulation (OELM), differs primarily in that it is the laryngoscopist who, by reaching around with the right hand, manipulates the anterior neck and identifies the position of the larynx that best exposes the laryngeal inlet. Once identified, the assistant assumes the position of the laryngoscopist's hand so that intubation can be performed.

Although both manipulations improve the laryngeal view [22–24], OELM seems to be superior [25]. Given the frequency of suboptimal laryngeal views during inline immobilization [26], these maneuvers, preferably OELM, should be used whenever visualization is poor. Cricoid pressure, the "Sellick's maneuver," is used to prevent stomach insufflation and regurgitation, yet it may make intubation more difficult [27–29]. Although it is still recommended, cricoid pressure should be relaxed, or even removed, if it is believed to impede intubation significantly.

Tracheal tube introducers

The tracheal tube introducer, originally the gum elastic bougie, was developed decades ago to assist in difficult intubations (Fig. 1). It is a long, thin, semirigid adjunct that, with the aid of a laryngoscope, is passed through the laryngeal inlet and over which an endotracheal (ET) tube is advanced into the trachea. Although ideally used when a portion of the laryngeal inlet is visible, it can be effective when only the epiglottis is seen [30]. This attribute, coupled with the fact that it is not affected by the presence of blood and secretions, makes the bougie well suited in the trauma setting.

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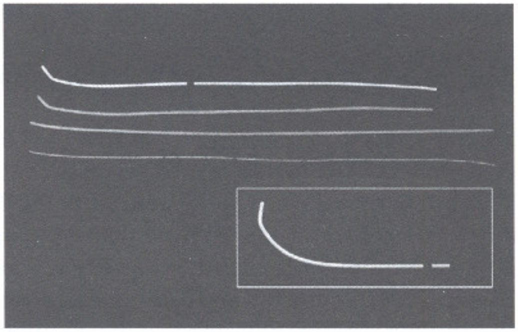

Fig. 1. Several types of tracheal tube introducers. The gum elastic bougie (dark yellow) is reusable and comes in curved- and straight-tip adult forms and a straight pediatric form. The straight bougies are 70 cm, and the curved-tipped bougies are 60 cm. The blue introducer (Flextrach ETTube Guide) is polyethylene, designed for single use, and comes only in a curved-tip adult form (60 cm). The inset demonstrates the 60° optimum curve if none of the laryngeal inlet can be seen on laryngoscopy.

Its efficacy was demonstrated prospectively in difficult intubations in the operating room (OR), as a key component of a difficult airway algorithm in the OR, and it has been compared favorably to conventional laryngoscopy in the emergency department (ED) [31–33]. Despite this track record, the tracheal tube introducer has seen limited use in the United States.

The original adjunct, called the gum elastic bougie or simply "the bougie," is available in reusable form for adults and pediatrics (Eschmann Tracheal Tube Introducer, Portex Sims, Kent, UK). The adult version accommodates a 5.5-mm ET tube, whereas the pediatric version can accommodate a 4.0-mm tube. An adult polyethylene introducer, designed for single use, also is available (Flextrach ETTube Guide, Greenfield Medical Sourcing, Inc., Austin, Texas).

Ideally, tracheal tube introducer-assisted intubation is a two-person procedure, with the assistant handing the introducer to the operator after the best laryngoscopic view has been obtained. If the laryngeal inlet is not visible, a 60° distal bend is placed in the introducer, and it is passed just under the epiglottis and directed anteriorly (see Fig. 1, inset). The assistant slides the ET tube over the introducer, and the operator passes the tube through the larynx. A 90° counterclockwise rotation is recommended just before entering the larynx to avoid the ET tube tip catching on laryngeal structures (Fig. 2) [34]. The laryngoscope is removed only after successful placement of the ET tube.

There are several confirmatory findings after successful introducer placement. Success is indicated, up to 90% of the time, by feeling clicks produced by the angled tip of the introducer as it strikes against the tracheal rings [35]. Also, an assistant usually feels confirmatory movement in the airway if the anterior neck is palpated. If there is any question about whether the introducer is in the airway, it should be advanced at least 40 cm, at which point

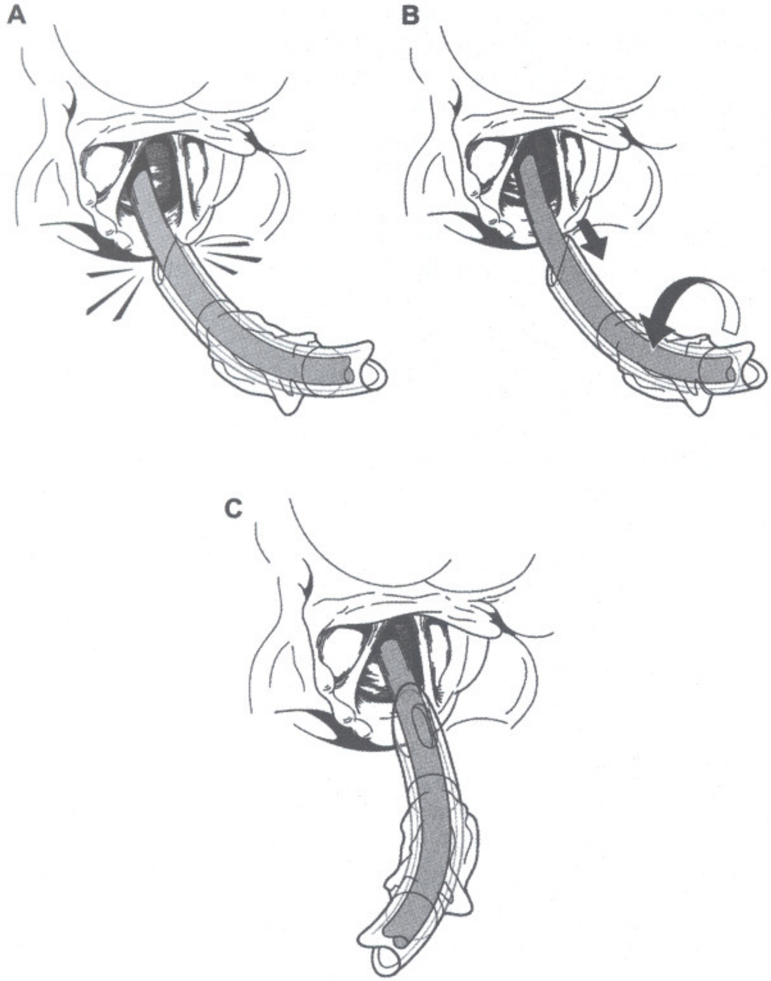

Fig. 2. A common cause of difficulty when railroading an ET tube over a tracheal tube introducer. (*A*) ET tube tip caught on the right arytenoid as it is being railroaded over the introducer. Corrective maneuvers: (*B*) ET tube is withdrawn 2 cm to disengage the arytenoids and counterclockwise rotation of ET tube 90° to orient the bevel posteriorly. (*C*) The bevel of the ET tube is facing posteriorly and allows for smooth passage through the glottis. (*Courtesy of* Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, MN.)

resistance should be felt as the introducer passes the carina into a main bronchus.

In the prehospital setting, where assistance may not be available, removal of the laryngoscope may be required so the operator can mount the ET tube onto the introducer. Once the tube is on the introducer, the laryngoscope may be reinserted and the tube rotated 90° counterclockwise to ensure successful passage of the tube. Mounting the tube onto the introducer and introducing them as a unit is not advised because it often is difficult to direct the introducer into the laryngeal inlet as it moves within the ET tube.

In addition to its usefulness in multiple trauma, the tracheal tube introducer can be useful when intubating patients who have blunt and penetrating upper airway injury. In this setting, a carefully passed introducer that advances into the trachea without resistance is added assurance that an ET tube will be able to be placed without causing further damage. It also can be used as an introducer for an ET tube being placed through an open neck wound [36] or, as in the author's institution, when performing a cricothyrotomy.

Laryngeal mask airways

The laryngeal mask airway (LMA) and the intubating LMA (ILMA) are excellent rescue devices for the "cannot intubate/cannot ventilate" situation. Both devices are valuable for rescue ventilation, but the ILMA is superior as a conduit for intubation [37]. As ventilatory devices, their reliability has been excellent. The ILMA also is successful when intubating patients with known difficult airways [38,39]. In the OR, blind intubation through the ILMA has an overall success rate of 90%; when aided by fiberoscopy, the success rate approaches 100% [37]. LMAs are contraindicated in patients with less than 2 cm of mouth opening and are unlikely to be successful in patients with grossly distorted supraglottic anatomy from disease processes or postradiation scarring or in patients with an intact gag reflex.

Most intubations through the ILMA are performed blindly, using the designated LMA ET tube or a standard ET tube. If a standard ET tube is used, it should be inserted so that the curve is opposite the normal orientation (Fig. 3A). This results in the ET tube exiting the ILMA at a less acute angle and allows it to pass into the trachea more easily (Fig. 3B) [40]. If difficulty is encountered, a fiber-optic scope can be helpful in guiding intubation.

If an LMA has been placed, blind ET tube placement is not an option. A fiber-optic scope must be used or, better yet, a hollow introducer, such as an Aintree Intubation Catheter (Cook Critical Care, Bloomington, Indiana; www.cookmedical.com) in conjunction with a fiber-optic scope, is placed though the LMA into the trachea (Fig. 4). Once placed, the LMA is removed, and an ET tube is railroaded over the hollow introducer into the trachea. Use of a regular tracheal tube introducer is not recommended because of a high failure rate [41]. If intubation fails, despite the recommended adjustment maneuvers and fiber-optic assistance, definitive airway control—using a retrograde wire or a surgical airway—can be accomplished in a controlled fashion while the patient continues to be ventilated with the laryngeal mask [42]. An excellent resource for troubleshooting LMA difficulties can be found on the company's website (www.lmana.com) under "Insertion Technique and Maneuvers Guide."

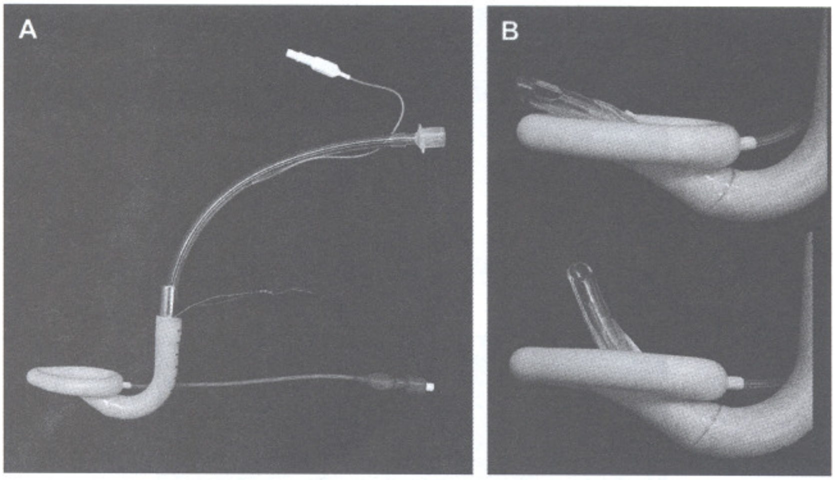

Fig. 3. Intubating through an ILMA using a standard tracheal tube. (*A*) The tracheal tube is inserted so the curve of the tube is opposite the curve of the ILMA. This allows the tube tip to exit the ILMA at an angle more conducive to smooth passage into the trachea. (*B*) Angle of the tracheal tube tip after normal orientation of the ET tube (*lower*) versus the correct "reverse curve" orientation (*upper*).

LMAs provide an excellent means of oxygenating and ventilating when facemask ventilation is difficult or impossible. In addition, the ILMA is particularly useful in managing patients who are difficult to intubate with direct laryngoscopy. Thus, by facilitating the management of difficult/failed ventilation and difficult/failed intubation, the ILMA has become an indispensable component of any difficult airway algorithm.

The Combitube and laryngeal tube

The Esophageal-Tracheal Combitube remains an effective intermediate airway that is used primarily in the prehospital setting. Its popularity has decreased as the use of laryngeal masks has increased. Its biggest drawback is the difficulty establishing a definitive airway after the Combitube has been placed. The laryngeal tube, also known as the King LT, is a new intermediate airway that is replacing the Combitube in some prehospital systems because of its simpler design and availability in a disposable version (Fig. 5). A major difference between the King LT and the Combitube is that it is designed specifically not to go into the trachea.

Lighted stylet intubation

The Trachlight (Laerdal Medical Corp., Wappingers Falls, New York) was introduced in 1995 and is the only lighted stylet, among several

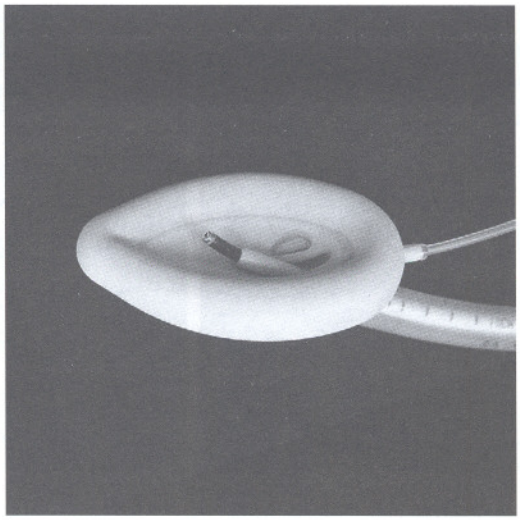

Fig. 4. Facilitating intubation through an LMA: a hollow introducer (Aintree Intubation Catheter, 60 cm) is placed through the LMA and into the trachea and guided by a fiberoptic scope. Then the LMA is railroaded over the introducer into the trachea. (*From* Roberts, Hedges, editors. Tracheal intubation. In: Clinical procedures in emergency medicine. 5th edition. Philadelphia: Elsevier; in press; with permission.)

available today, that has a proven track record. By transilluminating the soft tissues of the neck, the light serves to guide the tube into the larynx (Fig. 6). It compared favorably with direct laryngoscopy in a randomized study of 950 surgical patients [43], and, in another large series, also by

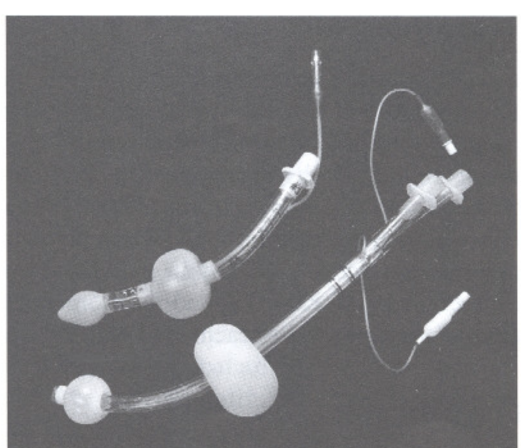

Fig. 5. The Combitube (*bottom*) and the King LT (*top*).

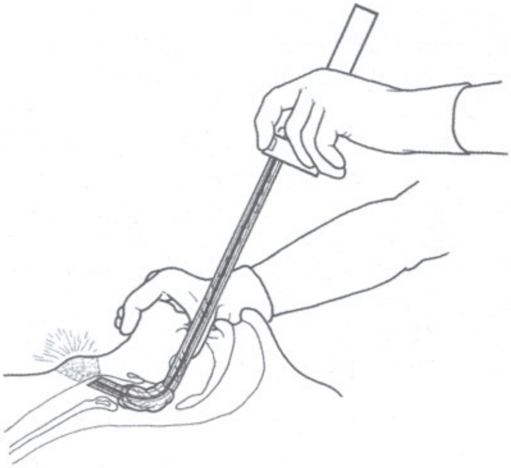

Fig. 6. Lighted stylet intubation. Use of the Trachlight for ET intubation using transillumination of soft tissues as a guide to placement. (*Courtesy of* Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, MN.)

Hung and colleagues [44], the device was 99% successful in intubating patients who had difficult airways. The stylets come in adult, pediatric, and infant sizes and can accommodate down to a 2.5-mm internal diameter (ID) tube (Fig. 7).

The patient's head and neck are optimally placed in the neutral or, if possible, slightly extended position. This makes the Trachlight well suited for the patient who has experienced trauma, especially given the fact that its success is not impacted by the presence of blood or secretions. Because lighted stylet intubation is a blind approach, it should be avoided in patients with expanding neck masses or laryngopharyngeal trauma. Morbid obesity is the most common cause for failure because of the difficulty transilluminating through generous soft tissue.

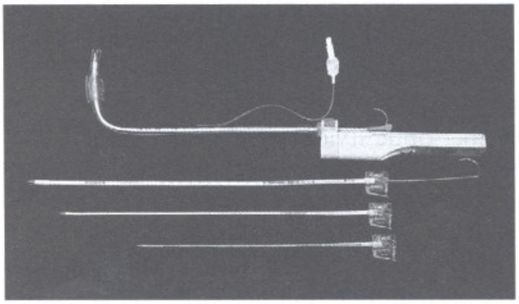

Fig. 7. Trachlight and related stylets. The malleable stylet is bent at a 90° angle, 6.5 to 8.5 cm from the tip (marked on stylet). The smallest stylet accommodates a 2.5-mm ID tube.

The clinician stands at the head of the patient. When this is not possible, the patient can be approached from either side. With the patient's head and neck in the neutral position or slightly extended, the jaw is grasped near the corner of the mouth, between the thumb, index, and middle fingers, and lifted to elevate the tongue and epiglottis (see Fig. 6). A transilluminating glow indicates the location of the tube tip. Application of cricoid pressure may enhance the transillumination [45]. The overhead light often must be dimmed in the obese patient. Positioning is optimal when a light bulb–like glow emanates from the midline, just below the level of the thyroid prominence. In extremely thin patients, it is possible to observe transillumination and still be in the esophagus. The clue is that the glow is diffuse if the tip is in the esophagus, as opposed to the well-circumscribed glow of intralaryngeal placement.

The Trachlight is a safe, effective, rapid, and inexpensive intubating device that is placed with the patient in neutral position and is not affected adversely by blood. These features make it especially amenable to the trauma setting.

Semirigid fiber-optic stylets

A class of devices that incorporate fiber optics into a semirigid metal or metal-reinforced stylet was introduced in the late 1990s. They can be used in conjunction with direct laryngoscopy or alone. They require direct laryngoscopic assistance in 8% to 20% of cases and, in general, are more successful when used in this way [46,47]. In either case, the tip of the fiber-optic stylet, with its overlying ET tube, is passed under the epiglottis and directed through the glottis into the trachea. Visibility can be hampered by blood and secretions, but less so than with flexible fiberoscopy [48]. They also are easier to learn how to use. The Shikani Optical Stylet and Levitan FPS Scope (Clarus Medical, Minneapolis, Minnesota) are examples of these malleable optical stylets (Fig. 8). Most often, the Shikani Stylet is used similarly to the Trachlight, with the added feature of being able to see fiber-optically what is just beyond the tube tip. The Levitan Scope is designed to be used with a laryngoscope, serving as a stylet for the tracheal tube while providing fiber-optic visualization if required. The Levitan stylet can accommodate a minimum tube size of 5.5-mm ID, whereas the Shikani comes in two sizes: the adult, accommodating a 5.5-mm ID tube, and a pediatric version that accommodates a 3.5-mm ID tube.

The semirigid fiber-optic stylets are useful in patients in whom the glottis cannot be seen readily. Blood and secretions may complicate their use, but less so than with flexible fiberoscopy. The Shikani scope was more successful than the gum elastic boogie in simulated Cormack and Lehane Grade 3 views [49]. There are no absolute contraindications and no reported complications with semirigid fiber-optic stylets, other than the failures or prolonged attempts usually related to poor visibility from blood and secretions [46].

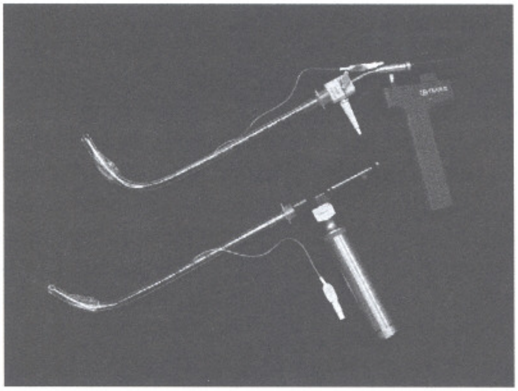

Fig. 8. Examples of semirigid fiber-optic stylets: the Shikani (*top*) and Levitan (*bottom*). The recommended bends when used alone (*top*) and when used with a direct laryngoscope (*bottom*) are demonstrated. The sliding adapter on the Shikani stylet allows for various lengths of tracheal tubes.

Semirigid fiber-optic stylets combine the features of direct and indirect laryngoscopy and provide a valuable tool when one is faced with a difficult airway. They can be used alone or in conjunction with a laryngoscope. They are considerably less expensive than rigid fiber-optic devices and are easier to use than flexible scopes. There are no head-to-head clinical trials with other devices; however, early reports suggest that the semirigid fiber-optic stylets have a role to play in managing the airway in trauma.

Nasal and orotracheal intubation over a flexible fiber-optic bronchoscope

Flexible fiber-optic intubation is cited often in the anesthesia literature as the preferred method for intubating a patient with an unstable C-spine. It also is recommended in patients with suspected or known injury to the upper airway. In a survey at the 1999 annual meeting of the American Society of Anesthesiologists, 75% of respondents said they would use awake fiber-optic intubation in the setting of cervical spine disease, yet only 59% felt competent with this approach [50]. In the ED, the success rate is 50% to 90% [51–53]. Failure is attributed most often to poor visibility from blood, vomitus, and other secretions. Mlinek and coworkers [53] found that successful ED fiber-optic intubations averaged 2 minutes, whereas failures averaged 8 minutes; they recommended considering alternative approaches if intubation attempts take more than 3 minutes.

Fiber-optically guided intubation can be accomplished using the nasal or oral route. The nasal approach is technically easier because the angle of insertion allows for easier visualization of the larynx, with minimal manipulation of the fiberscope, and because patient cooperation is not as critical. Insertion using the oral route can be facilitated by using an oral-intubating airway (Fig. 9). Contraindications to the nasal approach are severe midface trauma and coagulopathy. Active airway bleeding and vomiting are relative contraindications for both approaches because successful intubation is unlikely in these settings. If the clinician is inexperienced in fiber-optic intubation, significant hypoxia is another relative contraindication to its use.

The primary advantages of fiber-optic intubation are the ability to visualize upper airway abnormalities, to negotiate difficult airway anatomy, and to carefully perform tracheal intubation with visual guidance. A major limitation in trauma is the lack of visibility in the presence of blood and secretions. If blood is present, it is best to avoid the fiber-optic scope.

Rigid fiber-optic laryngoscopy

Rigid fiber-optic laryngoscopes are designed to approximate the anatomy of the upper airway and provide indirect fiber-optic visualization of the laryngeal inlet. Examples include the Bullard laryngoscope (Circon Corp., Stamford, Connecticut), the UpsherScope (Mercury Medical, Clearwater, Florida), and the WuScope (Achi Corp., San Jose, California). These devices offer the advantage of a conventional fiber-optic scope but require less training [54]. They are well suited for patients who have potential cervical spine injury because no movement of the neck is necessary. Case reports also suggested their usefulness in patients who had upper airway distortion from mass or hematoma [55,56]. One potential advantage of the WuScope is that its fiber-optic element is relatively protected from blood and secretions by its tubular blade.

The Bullard laryngoscope comes in two sizes: pediatric (newborn to 10 years) and adult. It can be used in awake or unresponsive patients [57]. At least 2 cm of occlusal opening is necessary for the introduction of the scope and an ET tube. The technique for introducing the Bullard

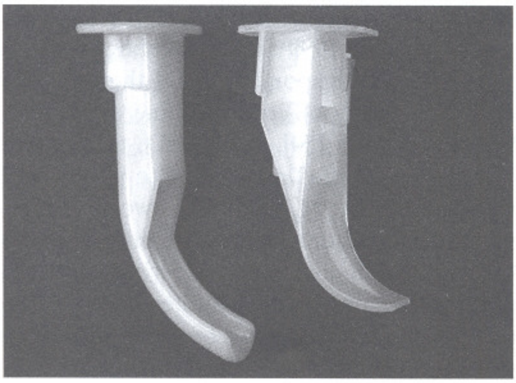

Fig. 9. Examples of oral intubating airways. The Williams Airway Intubator (*left*) cradles the ET tube in an open, curved guide, whereas the Ovassapian Fiberoptic Intubating Airway (*right*) positions the ET tube on the posterior surface of the intubation airway.

laryngoscope blade is similar to that for direct laryngoscopy (Fig. 10). With the glottis in view, the tube is advanced off the attached stylet and into the larynx. Cricoid pressure does not seem to interfere with Bullard scope success [58]. A newer, multifunctional stylet has a hollow lumen that allows an introducer to be passed through it and into the laryngeal inlet and over which the tube can be advanced. Plastic tip extensions are available for the larger patient in whom the epiglottis may be difficult to elevate.

The major difficulty in using rigid fiber-optic laryngoscopes is the inability to visualize the larynx because of blood, emesis, or secretions; a possible exception is the WuScope, with its relatively protected optical element, but it has yet to be studied in this setting. Once visualized, the glottis usually can be intubated, although accessing the inlet and passing the tube occasionally may be difficult.

Video-assisted laryngoscopy

Video-assisted laryngoscopy transmits an image from an optical element located on the laryngoscope blade to a monitor. In addition to providing indirect images that may be unobtainable with direct laryngoscopy, the image is enhanced by magnification and a wide-angle view. The newer devices incorporate miniature video cameras on their blades. The ability to view the images on a monitor provides immediate feedback to an assistant providing

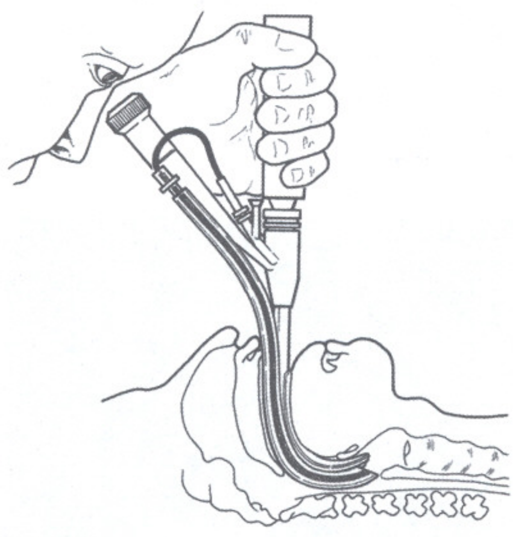

Fig. 10. Bullard laryngoscope. Anatomically shaped laryngoscope visualizing the glottis; tracheal tube is mounted on the attached stylet to facilitate laryngeal placement. (*Courtesy of* Department of Emergency Medicine, Hennepin County Medical Center, Minneapolis, MN.)

external laryngeal manipulation. Video-assisted laryngoscopy also has great potential as a teaching aid.

The GlideScope videolaryngoscope (Verathon, Bothell, Washington), first introduced in 2001, is the first of a new class of video-assisted rigid scopes that provide enhanced video views of the laryngeal inlet while being less likely to be affected by the presence of blood and secretions. There are three sizes: small for neonates and infants, medium for children and small adults, and large for adults. It comes with a small monitor on a stand or a smaller, more portable monitor. The McGrath Portable Video Laryngoscope (Aircraft Medical Ltd., Edinburgh, UK) is a device with similar characteristics, but it is more compact, has an adjustable blade length, and uses disposable blade covers (Fig. 11). It is new, and no studies have been reported on its use.

The GlideScope has a miniature camera embedded midway along the undersurface of the blade that has a 60° midblade angulation (Fig. 12). Blood and secretions are unlikely to compromise laryngeal visualization because of the camera's orientation, its location well away from the blade tip, and its antifogging technology. Visualization of the laryngeal inlet is excellent and is usually less of a problem than placing a tube through it. Difficult laryngoscopic cases are intubated more easily with this scope than with direct laryngoscopy, but easy cases are more time consuming because of difficulties in advancing the tube [59]. A contraindication is a small mouth through which the blade cannot be passed safely (opening less than 2 cm). Learning to use the GlideScope is easy because the overall feel of the device is similar to that of a conventional laryngoscope. The absence of fiber-optic elements increases its durability and decreases inevitable breakage expenses.

The styletted tracheal tube is usually bent to conform to the 60° angle of the GlideScope blade (see Fig. 12). The GlideScope blade is placed into the mouth and, under direct vision, is advanced in the midline. Verifying midline position on the monitor, the uvula is passed as the GlideScope blade

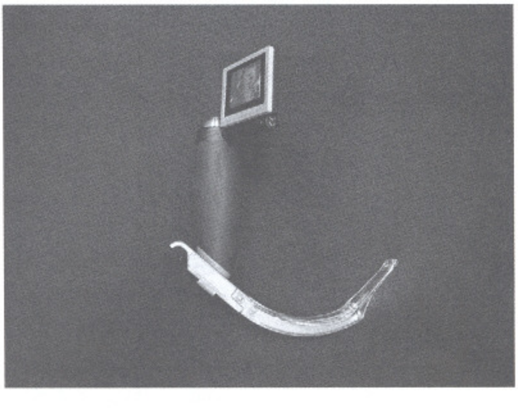

Fig. 11. The McGrath Portable Video Laryngoscope.

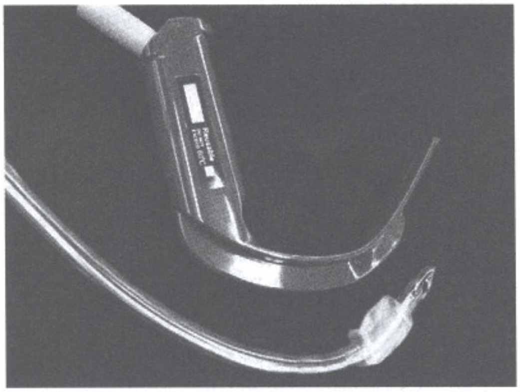

Fig. 12. The GlideScope. The ET tube has the 60° bend recommended by the manufacturer.

is slipped behind the tongue, hugging the tongue base. With a gentle lifting motion, the tip of the blade enters the vallecula, and the epiglottis is seen and elevated out of the way to expose the laryngeal inlet. The ET tube is passed blindly along the side of the blade and into the hypopharynx. When the tip of the ET tube comes into view, it is directed into the glottis and advanced to the appropriate depth. If difficulty is encountered trying to access the laryngeal inlet, success may be achieved by a variety of means, including application of external laryngeal pressure, increasing the bend of the stylet, using a tracheal tube introducer, or using a Parker Flex-It Stylet (Parker Medical, Englewood, Colorado) [60]. This is a new device, but several minor injuries have been reported: two cases of puncture of the right palatopharyngeal arch, with one requiring surgical repair [61].

Video-assisted laryngoscopy is a major advancement in the visualization of the laryngeal inlet. The GlideScope, the first device that incorporates micro video camera technology, provides an improved laryngeal view compared with difficult direct laryngoscopy while avoiding some of the problems associated with fiber-optic bronchoscopy. It has yet to be studied extensively in the setting of difficult intubation, although preliminary reports are promising [62]. Most intubation failures result from the inability to pass the tube through the larynx, despite adequate glottic views [60]. Improvements in the configuration of the tracheal stylet should decrease this problem.

Blind nasotracheal intubation

There are few indications for blind nasotracheal intubation in trauma. One potential circumstance is in the patient with minimal mouth opening, because all of the newer devices that provide an indirect view of the laryngeal inlet require at least 2 cm of mouth opening. In this situation, nasotracheal intubation may be a reasonable option if a surgical airway is not immediately indicated.

Surgical airways

Cricothyrotomy remains the preferred procedure for establishing a definitive emergency surgical airway. The four-step approach, first described in 1996 [63], has gained popularity; in a series of 50 patients [64], the complication rate compared favorably with that found when the more traditional approach was used [65]. This approach begins with a smaller, horizontal stab wound that is carried down through the cricothyroid membrane. The tracheal hook is placed caudally under the cricoid cartilage as opposed to superiorly, under the inferior edge of the thyroid cartilage, as with the traditional approach. Regardless of the approach, a generous vertical incision should be made if there is difficulty identifying the cricothyroid membrane [65,66]. In addition to gaining exposure in the patient with a large neck, this incision permits definitive, digital identification of the membrane and reduces the chances of suprathyroid tube placement. If difficulty is encountered placing a Shiley tracheostomy tube, a tracheal tube introducer can be inserted and a #6 ET tube passed over it into the trachea.

Percutaneous cricothyrotomy is another potential approach for establishing a surgical airway. Schaumann and colleagues [67], in a large, cadaveric study comparing the Seldinger technique (Arndt Emergency Cricothyrotomy Catheter Set, Cook Critical Care, Bloomington, Illinois) to the standard surgical approach, concluded that the Seldinger technique had the advantage of being quicker. They failed to mention, however, that 4 of 100 catheters placed with the Seldinger technique ended up in the subcutaneous tissue. This serious complication results from the insufficient catheter length (6 cm) used in the study; this study, using normal-sized cadavers, undoubtedly underestimates the likelihood of this complication occurring in a patient with a large neck. The Melker Cricothyrotomy Catheter Set (Cook Medical, Inc., Bloomington, Indiana) (9 cm) is long enough for most patients; however, even with a vertical skin incision, sets of this variety can be difficult to place through the tissues of the anterior neck [68]. Thus, although the percutaneous approach is far better than no surgical attempt at all, the approaches that ultimately permit digital identification of the cricothyroid membrane and incorporate a scalpel incision through the membrane remain the preferred surgical approaches for the emergency trauma airway.

Summary

Conceptually, the management of the airway in trauma has not changed significantly in recent years. The safety of inline immobilization and rapid sequence intubation has been reaffirmed clinically. Although the general management has not changed, the choice of airway devices has markedly increased. The most important among these is the ILMA because it can provide effective rescue ventilation and intubation. The newer devices that allow for indirect visualization of the laryngeal inlet also will contribute to effective trauma airway management.

Despite the advances in intubating devices, direct laryngoscopy likely will continue to be the initial approach to intubating the patient after trauma. As with any intubation, preoxygenation is essential and, by extending the apnea time before desaturation, it can make the difference between a successful and a failed intubation. Positioning, another key element in successful intubation, is more complicated in the setting of trauma; however, it can be improved upon, from a neurosurgical and an airway perspective, by elevating the head off the backboard. If the laryngoscopic view is suboptimal, intubation often can be accomplished rapidly using a tracheal tube introducer. External laryngeal manipulation also may be useful at this juncture. These steps should be accomplished rapidly and usually result in successful intubation. If unsuccessful, a device that provides indirect glottic visualization should be used. Alternatively, especially in the setting of oxygen desaturation, an ILMA can be placed to ventilate and intubate the patient. Cricothyrotomy remains the ultimate back-up airway and should be performed using the technique that corresponds best to the patient's body habitus and operator experience.

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