Clinical Applications Of Video Laryngoscopy

Video laryngoscopy (VL) is the latest frontier in airway management. Its uses, already multiple, are expanding as the technology matures. The following article covers the spectrum of clinical applications for VL—from awake intubation to telemedicine. Written by true pioneers in the use of these devices, each chapter is meant to stand alone. Taken together, they comprise the most comprehensive overview of VL published to date.

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Transitioning From Direct to Video Laryngoscopy

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Following the introduction of the straight (Miller, 1941) and curved (Macintosh, 1942) laryngoscope blades, laryngoscopy had remained largely unchanged for more than 50 years. With the development of rigid fiberoptic laryngoscopes—the first generation of video laryngoscopes—clinicians benefited from advances such as eyepieces that could be attached to optional video cameras, such as the Bullard (Gyrus ACMI), the WuScope (Achi Wu), and the UpsherScope (Mercury Medical), or used with a prism to achieve the same effect (EVO, Truphatek; Viewmax, Teleflex).
Rigid fiberoptic laryngoscopes placed the observer’s eye close to but above the glottis, allowing for controlled insertion and advancement of an endotracheal tube (ETT) between the vocal folds. Nonetheless, these rigid fiberoptic laryngoscopes failed to gain traction within the anesthesia community.2,3

Fiberoptic laryngoscopy provided a non-line-of-sight view and the use of a dedicated monitor with an attached video camera embodied the essential concepts of video laryngoscopy (VL). Weiss’s modified Macintosh direct laryngoscope incorporated an ultra-thin fiberoptic bundle into an angulated blade,4 and the Storz (Karl Storz Endoskope GmbH) Berci-Kaplan DCI Video-Macintosh5 coupled a proprietary light source, video processor, and monitor with a Macintosh laryngoscope. Both of these devices looked and behaved in a familiar fashion yet had the functionality of video laryngoscopes. They obviated the need to achieve a line-of-sight view by tissue compression, distraction, and external force.

Video laryngoscopes lack the versatility of flexible bronchoscopic intubation (FBI)—they cannot be introduced through the nose or a tracheostomy, precisely position a bronchial blocker or double-lumen tube, or perform pulmonary toilet—but they do offer some advantages. They are easy to use, less fragile, and provide a supraglottic vantage point.

In 2001, Canadian surgeon John A. Pacey, MD, was the first to embed a miniature video chip (complementary metal oxide semiconductor) into a modified Macintosh laryngoscope—the GlideScope video laryngoscope (GVL, Verathon).6 Several other products recently have been introduced by other manufacturers, including the McGrath Series 5 (Aircraft Medical), the C-MAC (Storz), the AWS-S100 (Pentax), and the disposable optical Airtraq (Prodol, Spain).1,7

### Current Options for Video Laryngoscopy

Channeled video laryngoscopes have a tube slot to facilitate delivery of the ETT. Essentially, the scope rather than the ETT must be aimed at the larynx because the ETT cannot be independently manipulated. The GlideScope GVL and McGrath video laryngoscope have blades that are angled approximately 60 degrees upward. With these devices, the larynx often is not directly visible despite an excellent view on the monitor. Thus, a stylet should always be used. On the other hand, the blades of the Storz DCI and C-MAC resemble a conventional Macintosh and therefore it often is possible to intubate without a stylet. The reduced upward deflection means that the view obtained by the video chip is more dependent on a wide-angle camera than its upward orientation and often, external laryngeal pressure may be required.8 The C-MAC has been introduced only recently and there have been no studies to evaluate its performance.

Of the video laryngoscope systems (Table 1), the GlideScope GVL has been most extensively studied. Published reports show that compared with direct laryngoscopy (DL), VL and the GlideScope GVL in particular, results in improved laryngeal exposure, requiring less force and cervical manipulation (Figure). Several studies have observed that teaching laryngoscopy is more easily achieved with a video rather than a direct laryngoscope, although only the Storz DCI and the C-MAC are used similarly to a direct laryngoscope.5,9-11 When using other video laryngoscopes, a somewhat different technique is being demonstrated, although it still serves as a useful way of showing airway anatomy, engaging those in attendance and generating confidence and enthusiasm. Naïve laryngoscopists prefer VL to DL12 and learn VL more quickly than either DL13 or FBI14 and it is possible that they acquire DL skills more

### Table. Currently Available Video Laryngoscopes

<table>
<thead>
<tr>
<th>Device</th>
<th>Channeled</th>
<th>Disposable</th>
<th>Portable</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airtraq</td>
<td>Yes</td>
<td>Totally</td>
<td>Yes</td>
<td>Infant–large adult</td>
</tr>
<tr>
<td>GlideScope Cobalt</td>
<td>No</td>
<td>Blade</td>
<td>No</td>
<td>Sizes 1–4</td>
</tr>
<tr>
<td>GlideScope GVL</td>
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<td>No</td>
<td>No</td>
<td>Sizes 2–5</td>
</tr>
<tr>
<td>GlideScope Ranger—reusable</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Sizes 3–4</td>
</tr>
<tr>
<td>GlideScope Ranger—single use</td>
<td>No</td>
<td>Blade</td>
<td>Yes</td>
<td>Sizes 1–4</td>
</tr>
<tr>
<td>McGrath Series 5</td>
<td>No</td>
<td>Blade</td>
<td>Yes</td>
<td>3 adult lengths</td>
</tr>
<tr>
<td>Pentax AWS-S100</td>
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<td>Blade</td>
<td>Yes</td>
<td>Adult</td>
</tr>
<tr>
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<td>No</td>
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</tr>
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<td>No</td>
<td>No</td>
<td>No</td>
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<td>Truview EVO2</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Infant–large adult</td>
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quickly after VL exposure. Nouruzi-Sedeh et al analyzed the success rates of novice operators using DL versus VL.\textsuperscript{15} When performed by novices, VL had a success rate of 93%, compared with 51% for DL.\textsuperscript{15} Video capture permits playback and analysis under less stressful conditions and likely promotes skill acquisition. Such video capture also might become an integral part of continuing quality improvement and clinical documentation. This would be especially helpful when emergent airway management is provided by non-physicians as a delegated task.

**Barriers in Airway Management**

Advances in airway management have been stifled by imprecise and misleading terminology. For example, the American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway\textsuperscript{16} and other studies refer to “difficult” or “awkward” airways\textsuperscript{17} when laryngoscopy fails to visualize the glottis, despite *multiple attempts*.\textsuperscript{16} A meta-analysis by Shiga, involving more than 50,000 adults, found that unanticipated failure to visualize the airway occurs in a mean of 5.8% of cases.\textsuperscript{18} Adnet found that moderate difficulty was encountered in 6.3% of DLs attempted in the operating room and 16.1% outside of the operating room.\textsuperscript{19} It is important to acknowledge that laryngoscopy that fails to identify any part of the larynx is neither difficult nor awkward—it is a *failed laryngoscopy*—and when this occurs, it is most commonly dealt with by repeated laryngoscopic attempts.\textsuperscript{20} This is much like landing an airplane while being visually impaired. Although such a landing may be successful, most would regard it as a “near miss.” For decades, we tolerated the necessity of blind and repeated attempts because we lacked better tools; but the evidence demonstrates that multiple attempts are associated with minor and serious morbidity.\textsuperscript{20,22} Our predictive tests for a difficult laryngoscopy are neither sensitive nor specific.\textsuperscript{18} They are even less predictive when VL is used. In the meantime, we should be very clear that the traditional metrics of airway assessment are (marginal) predictors of difficulty for DL and do not identify a difficult laryngoscopy or intubation performed by an alternative technique (such as VL).

**Video Laryngoscopy: An Appropriate Alternative**

So what is the role of the video laryngoscope in today’s airway management? Although most video laryngoscopes are capable of affording better laryngeal exposure, practice at delivering and advancing the ETT increases the operator’s success. Such experience is best acquired when no difficulty is anticipated. For most, this will promote better recognition of the limitations of both the device and the operator’s skill. As experience increases, many known difficult DLs will in fact turn out to be easy VLs. When there is uncertainty about the appropriateness of VL, it is possible to perform awake VL\textsuperscript{22,23} or combine VL with FBI.\textsuperscript{10}

These permit the maintenance of spontaneous ventilation and/or the ability to visualize ETT advancement to and through the vocal cords. With increasing use of VL, there undoubtedly will be pressure to reassess our airway algorithms for the management of airways we have traditionally regarded as difficult.

**References**

Teaching Video Laryngoscopy

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It can be challenging to teach someone how to use a video laryngoscope (VL). Many experienced practitioners feel they already know what they are doing and expect use of a video laryngoscope to be intuitive. On the other hand, novice practitioners who have some experience with direct laryngoscopy (DL) expect intubation with a video laryngoscope to be much easier. The reality is that there are significant differences in the use of the devices, the view obtained, and the technique needed to insert the tube into the trachea. These distinctions necessitate a curriculum for VL intubation that is different from traditional DL and intubation.

For the purposes of this section the term student will be used to describe the novice user of a VL. The student could be any anesthesia provider or other health professional who wants to learn how to intubate using the VL.

Teaching Techniques for Video Laryngoscopy

When introducing an anesthesia provider to a VL for the first time, the basic functions of the device and some tips and challenges should be reviewed before the patient is in the operating room. It should be noted that the interincisor distance needed for VL intubation is smaller than that needed for DL. This may not be obvious because the VL blade is not considerably thinner than the blade of traditional Miller or Macintosh laryngoscope blades. However, when one is performing DL, the final position of the blade will be at an angle that is shallow relative to the plane created between the patient’s upper and lower incisors. VL devices frequently have a relatively curved design that allows the portion between the teeth to be relatively perpendicular to the interincisor plane.

The location of the camera, light-emitting diodes (LEDs), and heating element are reviewed. Turning on the device prior to starting the anesthetic induction of the patient serves 2 purposes: First, it confirms that the device is working and that a clear image can be obtained before the patient has been rendered unconscious. Second, the lens has a chance to get warm before being inserted in the airway, thereby reducing fogging.

There are important differences between the direct laryngoscope and VL. First is that VL intubation requires that the endotracheal tube (ETT) and stylet be prepared in a manner different than for DL. The stylet should be lubricated to facilitate passing the ETT off the stylet. When using a VL with a rigid stylet, it may be helpful to load the tube with “reverse camber.” This is where the tube is spun 180 degrees from its usual orientation on the stylet. When this is done, the radio-opaque stripe


is on the concave side of the tube rather than the convex side where it usually resides. Loading the tube with reverse camber allows it to pass into the larynx more easily. The thick plastic end of the stylet engages the 15-mm adapter on the end of the ETT and prevents it from spinning to its normal orientation.

When using a VL with a standard malleable stylet, such as the GlideScope, it must be bent differently from its usual DL shape. The GlideScope user’s manual suggests bending the stylet tip at least 90 degrees. The optimal configuration may not be obvious from this description. A useful technique is to load the ETT on the stylet and then bend the stylet so that the shape approximates the convex surface of the blade to be used (Figure 1). When performing DL, one usually bends the end of the stylet coming out of the 15-mm adapter to the right so that it does not interfere with vision during laryngoscopy. When preparing a stylet for VL, it often is helpful to bend the end of the stylet “backward” so that it will be pointing toward the person performing the intubation. This allows the operator to easily withdraw the stylet with his or her thumb while advancing the tube with his or her fingers (Figure 2).

This is important because the relative motion of the tube and stylet for VL intubation is different from that for DL intubation. Often during DL, the stylet is removed after the tube is in the trachea. The tube is motionless and the stylet is pulled back. The optimal motion with the VL is to have the stylet be motionless and advance the tube over the stylet. It is helpful to have the student practice advancing the ETT off the stylet in this manner prior to his or her first GlideScope intubation. Once these preparations have been made, the intubation technique should be discussed.

**Tips for Intubation**

When teaching in the operating room, one or 2 key teaching points should be made; and the student should be left with the following aphorism for VL intubation:

1. The hard part of DL is obtaining a good view. Once you can see the larynx, you can almost always intubate the trachea.
2. With VL intubation, the inverse can be encountered. It usually is easy to see the vocal cords, and the challenge can be passing the tube into the trachea. As the larynx comes into view on the display, the student should be pleased with a Cormack-Lehane grade II view. The more the blade is lifted, the more anterior the larynx becomes, making it harder to insert the tube.

**Challenges With Video Laryngoscopy**

There is an adage that in order to understand a tool, one needs to know how it can be misused or how it can cause injury. Therefore, it is important that the anesthesia provider be aware of potential complications associated with the VL devices.

There have been case reports of laceration of the soft palate and palatoglossal arch caused by inserting the blade or tube without directly looking in the patient’s mouth. It is very easy to get in the habit of looking at the video display during these processes. Students should be instructed to watch the blade until the tip goes out of view behind the tongue. If the student starts to look at the screen too early, the instructor should cover it with his or her hand and remind the student to look in the patient’s mouth.

Once the larynx has been adequately visualized, the tube should be handed to the student, and he or she should be instructed to watch the tube until the tip goes out of view behind the tongue. Once the tip of the ETT can be seen on the monitor, there is a 2-step process to...
facilitate intubation. First, the operator must place the tip of the tube into the laryngeal opening. The tip must be directed anterior to the arytenoid cartilages. Once the tip is properly located, the tube must be advanced off the stylet and into the airway. This is where practice delivering the tube off the stylet is valuable. If the student is having trouble manipulating the tube off the stylet, the instructor should provide assistance by holding the stylet and instructing the student to advance the tube. Another approach is to alternate withdrawing the stylet approximately 2 to 5 cm followed by advancing the tube the corresponding amount, then alternating, stylet out, tube in, stylet out, tube in, and so on.

If the axis of the tube is not well aligned with the axis of the larynx, it can be difficult to advance the tube. If this occurs, there are 3 maneuvers that can help: 1) withdraw the VL slightly, trying to lift the tongue, but not the larynx in an effort to bring the axis of the tube into better alignment with the axis of the larynx; 2) spin the tube as it is advanced off the stylet to minimize the tendency of the tube to curve into the anterior wall of the trachea; 3) remove the tube and reload it with reverse camber.

If the patient has a small oral aperture, occasionally one will encounter difficulty placing the tube in the mouth after the VL is in proper position. The student can try sliding the VL to the left, allowing more room for the tube to be inserted to its right side. Another technique for the small mouth problem is to remove the VL, then insert the tube until it disappears behind the tongue, and then reinsert the VL.

Because the instructor can see the tube’s position, its proper location is easily confirmed. Once the tube is in the proper position with the cuff 5 to 10 mm below the vocal cords, the VL is carefully removed from the mouth while holding the tube in place. The VL is disconnected from the video cable (if it has one), the cleaning cap is placed over the video connector port, and the blade is placed in an appropriate location for cleaning and disinfection. After the student has properly secured the ETT, the function of the cleaning cap can be demonstrated.

References

Step 1: Introduce the Video Laryngoscope

With the patient appropriately positioned, the operator uses the left hand to introduce the VL into the midline of the oral pharynx and gently advances until the blade tip is past the posterior portion of the tongue. This step is done using direct vision. In other words, the operator is looking directly into the patient’s mouth, as is the case for DL.

Step 2: Obtain the Best View

With the scope now inserted, the operator turns his or her eyes to the video screen in order to manipulate the scope and obtain the best view of the glottis. Unlike conventional laryngoscopy, the VL is a midline instrument and no lateral displacement of the tongue is required. Additionally, and also in contrast to DL, the glottic view is optimized by a combination of advancing or withdrawing the laryngoscope slightly while increasing the tilt on the blade to seat the device in the vallecula or on the posterior surface of the epiglottis.
to obtain the best glottic view. All of this is done using video visualization with the eyes directed at the video screen the entire time. When the VL is appropriately positioned, the glottic aperture is seen in the center of the upper third of the video display.

Step 3: Introduce the ETT

Usually, the video image of the glottis is a Cormack-Lehane grade I or II view1 and the operator immediately is tempted to insert the ETT and attempt to navigate it through the glottic aperture while continuously visualizing the video screen. In fact, it is better to maintain the laryngoscopic position in the mouth with the left hand but to avert the eyes from the video screen back to the patient’s open mouth. The ETT, which is shaped by the stylet to match the bend of the VL blade, is then inserted under direct vision until the distal tip of the ETT is judged to be very near the distal tip of the laryngoscope blade.4 This relationship is quickly and easily achieved, but only then does the operator return his or her eyes to the video screen.

Step 4: Intubate

Returning one’s eyes to the video screen allows one to see the glottic aperture as before (sometimes slight readjustment of the blade is required) and, near it, the tip of the ETT. Using video visualization, the ETT is then advanced on a smooth curve through the glottis and intubation proceeds as described elsewhere in this review. Viewing the entire insertion step on the video screen allows the operator to quickly become facile with the notion of gently rotating or angling the tube using the right hand to redirect as necessary.

Summary

In summary, the views of the 4 steps are as follows:
1. “in the mouth” to introduce the laryngoscope;
2. “at the screen” to obtain the best glottic view;
3. “in the mouth” to introduce the ETT; and
4. “at the screen” to intubate.

Over several years of working with both novice and experienced video laryngoscopists, I have found that this simplified 4-step approach makes intubation easier and more intuitive.

* This technique may not be applicable to all VL devices.

References

stylet—or the Satin-Slip (Mallinckrodt) disposable intubating stylet. Otherwise, the ETT is floppy and very hard to direct through the vocal cords. A stylet is not used for nasal intubation.

2. The primary limitation in using a VL is not in getting a good view of the glottis, but rather in manipulating the ETT through the vocal cords. This is because the ETT tip often tends to hit against the anterior tracheal wall. When this happens, it is often helpful to retract the stylet by 3 to 5 cm, as this often advances the ETT into a more favorable position. Sometimes, even when the stylet is removed completely, the ETT still abuts the anterior tracheal wall; in these cases, the ETT should be twisted by 180 degrees.

3. When initially placing the VL blade or the ETT, learners should first look into the patient’s mouth and not at the monitor, in order to prevent injury to any oropharyngeal structures.

References
Potential Challenges

The following are potential challenges associated with the use of VL.

1. The tendency to insert the VL too deeply (esophageal view) is a common cause of failing to obtain the desired laryngeal view. Observing the view while carefully withdrawing the VL usually will produce the desired view. With experience, one becomes accustomed to observing blade advancement with the VL monitor and integrating this information with the tactile sensations that accompany smooth insertion of the blade.

2. Some neonates or infants may present with insufficient room to maneuver the ETT within the mouth and pharynx. This is remedied with the techniques mentioned in the previous section.

3. In some neonates or infants, the VL may initially provide an anterior view of the larynx (i.e., only arytenoids or posterior glottis visible at the top of the monitor screen). The operator should avoid the tendency to attempt to improve the view by advancing the VL further. Rather, he or she should optimize the view by either maintaining blade position or slightly withdrawing the blade while applying the external manipulations mentioned previously (backward pressure or the BURP maneuver). Furthermore, the “shared view” provided by the VL monitor can permit an assistant to effectively aid in obtaining and maintaining the best possible laryngeal view. It also may be worthwhile to determine whether blade insertion that lifts the epiglottis or blade insertion into the vallecula provides the best view. Finally, in a subset of patients, the use of a shoulder roll may further improve the view.

4. Uncertainty about the trajectory of an ETT or the position of Magill forceps is rectified by carefully withdrawing the VL to provide a broader view of the laryngeal and pharyngeal structures. This will aid in the location and direction of the ETT and forceps. As well, this may minimize the risk for inadvertent trauma to the soft tissue structures such as the palate, tonsillar pillars, and uvula.

Unique Applications

Endotracheal Tube Exchange: VLs are able to provide both the operator and the assistant with an excellent view of the larynx that permits the replacement ETT to be pre-positioned in a fashion that facilitates expedient insertion immediately following withdrawal of the original ETT.

Insertion of Other Devices: VLs may be used to facilitate the esophageal insertion of nasogastric tubes, feeding tubes or, in some circumstances, transesophageal echocardiography probes.

(See also “Video Laryngoscopy and the Pediatric Airway,” page 47.)
was given blindly at first, and another 5 mL was sprayed directly on the glottic structures using the VL (GlideScope, Verathon) for guidance. When the VL was introduced a second time, the endotracheal tube was passed into the glottis without difficulty. The patient was then induced with etomidate, having only a 10% ejection fraction. A transesophageal echocardiogram probe placed after the induction of anesthesia showed severe global hypokinesis in the 4-chamber view. An epinephrine infusion was used for inotropic support. The patient did well and was unintubated in the intensive care unit when seen postoperatively.

References

Special Cases in Neuroanesthesia
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Airway management in neuroanesthesia is sometimes challenging because of the nature of the cases and the occasional need for urgent and expeditious endotracheal intubation (ETI). The neurosurgical patient may present with a brain tumor or cerebral aneurysm requiring carefully controlled laryngoscopy with minimal hemodynamic response. The patient also might present with acromegaly for pituitary surgery or may have a previous history of difficult intubation. The unanticipated difficult airway becomes a greater challenge when one also is focused on potential rupture of a cerebral aneurysm or increased intracranial pressure (ICP). Other challenges include the patient in need of cervical spine surgery who has limited neck movement, as well as the patient in a remote location who is in need of diagnostic procedures.

Applying Video Laryngoscopy To Neurosurgical Patients
If performed incorrectly, laryngoscopy and intubation can severely compromise intracranial dynamics and increase morbidity. Both the sympathetic and parasympathetic nervous systems mediate cardiovascular responses to ETI. Acute increases in ICP and mean arterial pressure during laryngoscopy and ETI have been well documented. Video laryngoscopy (VL) is a new and useful technique in airway management and has many benefits for the neurosurgical patient. An adequate glottic view often is easily obtained during VL, and frequently is superior to that obtained by direct laryngoscopy (DL). Video laryngoscopes allows for indirect laryngoscopy without alignment of the oral, pharyngeal, and tracheal axes. An early study of 50 elective patients by Rai and colleagues demonstrated ease of use. The GlideScope (Verathon Medical) provided a Cormack-Lehane grade I view of the glottis in 44 cases and a grade II view in six cases. The view of the larynx was improved in almost half (23) of the cases. The success rate of intubation after the first 8 patients was 100%. Hemodynamic responses often are minimized if appropriate doses of anesthetic are given. The ability to demonstrate and confirm intubation also is extremely useful as laryngoscopy is sometimes obtained with the “head away” from the anesthesia machine.

Topicalization of the larynx and trachea can prevent increases in arterial blood pressure during intubation and positioning of the patient. Several techniques using VL are beneficial for the neurosurgical patient. Following induction and mask ventilation, DL may be performed and local anesthetic sprayed into the larynx using a laryngeal tracheal anesthesia (LTA) kit (Abbott Laboratories). This allows one to assess and grade the laryngeal view as well as provide analgesia to the trachea. Additionally,
one can observe the patient’s hemodynamic response and provide more narcotic, induction agent or β-blocker if needed. The VL is then used for laryngoscopy and ETI. This provides a comparison of the DL view and is well tolerated due to the application of anesthetic to the trachea. It also is possible to use the MADgic Laryngo-Tracheal Atomizer (Wolfe Tory Medical) for spraying topical anesthetics in the laryngotracheal region using the VL.\(^6\) This device can be shaped according to the curve of the VL and allows one to topicalize the airway prior to intubation in the awake or asleep patient.

Acromegaly is an endocrine disease resulting from a pituitary growth hormone-secreting adenoma, which ultimately results in changes in the outward appearance of the patient. Airway management challenges have been attributed to prognathism, macroGLOSSIA, and thickening of pharyngeal and laryngeal soft tissue. Schmitt found a 26% incidence of Cormack-Lehane grade III views on DL in acromegalic patients.\(^7\)

At our institution, we have had excellent results using a GlideScope as a primary or secondary instrument for intubating patients with acromegaly (Figure 1). The GlideScope’s construction allows for easy navigation around the large tongue and usually provides excellent visualization of the glottic opening. Experience with the device is recommended in normal airways before use in a potentially difficult airway.

**Addressing Patients With Difficult Intubation**

Difficult intubation is well recognized as more common in patients with cervical spine disease. In particular, ankylosing spondylitis, rheumatoid arthritis, and Klippel-Feil abnormality are conditions that present additional difficulty. One of the problems in predicting difficult intubation is its incidence and the sensitivity and specificity of the tests used to detect it.

The patient who presents for elective surgery with symptoms of cervical myelopathy deserves careful airway management to avoid further injury. Intubation techniques described for the patient with a cervical spine injury are appropriate and best performed by experienced practitioners. When possible, awake intubation (AI), followed by the demonstration of extremity movement, is ideal and recommended. When AI is not possible, or not essential, a technique that produces minimal head movement and airway maintenance is acceptable (Figure 2). During intubation under general anesthesia with neuromuscular blockade and manual in-line stabilization, the use of the VL produced better glottic visualization, but did not decrease movement of the nonpathologic C-spine significantly when compared with DL.\(^8\) A study comparing a variety of laryngoscopes in patients who were intubated with cervical spine immobilization showed that the GlideScope and the Airway Scope AWS-S100 (Pentax) video laryngoscopes required more time but reduced intubation difficulty and improved glottic view compared with the Macintosh laryngoscope.\(^9\)

Patients with cerebrovascular or spinal disease for interventional neuroradiology often require general anesthesia with ETI to ensure a motionless study. Patients may present with many of the considerations described previously (eg, increased ICP, changing neurologic status, hemodynamic instability), yet they will be anesthetized in a location other than the operating room. Other considerations include the occasional need for a rapid-sequence induction or intubation on a flat table.

In the patient with an anticipated difficult airway, awake fiber-optic intubation remains the standard of care; however, this view is gradually changing as a result of the success and ease of use of VL. Remarkably, the VL and the fiber-optic bronchoscope can be combined
for additional success in the very challenging situation. Use of the VL is promising in the intubation of the difficult airway as primary or rescue devices and have proved invaluable in the management of patients undergoing neurologic surgery.

**Tips and Techniques**

1. The operator should always begin in the midline of the mouth, following the uvula as the VL enters. If the blade is turned sideways for a small mouth opening or large chest, re-orient to the midline.
2. Obtain the “best view” possible by withdrawing the blade in the vallecula to reveal the epiglottis, vocal cords, and arytenoid cartilages.
3. Use a stylet with a small curve at the end.
4. Head position of the patient is important; a sniffing or slightly extended position is beneficial.

**References**


**Nasal and Awake Intubation**

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**Nasotracheal Intubation**

When an individual is at rest, the normal human airway anatomy facilitates easy conduction of air from the nares to the trachea. Therefore, it should not be surprising that techniques such as blind nasotracheal intubation are possible, because a nasotracheal tube (NTT) will naturally itself toward the glottis. However, the most common technique for inserting an NTT—direct laryngoscopy (DL)—involves substantial distortion of the normal airway anatomy to sufficiently align the larynxal, pharyngeal, and oral axes so that the user can visualize the vocal cords. With DL, the trachea is moved anteriorly, and as a result, the tip of a preformed NTT will tend to sit posterior to the glottis, requiring the frequent usage of Magill forceps to lift the tip of the NTT anteriorly to the glottis. The use of forceps can result in mucosal trauma, bleeding, and a longer intubation time caused by the manipulation of the NTT tip. With video laryngoscopes (VLs), less anterior force is necessary in order to visualize the glottis. This results in less distortion of the normal airway anatomy, and should facilitate the passage of the NTT. Additionally, a decrease in the need for Magill forceps should be seen because a more anatomic alignment of the airway is preserved. A study of novice operators comparing the GlideScope (Verathon Medical) with direct laryngoscopy for NTT demonstrated a much shorter time to intubation in the VL group (45±313 vs 114±337 seconds; P<0.001), whereas a prospective observational study showed good times to intubation as well as glottic exposure when using the VL for nasotracheal intubation.2

More evidence of the usefulness of video laryngoscopy for nasotracheal intubation was provided by a prospective randomized clinical trial of 70 patients.3 The study found that using a VL for nasotracheal intubation was easier, faster, demonstrated better glottic exposure, and resulted in a significantly lower incidence of moderate to severe sore throat in patients on postoperative day 1. Only 4 patients required intubation with the VL to prevent one moderate to severe sore throat. As anticipated, use of Magill forceps was common in the group undergoing DL, but not used at all in the VL group. Thus, video laryngoscopy has important benefits for the anesthesiologist (eg, easier and faster), as well as the patient (eg, lower incidence of sore throat).
Awake Video Laryngoscopy

It may be necessary to intubate a patient with a suspected or documented difficult airway while “awake” and breathing spontaneously. Although no instrumentation or topicalization was used in the first case (documented in 1880) of awake intubation (AI), virtually any intubation technique can be used in the awake patient once adequate topical anesthetic is applied. Because of its tremendous versatility, fiber-optic intubation is probably the most commonly used technique for AI. However, it is not considered a rapid technique. DL is rapid, but is less likely to be successful in a difficult laryngoscopy situation. Video laryngoscopy has been shown to be rapid and to consistently improve the glottic view when the Macintosh blade provides a suboptimal view. Video laryngoscopy can be an excellent back-up plan in the setting of unexpected difficult laryngoscopy.

Several authors have described excellent results performing AIs using a VL and our experience has been similarly favorable as it is easy, straightforward, and significantly faster than fiber-optic intubation. It also has the advantage of being less susceptible to secretions and/or damage. Additionally, VLs have been used as an adjunct to awake fiber-optic intubation with good results.

Perhaps the most significant value of VLs for AI may be to avoid the situation entirely. Patients with previous failed DLs and subsequent awake fiber-optic intubation have been able to avoid a repeat AI now that VLs are available. After minimal topicalization with 4 cc of nebulized 4% lidocaine, a “quick look” with a VL can be undertaken in the surgical preparation area. Once an excellent glottic view is confirmed, the patient can be anesthetized (with short-acting agents if appropriate) and intubated using a VL. For the remaining patients for whom a good-quality glottic view is not demonstrated, the operator should proceed to complete the topicalization and undertake AI.

References
The Intensive Care Unit and Remote Locations Outside the Operating Room

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Video laryngoscopy (VL) offers a vast technological step forward for the airway practitioner. VL has been shown to improve glottic visualization in the vast majority of patients undergoing elective surgery and serves as a valuable adjunct to facilitate intubation in the patient with a known or suspected difficult airway. Its potential use in the remote location outside the operating room (OR) for urgent and emergent airway interventions that may take place in the intensive care unit (ICU), the emergency department, the hospital floor, or cardiac catheterization suite is far-reaching, especially in light of the fact that emergency airway management is fraught with difficulty and patient safety concerns. Video-augmented periglottic visualization allows the adaptation of VL for airway procedures well beyond tracheal intubation plus a variety of ingenious applications and uses.

Table 1. Potential Advantages: Continuous Glottic Viewing During ETT Exchange

| Pre-exchange airway evaluation to assist with management strategy |
| Assessment of glottic status to allow up sizing of replacement ETT |
| Confirmed passing of AEC into trachea (via ETT) |
| Confirmation of ongoing AEC positioning within trachea (during exchange) |
| ETT manipulation to reduce arytenoid, vocal cord, and posterior structure hang-up |
| Observation/confirmation of reintubation of trachea with replacement ETT |
| Monitoring of depth of replacement ETT during intubation and following AEC removal |
| Observation of passive/active regurgitation and/or aspiration during exchange |
| Observation/evaluation of any laryngeal-glottic intubation trauma/damage/injury |
| Intubation adjunct for rescue if AEC or ETT becomes displaced or reintubation fails |
| Teaching/educational benefit for trainees and nursing and respiratory therapy staff |

AEC, airway exchange catheter; ETT, endotracheal tube

Endotracheal Tube Exchange

Endotracheal tube (ETT) exchange may be required as a result of ETT dysfunction, luminal narrowing or occlusion, or a need to change the size or entry route (oral vs nasal vs submental). The ETT exchange often is facilitated via an airway exchange catheter (AEC) to maintain continuous access to the airway during the exchange. The exchange procedure often is combined with conventional direct laryngoscopy (DL) to assist with opening the pathway to ease ETT passage. Visualization of the glottic structures of the intubated airway with DL, especially in the patient with a difficult airway, may be restricted partially or completely. The inability to visualize the periglottic structures during the exchange may contribute to management problems if difficulty arises when advancing the ETT. This may delay the reintubation, injure airway structures, or increase the risk for airway and/or hemodynamic complications.

Advanced laryngoscopic techniques offering “around-the-corner” visualization may overcome the limited “line-of-sight” view offered by conventional laryngoscopy. VL makes it possible to transform a “blind” high-risk exchange into one with full or near-full glottic visualization. The potential advantages of continuous glottic visualization during high-risk ETT exchange are outlined in Table 1.

Despite the improved ability to visualize the glottis with VL, maintaining continuous access to the airway during the exchange remains paramount; thus, VL serves as an adjunct to the AEC, not as an alternative. ETT exchanges under clinical circumstances that prohibit the use of an AEC (eg, luminal obstruction or narrowing) may be assisted with VL. Changing a double-lumen ETT (DLT) to a single-lumen ETT (SLT) may be challenging as a result of secretions, edema, cardiopulmonary dysfunction, limited space in the oropharynx, and the need to incorporate a smaller diameter AEC. Reintubation over the smaller AEC with an SLT (>7.0 ID) under “blind” circumstances may be a difficult process.

Two recent cases at Hartford Hospital highlight the importance and advantage of glottic visualization during ETT exchange. Two patients requiring ETT exchange (DLT to SLT in the ICU, both with known difficult airways) underwent VL-assisted exchange, and each suffered inadvertent removal of the AEC from the tracheal position during removal of the “old” DLT. The practitioner was able to reintube the trachea without incident.

An ongoing feasibility study at Hartford Hospital suggests an improvement in patient safety during ETT exchange for the patient with a difficult airway when using VL-AEC versus DL-AEC (ie, hypoxemia reduction: 15% to 4%, bradycardia: 5% to 2%, and an improved first attempt success: 78% to 93%). VL offered a full or near-full view of the periglottic anatomy in 94% of patients who had no visualization with best attempts by conventional DL. It should be noted that in approximately 5% of ICU patients, placement of a rigid video laryngoscope may be hindered by anatomic limitations, by
virtue of a halo-vest apparatus, cervical spine immobility, restricted mandibular hinging motion, or limited mouth opening.13,17

Successful use of any advanced laryngoscopy equipment, however, is still dependent on operator skill, judgment, and patient selection. Therefore, alternative airway devices and techniques should be immediately available at the bedside. The portability of VL devices is particularly advantageous for intubation in settings outside the OR.

**Exubation of the Difficult Airway**

Exubation of the difficult airway has been highlighted as an area of weakness in patient care.18 A preformulated extubation strategy for the patient with a known or suspected difficult airway should be developed in order to potentially reduce post-extubation airway management complications.19,20 An examination of the upper airway to evaluate its patency, tissue injury, edema, or ease of visualization may serve as a supplemental component of an extubation strategy. Decision making for timing and whether to commit the patient to an extubation strategy. Video laryngoscopes that can record airway devices and techniques by adopting an aggressive device and techniques should be immediately available at the bedside. The portability of VL devices is particularly advantageous for intubation in settings outside the OR.

Emergency Intubation in the Remote Hospital Location

Emergency airway management outside the OR may be fraught with difficulties.5-10 Ideally, improvement of the first-pass success rate with urgent and emergent tracheal intubation would be a goal of the airway management team. The emergent circumstances clearly differ from the elective forum in the OR; thus VL-assisted visualization does not necessarily equate to effortless or undemanding tracheal intubation. Secretions, blood, vomitus, facial and airway edema, cervical spine immobility, bandages and dressings, a halo-vest apparatus, or uncertain aspiration risk are but a few of the potential risk factors for airway management difficulties. Furthermore, hemodynamic aberrations, cardiopulmonary instability, and other systemic maladies add to the problems inherent in the critically ill patient.

Is VL the panacea for airway management in the remote location? An analysis of critically ill patients who underwent emergent tracheal intubation outside the OR (N=168, Hartford Hospital database) with VL showed that experienced personnel obtained either a full or near-full laryngeal view (Cooper’s grades 1 and 2) in 96% of encounters. Intubation success was 98% by anesthesia staff experienced with VL.1 Of these 168 cases, 122 involved VL as an airway rescue device following failed attempts with other devices (DL, bougie, or laryngeal mask airway). The vast majority of these patients (94%) had a full or near-full view with VL. The remaining 46 patients had either a known or suspected difficult airway and underwent primary VL management as the first step toward tracheal intubation. A full or near-full periglottic view was obtained in nearly all patients (96%), with the practitioner achieving more than a 90% first-pass success rate. Of note, limitations to VL success were varied (9 cases excluded from the 168 patients) and included operator-dependent constraints, lack of maintenance, and clinical characteristics of the patient such as limited mouth opening.

**Tips and Techniques**

For practitioners delivering emergency airway care in remote hospital locations, it is important to be prepared for the unexpected and assume the “worst-case scenario” when arriving at the bedside of a critically ill patient in need of airway management. Complete reliance on VL technology is ill-advised and shortsighted. VL is an adjunct to our airway arsenal, not a replacement. A patient’s airway that may have been deemed appropriate for an awake fiber-optic approach in the past may not be best served by now inducing, paralyzing, and looking with VL.

Practitioners who wish to sidestep the basic fundamentals of airway management and the use of other accessory devices and techniques by adopting an aggressive stance with VL as their main (or only) approach, may be met with despair when “VL fails” or “does not do its job.” Even excluding inexperience as a reason for failure, most limitations and failures remain practitioner-dependent.

**Miscellaneous Applications**

The ability to assess the oral cavity, oro-hypopharyngeal region, periglottic structures, and the criopharyngeal opening provides the practitioner a new dimension of advancing past “blind” techniques for insertion of a variety of tubes, conduits, and instruments. With extreme caution, the traumatized airway may be assessed for injury via VL. The author has used VL for a variety of miscellaneous, non-airway applications as outlined in Table 2. The ability to overcome the limitations of “blind” procedures by providing indirect visualization of the upper airway structures with the potential of improving safety and reducing patient...
Table 2. Miscellaneous Applications Of Video Laryngoscopy

<table>
<thead>
<tr>
<th>Passage of nasogastric, orogastric, or enteral feeding tubes</th>
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<tbody>
<tr>
<td>Advancement of dilating bougie for esophageal procedures</td>
</tr>
<tr>
<td>Passage of a transesophageal echocardiography probe</td>
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<tr>
<td>Placement of upper gastrointestinal endoscopy equipment</td>
</tr>
<tr>
<td>Foreign body extraction (eg, bridgework, tooth, crown, filling)</td>
</tr>
<tr>
<td>Evaluation of the oral cavity, oro- and hypopharyngeal structures for trauma, infections, healing</td>
</tr>
<tr>
<td>Visualization of laryngeal function</td>
</tr>
</tbody>
</table>

Based on references 22 and 23.

injury, although not evidence-based, seems logical.

Conclusion

VL plays an important role in the OR for airway management. In remote locations, VL offers a varied role as an adjunct for intubation, extubation, ETT exchange, and airway assessment, and to ease placement of other devices into the aerodigestive tract. Understanding the indications, proper use, and limitations of VL is paramount in optimizing its role in patient care. Additional indications and uses will accumulate as experience with this technology grows.

References

Airway management in the emergency department (ED) is challenging for the emergency physician. Patients in need of intubation frequently present with medical or traumatic conditions that greatly increase the difficulty in managing the airway. Because of the precipitous development of their condition and their unplanned presentation, there usually is little time to perform a proper evaluation to determine existence of a difficult airway. The presence of a head injury or intoxicants renders some options for airway management (eg, awake flexible fiber-optic intubation) impractical or even impossible. The introduction of video laryngoscopy (VL) to clinical practice has greatly increased the options for emergency airway management and is a vital piece of equipment for the emergency physician. Various configurations of VL have been used in the University Medical Center’s ED for several years.1-4 What follows is a description of the clinical experience with VL and alternative applications for its use in the center’s ED.

VL has proven very useful for many types of airways often seen in the ED. Its greatest use, however, is in patients in whom it typically is difficult to obtain a “straight line of sight” to the airway. The most obvious of these is the patient with blunt trauma whose cervical spine is immobilized. The presence of a cervical collar frequently makes direct visualization of the airway difficult. One can bring a view of the airway “outside the patient” onto the monitor. This allows intubation to be easily achieved with absolutely no movement of the immobilized cervical spine (Figure 1). Likewise, in the patient with limited neck motion and mouth opening as a result of conditions such as severe rheumatoid arthritis, VL allows easy intubation even when direct laryngoscopy (DL) has proven difficult or impossible. At the University Medical Center’s ED, VL has been used successfully for awake intubation (AI) when there is concern about paralyzing the patient because of potential for a difficult airway. ED physicians there have found that AI with VL is better tolerated than awake DL because very little pressure is exerted on the patient’s tongue (Figure 2). Using ketamine sedation only, VL can provide an excellent view of the airway and allow intubation without performing a risky rapid-sequence intubation.

**Tips and Techniques for Difficult Intubations**

In addition to using VL for difficult intubations, these ED physicians have found it useful for other airway-related issues in the ED, such as confirming tube placement in patients intubated in the field. On more than one occasion, patients with field nasotracheal intubations arrived in the ED with all conventional confirmatory tests positive for tracheal intubation. Equal breath sounds, excellent oxygen saturations and positive end
Tidal capnometry were noted. However, when VL was used to confirm placement, the tube was found to be supraglottic. The tip of the tube was entering the laryngeal inlet, but the cuff was sitting above the vocal cord. Deflation of the cuff and advancement of the tube under videolaryngoscopic observation easily remedied the problem.

Video laryngoscopes also can be used to perform tube exchanges in patients with air leaks secondary to a malfunctioning cuff or inappropriately sized tube. The devices allow excellent observation of the tube as it is “railroaded” down the tube exchange catheter and minimizes trauma to the larynx by allowing the operator to see what is happening as the tip approaches the laryngeal inlet (Figure 3). The operator, or an assistant, then can manipulate the tube appropriately, avoiding traumatization of the arytenoids. Usually this involves retraction of the tube by a few centimeters and rotation 90 degrees counterclockwise. VL also can be used in the ED to evaluate for and remove foreign bodies in the upper airway with the assistance of Magill forceps.

Occasionally, VL has been used to monitor clinical progression of certain disease states. For example, when a patient with adult epiglottitis is intubated in the University Medical Center’s ED with the flexible fiberoptic scope, VL is used afterward to document the amount of airway edema present. Photos are printed of the glottic view visualized with VL and these are then placed in the patient’s chart. This allows the intensive care unit physicians and ear, nose, and throat surgeons involved in the ongoing care of these patients to have a baseline evaluation of the airway. Repeat VL is then performed in the intensive care unit after appropriate treatment and this has aided in the decision to safely attempt extubation (Figure 4).

References
Teaching in the Simulation Laboratory and Teaching Airway Anatomy

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When fiber-optic bronchoscopy was first introduced, many clinicians found it frustrating to teach because the teacher and the student could not visualize the anatomic structures (or lack thereof) at the same time. Just as video technology has made it easier to teach and learn fiberoptic intubation, video laryngoscopy (VL) will most likely make it easier to teach and learn video and direct laryngoscopy (DL) and tracheal intubation.

At the University of Chicago School of Medicine, every third-year medical student spends 2 weeks in a required Anesthesia, Perioperative Medicine and Pain Management clerkship. The students rotate in groups of 3 making it challenging to teach DL. Either one student at a time gets a chance to perform DL and intubate with the instructor looking over his or her shoulder, or an instructor will perform DL and have the students take turns one at a time looking at the laryngeal view, prolonging the time the patient is subjected to laryngoscopy.

It can be especially helpful to demonstrate a VL intubation to all 3 students concurrently prior to their first attempt at DL. This allows them to see proper body mechanics, as well as the anatomy of the laryngeal opening, proper intubation technique, and final location of the tube with the cuff just below the vocal cords (Figure).

The students are told that “viewing intubation from the perspective of the VL is like seeing a play from the perspective of the orchestra conductor while the view with DL is like seeing the play from the second balcony. The players are the same, but the view is significantly different.”

VL can help to teach anatomy, particularly the proximal esophagus and the back of the cricoid cartilage; surprisingly, many experienced residents do not realize the size of the posterior aspect of the cricoid. By understanding this, they are better able to perform the Sellick maneuver. The shared view of the video monitor also makes it possible for the instructor to comment on anatomic points of interest like an omega-shaped epiglottis, vocal cord nodules, or edematous vestibular folds. However, it is difficult to spend more than a few seconds during the course of laryngoscopy to illustrate one or 2 quick points.

VL is a relatively new technology for solving difficult airway problems. Although video laryngoscopes are not mentioned in the 2003 American Society of Anesthesiologists (ASA) Practice Guidelines for Management of the Difficult Airway, they do play a significant role in the management of the patient with a difficult airway. The advantages and disadvantages of VL can be well explored during a simulation of a difficult airway scenario using a high-fidelity mannequin.

Tips and Techniques

VL can be used during an awake intubation after proper topical anesthesia has been administered with or without sedation. In a simulation involving the nonemergent pathway where ventilation is adequate but attempts at intubation via DL have been unsuccessful, VL offers some unique advantages over other techniques:

1. Video laryngoscopes are rigid scopes that can help open the airway, unlike fiberoptic intubation, which must rely on oral airways or external maneuvers to create an open space for the endotracheal tube.
2. Because the optics are an integral part of the blade, they will stay relatively anterior in the airway and will be less prone to contamination with blood or secretions in the airway, which are the Achilles heel of flexible fiberoptic and optical stylet devices.
3. The devices require minimal setup time and can be rapidly inserted and used. The operator can quickly determine if the video laryngoscope will be helpful in securing the airway. With many other advanced airway management techniques, it can take one or 2 minutes to determine if the technique will work prior to abandoning it and moving on.
4. Because others in the room can see the video monitors of some devices, they are better able to help.
5. Because others in the room can see what the anesthesia provider can see, they often are more patient in the setting of a difficult airway than if the operator is the only one who can see or if a blind technique such as use of an intubating laryngeal mask airway is being attempted.

The one area of debate that may arise is what constitutes “multiple failed attempts” as described in the ASA’s guidelines. For example, if conventional DL has failed 3 times with different blades and head position, one may question the appropriateness of using VL. Although it may be a matter of interpretation, VL is

Figure. A look at the anatomic structures of the airway using video laryngoscopy.

Photo courtesy of Irene P. Osborn, MD.
significantly different from conventional DL and would be appropriate to use in this setting as long as ventilation with a face mask remains adequate.

In summary, VL provides several benefits for teaching airway anatomy and airway management techniques. Its optics allow the operator to “see around the corner.” Its screen lets others see what the operator sees, often allowing for better assistance and increased patience. It can create an open space in a closed airway and it is not prone to many of the pitfalls of flexible fiber-optic and optical stylet devices. As with all good tools, it does require one to learn its proper use and understand its unique hazards. However, with appreciation of some of the distinctive points of its use and a little practice, it can produce great benefits for patients and those managing their airways.

Reference

Disclosures
Dr. Cooper consults for and is a shareholder in Verathon Medical. He is on the speakers’ bureaus of Verathon Medical and Aircraft Medical, and has received equipment for evaluation or retention from Verathon Medical, Aircraft Medical, Karl Storz, Pentax, Prodol, and Truphatek.
Dr. Doyle has nothing to disclose.
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Dr. Turkstra has nothing to disclose.
Dr. Walls is a consultant for Verathon Medical.

Figure 1. Telebation being performed by a Tucson Fire Department paramedic in a moving ambulance.
The paramedic intubates with the GlideScope Ranger while viewing the large computer monitor in the rear of the ambulance.
with a standard RCA video output and connecting it to a compact battery-operated Wi-Fi transmitter. Each ambulance is equipped with a Wi-Fi receiver that picks up the signal from the Ranger and then transmits it through the existing network back to the base station at University Medical Center. The range of the Wi-Fi transmitter is 500 ft, and it allows intubations performed either in the ambulance or in the field to be transmitted over the telemedicine network. In the telemetry room at the University Medical Center’s ED, the attending physician on duty can visualize the intubation on a large computer monitor (Figure 2). An additional video feed is provided by an overhead camera in the ambulance, allowing the attending physician to see the paramedic and the patient (Figure 3). If desired, the video feed in the control room can be visualized in a full screen mode. The 2-way nature of the network allows the attending physician to provide verbal feedback and guidance to the paramedic, while the paramedic is able to ask questions as the procedure is taking place. To date, this system has been tested and used successfully throughout Tucson using mannequins in moving ambulances. The system presently is being prepared for application with patients. Studies will be necessary to determine if telebation improves the success rate of prehospital intubations. Combining the technical expertise of paramedics with the experience of skilled emergency medicine practitioners has the potential to greatly improve airway management practices in the field.

Reference