Endotracheal Intubation In Pediatric Patients Using Video Laryngoscopy: An Evidence-Based Review

Abstract

Endotracheal intubation of pediatric patients is an infrequent, though high-risk, procedure in emergency medicine. Emergency clinicians should be aware of available approaches to assist with successful intubation in pediatric patients. Video laryngoscopy involves the utilization of optical and video technology to facilitate indirect visualization of laryngeal structures during intubation. This technology can be advantageous when intubating patients with normal or difficult airways, and it is increasingly being used in the care of patients in the emergency department. A number of pediatric devices are now available, each with benefits as well as limitations and nuances in technique for use. This evidence-based review describes the emergence of video laryngoscopy into the pediatric and emergency medicine settings. A summary of the existing data on video laryngoscopy use in routine and difficult airways is included, and practical instruction on the use of 3 specific devices approved for use in pediatric patients is provided.

CME Objectives

Upon completion of this article, you should be able to:
1. Describe 3 types of video laryngoscopic devices available for use in pediatric patients.
2. Identify the benefits and drawbacks of specific video laryngoscopes.
3. Discuss the evidence in support of video laryngoscopy in the pediatric setting.
4. Assess the challenges that are presented by use of video laryngoscopy relative to traditional laryngoscopy.

Prior to beginning this activity, see “Physician CME Information” on the back page.

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Case Presentations

An 8-year-old boy is brought into the ED after a motor vehicle crash in which he was an unrestrained passenger. His mental status is depressed, with a GCS score of 7, and his cervical spine has been immobilized in a collar. His capnography shows bradypnea and hypercarbia, and he is intermittently desaturating. He has scattered ecchymoses over his chest wall. The pediatric emergency medicine fellow managing the airway has not previously intubated a trauma patient in the ED. You consider the best method to intubate this patient and provide guidance to the fellow...

A 5-year-old girl with a seizure disorder presented in status epilepticus, and is now somnolent after receiving 3 rounds of benzodiazepines and a loading dose of fosphenytoin. She has intermittent apnea and hypotension. Her end-tidal CO₂ remains elevated at 55 mm Hg, and she requires bag-valve mask ventilation during her apneic periods. Her last intubation procedure note reports a grade 2 Cormack-Lehane view. You are concerned about performing any diagnostic tests prior to securing the airway in this patient...

A 2-year-old girl with Pierre Robin sequence presents to the ED with respiratory distress and fever. She is ill-appearing, hypoxic to 88% despite a nonrebreather mask on 10 L/min of oxygen, and she is in moderate respiratory distress. A chest x-ray demonstrates multifocal pneumonia. She has a history of requiring airway support for pneumonia, and noninvasive support has been historically challenging secondary to her facial dysmorphisms. You wonder if intubating this patient will be difficult...

Introduction

Emergent endotracheal intubation is an infrequent, yet critical, procedure in pediatric patients in the emergency medicine setting. It can be lifesaving, though it also carries risks of significant morbidity (eg, hypoxia, aspiration, and esophageal intubation) and even mortality. Several studies have identified a clear relationship between an increased likelihood of adverse events and multiple attempts at intubation.¹⁻³ Yet, data from both single and multicenter pediatric studies demonstrate that first-pass success rates for emergent intubation are variable, ranging from 37% to 78%.⁴⁻⁷ It comes as little surprise, then, that adverse event rates in pediatric intubation in acute settings have been shown to be as high as 21%.⁷ Therefore, efforts to improve rates of first-pass success and decrease intubation-related complications are essential.

The concept of integrating video technology into laryngoscopy has led to changes in advanced airway management. The quantity of available data has increased in the anesthesia, critical care, and emergency medicine literature in recent years. (See Figure 1.) Given the high success rates for orotracheal intubation, particularly in the operating room setting, video laryngoscopy (VL) devices were generally only considered as alternative strategies for use in patients with difficult airways. However, with improving technology, decreasing cost, and wider availability, the use of VL has become increasingly common for routine cases and across more practice settings, including emergency departments (EDs) that care for children.

This review covers the available literature regarding VL use in emergency medicine and the pediatric setting, including use in the context of potentially difficult airways, and provides practical instruction on the 3 VL devices approved for use across the entire spectrum of pediatric ages: the GlideScope®, the Airtraq, and the Storz C-MAC®. (See Figure 2.)
The Need For Improved Devices In The Pediatric Population

**Unique Pediatric Considerations**

Pediatric patients have anatomic characteristics that can make intubation more challenging, even to skilled emergency clinicians. Their prominent occiput can cause unintended flexion of the neck while in the supine position. The tongue and tonsils are relatively large compared to the size of the oral cavity, and the epiglottis is often large and flaccid. These features can make it difficult to displace anatomic structures and create a direct line of sight to the larynx. Perhaps the most notable difference in the pediatric airway is the superior position of the larynx. This creates a more-acute angle from the oropharynx to the glottic aperture, which compounds the difficulty in obtaining direct visualization. Alternative approaches, such as VL, may serve to overcome some of these anatomic challenges in pediatric airway management.

**Decreased Clinical Opportunities**

In addition to the physical challenges related to the anatomy of pediatric patients, current data suggest that endotracheal intubation occurs much less frequently in children than in adults, at up to 3 to 6 times less often per 1000 patients. Changes in resuscitation guidelines, removal of the Accreditation Council for Graduate Medical Education requirement for advanced airway management skills training for pediatric trainees, and a trend toward increasing use of noninvasive ventilation for respiratory failure may have all contributed to the reduction in airway management experiences for trainees and practicing clinicians. VL has been shown to have a faster training time and provides secondary exposure to airway management through displayed images and recorded videos that may help fill this increasing void.

**Critical Appraisal Of The Literature**

A literature search was performed in the PubMed database using search terms video laryngoscopy, video laryngoscope, GlideScope®, Airtraq, and C-MAC®. More than 80 articles were selected for review, the majority from pediatric anesthesia, general anesthesia, and general emergency medicine literature. Five articles specifically addressed VL in pediatric emergency medicine. Due to the relatively recent implementation and development of VL devices, the majority of literature included is from the previous decade. (See Figure 1, page 2.)
ever, only 3 currently available devices are approved for use across the entire spectrum of pediatric ages, from neonates through adolescents. Blade shapes and angles vary from the standard Miller or Macintosh devices to those with increased curvature designed exclusively for indirect viewing. Some devices have been created with an incorporated channel to allow endotracheal tube (ETT) advancement following the curve of the instrument.

Devices also vary with respect to disposability. Some are manufactured as single-use, disposable products or with single-use blades. Other VLs are manufactured with no disposable components and require sterilization following each patient use. Most pediatric products now offer video capture components to allow recording for later review. Product selection is based largely on clinician or institution preference and budgetary constraints.

Potential Benefits Of Video Laryngoscopy

VL offers a number of potential advantages over traditional laryngoscopy, many of which are particularly applicable in pediatrics. Most notably, VL provides a unique vantage point that can facilitate glottic visualization. In addition, projected and recorded images allow for enhanced oversight, provide teaching opportunities, and allow for review to assess procedural performance metrics.

Line Of Sight

Direct laryngoscopy requires the clinician to have a direct line of sight along the blade to view the glottic opening. With direct laryngoscopy, line of sight is achieved through alignment of the oral, pharyngeal, and laryngeal axes. As illustrated in Figure 4, alignment can be performed by flexing the neck forward on the body and extending the head on the neck into “sniffing” position (35° neck flexion and 15° head extension). However, direct visualization of the glottis can still become obstructed by the tongue, which needs to be displaced laterally or superiorly into the submandibular space. VL obviates the need for this direct line of sight, as the camera allows indirect and improved visualization of the glottic opening. (See Figure 3, page 3.) This also may alleviate the need for substantial laryngeal forces during VL, as has been shown in numerous studies.19-21

Supervision And Training

In addition to improved indirect exposure of the glottic opening, VL allows real-time teaching and supervision during endotracheal intubation. During direct laryngoscopy, limited guidance can be provided to the emergency clinician, given the inability of others to see the laryngeal anatomy directly. Instead, guidance must be offered based on changes in vital signs and verbal descriptions provided by the clinician performing the laryngoscopy. VL, on the other hand, provides a shared view of the airway anatomy, allowing a second clinician to offer immediate guidance as needed.

Procedural Review

An added benefit when using many VL devices is the ability to save video recordings for later review. These can be used for teaching purposes, or as part of quality assurance measures to improve the care that is provided for critically ill patients. Multiple metrics can be evaluated, including grade of laryngeal view, first-pass success rates, number of intubation attempts, time to intubation, aspiration, esophageal intubation, and airway mucosal injuries.

Figure 4. Alignment Of Oral, Pharyngeal, And Laryngeal Axes

Optimal position can be achieved by insertion of a towel or roll under the shoulders of infants and young children or beneath the head in older children. Reprinted from Emergency Medicine Clinics of North America, Volume 26, Issue 4, Sharon Elizabeth Mace, MD, “Challenges and Advances in Intubation: Airway Evaluation and Controversies with Intubation,” pages 977-1000. Copyright 2008, with permission from Elsevier.
Many of these findings are difficult to assess by self-report and may be more accurately captured by video review.\textsuperscript{4,22}

**Video Laryngoscopy Use And Success Rates**

Original descriptions of VL use focused on adult populations within the controlled environment of the operating room.\textsuperscript{23,24} Over time, case series and comparative trials have emerged from practice settings outside the operating room, across a spectrum of healthcare providers, and inclusive of both adult and pediatric populations. Data are available from simulated as well as clinical contexts, examining routine and difficult airways, and from the management of select populations of patients. Meta-analyses have compiled much of the published data, allowing identification of patterns of findings.\textsuperscript{25,26}

**Use Of Video Laryngoscopy In Adults In The Emergency Department**

Sakles, Mosier, and colleagues have published a number of comparative trials by building a database of prospectively collected information on intubations performed in the general ED. A comparison of intubation performed using a C-MAC\textsuperscript{®} VL compared to a Macintosh blade showed that VL resulted in improved views and higher first-pass success rates.\textsuperscript{27} There was also a reduction in the number of recognized esophageal intubations and no increase in complications. A similar study comparing the GlideScope\textsuperscript{®} to direct laryngoscopy again found a higher first-pass success rate and a reduced number of esophageal intubations when using the video device, though intubation success rates ultimately favored direct laryngoscopy when multiple attempts were needed.\textsuperscript{28} A direct comparison of the GlideScope\textsuperscript{®} to C-MAC\textsuperscript{®} found no difference in performance.\textsuperscript{29}

Brown et al found that glottic exposure is improved when using a prior fiber-optic-based version of the C-MAC\textsuperscript{®} over direct laryngoscopy.\textsuperscript{30} Of the patients in the study who were found to have a Cormack-Lehane grade 3 or 4 view by direct laryngoscopy, 78\% improved to a grade 1 or 2 view when using the VL. (See Figure 5.) Conversely, only a small percentage of patients (3\%) were noted to have the view worsen when switching from direct laryngoscopy to VL. Similar benefits to laryngoscopy were identified when emergency clinicians compared the C-MAC\textsuperscript{®} with traditional laryngoscopy in a simulation setting.\textsuperscript{31} The VL device offered improved Cormack-Lehane views, was perceived to be easier to use, and resulted in faster time to intubation when used in difficult airway settings.

In summary, the available data from > 2000 patients in the general emergency medicine literature have provided convincing evidence that VL offers: (1) improved views, (2) higher rates of first-pass success, and (3) similar or decreased incidence/frequency of complications.

**Use Of Video Laryngoscopy In Pediatric Patients In The Operative Setting**

The majority of clinical data regarding the utility of VL in pediatric patients have come from the anesthesia literature. A number of prospective randomized trials of children undergoing elective surgery have identified that VL offers an improved glottic view over direct laryngoscopy, but equivalent or sometimes longer time to intubation. In 2 studies including children aged infancy through adolescence, the view achieved with the C-MAC\textsuperscript{®} was found to be better based on Cormack-Lehane scores and the percentage of glottic opening (POGO) scores.\textsuperscript{32,33}

Results from 2 trials comparing the GlideScope\textsuperscript{®} to direct laryngoscopy showed improved visualization. One study used POGO scores (median of 100\% for VL versus 80\% for direct laryngoscopy) while another utilized Cormack-Lehane scoring to demonstrate the improvement in cases where direct laryngoscopy offered suboptimal visualization.\textsuperscript{34,35} However, for studies with both the C-MAC\textsuperscript{®} and GlideScope\textsuperscript{®}, the time to intubation was equivalent or longer when using the VL compared to direct laryngoscopy.\textsuperscript{34-36} More recently, Sun and colleagues performed a meta-analysis of prospective, randomized trials within the pediatric anesthesia literature.

**Figure 5. Cormack-Lehane Grading System**

The original depiction of the laryngeal grading system described by Cormack and Lehane.

a. Grade 1 (full glottis)

b. Grade 2 (posterior glottis only)

c. Grade 3 (epiglottis only)

d. Grade 4 (unable to visualize epiglottis)

The collective results mirrored those of individual studies, including improved laryngeal view, no difference in first-pass success rates, and either no difference or increased time to intubation among experienced anesthesia clinicians. A small prospective study in children in the operating room and a meta-analysis of previous anesthesia studies have shown that the Airtraq may have advantages in terms of shorter time to intubation, improved visualization, and reduced rates of esophageal intubation.37,38

There are a few important considerations regarding the data obtained from VL use in the operating room setting. First, the clinicians performing the laryngoscopy in each of these studies were anesthesiologists with long-standing comfort and experience with direct laryngoscopy. Although most studies required some training and practice with the video devices prior to enrollment of study subjects, the relative exposure was likely significantly less than their prior experience with direct laryngoscopy. This is particularly important because the technique used with video devices is different from direct laryngoscopy (eg, the GlideScope® is designed to be “rocked” into position, which may be counterintuitive to clinicians who are accustomed to avoiding rocking when using direct laryngoscopy). Second, moving the vantage point to behind the base of the tongue is clearly advantageous in improving visualization of the glottis. However, such indirect visualization means that the ETT must then be passed around the curvature of the airway rather than along a straight line of sight. This can be physically challenging, particularly when using small, non-rigid pediatric endotracheal tubes. This difference in approach is perhaps most notable in blades that are more curved, such as the GlideScope®. This is supported by data from a study that recorded sub-components of total time to intubation. The study found that the time to initial glottic view was faster with the GlideScope®; however, the overall time to tracheal intubation (including tube passage) is longer, suggesting that the time for tube delivery was increased with this device.34

In summary, currently available data from the operating room setting support improved laryngoscopic views when using VL devices, though no definitive benefit with regard to time to intubation or intubation success has been noted. However, these findings may not generalize well to the ED setting, where intubation is often performed on unscreened and critically ill patients and by clinicians with significantly less experience with airway management. Use Of Video Laryngoscopy In Pediatric Patients Outside The Operating Room

Performing pediatric randomized controlled trials of VL versus traditional laryngoscopy outside the operating room carries obvious challenges. There exists a relative infrequency of airway management opportunities in pediatric patients, and clinical imperative would make study implementation difficult. Therefore, the available data evaluating VL use in acute airway management outside of the operating room are based substantially on performance on simulators rather than on patients. Interestingly, data regarding performance metrics when using VL in pediatric simulators have not been as compelling as in adult emergency medicine. Sylvia et al found no difference in success rates by pediatric clinicians, but a slightly longer time to intubation when comparing the GlideScope® to direct laryngoscopy (median of 36 seconds vs 23 seconds).39 A related study of pediatric interns also showed similar success rates between the GlideScope® and direct laryngoscopy, though there was a longer time to intubation when using the VL. Interestingly, despite these findings, the GlideScope® was the preferred device among the majority of participants.40 Finally, in a study using mannequins in both easy and difficult settings (eg, patients with cervical spine immobilization), GlideScope® intubations were found to take significantly longer than direct laryngoscopy (median of 37 seconds vs 18 seconds). Other outcomes including number of attempts, dental injuries, and failed intubations were not different across the 2 approaches.20

Using neonatal, infant, and adult mannequins, Donoghue et al compared C-MAC® to direct laryngoscopy use by pediatric emergency medicine trainees and faculty. They found that POGO scores improved with VL, though again, there were no differences in first-pass success rates on neonatal and infant simulators.41 Thus, similar to pediatric anesthesia literature, current data suggest that VL devices appear to provide an improved view, comparable success rates, and equivalent or slightly longer time to intubation for clinicians in the pediatric acute care setting.

The Difficult Airway

Anesthesiologists and experienced airway clinicians are commonly facile at achieving laryngeal views and achieve near-perfect endotracheal intubation success when using direct laryngoscopy in otherwise healthy patients.42 Therefore, demonstrating any additional advantage from VL may be challenging. Similarly, data from a large ED intubation registry that includes both adults and children show overall intubation success rates of 99%, which would also be difficult to surpass.43 However, the technological advantage of VL has consistently been shown to be improved glottic visualization. Therefore, the benefit of VL may be most demonstrable when utilized in patients with difficult airways in whom adequate visualization is otherwise challenging. Although there is some variation by specialty, emergency medicine experts define the difficult
airway as “one for which a preintubation examination identifies attributes that are likely to make laryngoscopy, intubation, [or rescue approaches]... more difficult than would be the case in an ordinary patient without those attributes.” These attributes may include findings related to anthropomorphic features, mouth opening, airway anomalies, and neck mobility. A related term, “difficult intubation,” is often used to describe circumstances in which difficulties with laryngoscopy and/or ETT passage result in the need for multiple attempts or involvement of physicians with advanced airway skills. Relevant contributors may include patient-specific factors, as well as those related to the clinical setting and the skill of the airway manager. Literature suggests that as many as 10% of intubations in the adult emergency medicine population are categorized as difficult.\textsuperscript{5,43,45}

**Video Laryngoscopy In The Adult Difficult Airway**

The majority of data regarding VL use in difficult airways come from experience in the adult population. Aziz and colleagues performed a randomized controlled trial in adult patients in the operating room, comparing the C-MAC\textsuperscript{®} laryngoscope to direct laryngoscopy in 300 patients with at least 1 predictor of a difficult airway (restricted cervical motion, Mallampati score of 3 or 4, reduced mouth opening, or prior history of difficult direct laryngoscopy). They found that use of VL resulted in higher rates of Cormack-Lehane grades 1 and 2 views, higher first-pass success rates, and a reduced need for laryngeal manipulation or use of a bougie, though with a slightly longer time to intubation.\textsuperscript{46}

Other studies have utilized mannequins rather than patients to compare performance of various VL devices to direct laryngoscopy. In a trial including 32 experienced anesthesiologists intubating patients with a difficult airway characterized by cervical immobilization collar, the C-MAC\textsuperscript{®} was found to have the shortest time to tracheal intubation, and it was perceived to be the easiest to use, while the Airtraq provided the best glottic view when compared to GlideScope\textsuperscript{®}, C-MAC\textsuperscript{®}, and traditional Macintosh blades.\textsuperscript{47} In a separate study comparing the GlideScope\textsuperscript{®} to direct laryngoscopy among anesthesiologists, intubation time was faster than with direct laryngoscopy in mannequins set to simulate difficult airway scenarios (23.5 seconds vs 70.5 seconds, respectively; \( P = .001 \)).\textsuperscript{48} In addition, the anesthesiologists found the GlideScope\textsuperscript{®} easier to use in the context of simulated difficult airways.

The emergency medicine literature also shows added benefit for VL over direct laryngoscopy in cases of difficult airways. Mosier et al retrospectively analyzed 772 patients who were noted to have predictors of difficult airways, including cervical immobility, obesity, small mandible, large tongue, short neck, blood or vomit in the airway, tracheal edema, secretions, and facial or neck trauma.\textsuperscript{49} In this select population, the odds of first-pass success when using the GlideScope\textsuperscript{®} was > 3 times that achieved during direct laryngoscopy. In a prospective simulation-based study with 39 emergency medicine residents and attending physicians, utilization of the C-MAC\textsuperscript{®} was noted to result in a superior view, a perception of easier use, and a shorter time to intubation in difficult scenarios.\textsuperscript{51}

One of the greatest challenges in airway management in emergency medicine is unexpected difficulty. Although a number of predictive features exist, patient condition often precludes the ability to fully evaluate for them. That is, clinical urgency may necessitate that airway assessment be abbreviated. Bair and colleagues found that a Mallampati assessment could not be performed in three-quarters of patients requiring emergency intubation.\textsuperscript{50} Similarly, a study by Levitan et al showed that approximately half of non–cardiac arrest patients presenting to the ED could not follow simple commands, and, therefore, would not be candidates for Mallampati scoring. Additionally, 40% were unable to be assessed for cervical spine mobility.\textsuperscript{51} Given this limited ability to fully prescreen patients, the likelihood of unanticipated difficulty can be expected to be higher in ED patients, and the advantage of improved visualization afforded by VL may be particularly helpful. Brown and colleagues demonstrated this advantage in a convenience sample of adult patients presenting to the ED. In the subset of patients with poor visualization (Cormack-Lehane grades 3 or 4 views) obtained using direct laryngoscopy, 78% had the view improved to grade 1 or 2 with the use of a C-MAC\textsuperscript{®} laryngoscope.\textsuperscript{30}

Thus, in the ED, where the ability to fully assess patients for difficult airways may be limited, VL may have advantages. Certainly, data in adults support improvement in view and success rate when difficult airways are encountered in this setting.

**Video Laryngoscopy In The Pediatric Difficult Airway**

The incidence of true anatomically difficult airways in the pediatric population is hard to determine. Data from a large anesthesia case registry suggest that the incidence may be approximately 1%, while a multicenter study on pediatric intensive care intubations reported difficult airway rates of nearly 15%.\textsuperscript{5,52} Nonetheless, the challenges posed by managing both anticipated and unexpected difficulty with pediatric intubations is an important topic. However, data regarding the role of VL in difficult pediatric airways are limited, and come largely from simulated scenarios and case series of neonatal and pediatric patients.\textsuperscript{53,54}

Two studies compared VL to direct laryngoscopy in simulated difficult pediatric airways. In
the first, 32 anesthesiologists and intensivists were asked to compare the GlideScope® to a traditional Miller 1 blade when intubating a mannequin with pharyngeal obstruction and tongue edema. There was no difference in time to intubation, perceived view, or ease of use. However, a majority of the pediatric anesthesiologists and intensivists reported that they would favor a Miller blade over the GlideScope® (66% vs 34%) in an emergency.  

Importantly, as discussed previously, these study subjects had years of collective experience using the Miller blade in routine, emergent, and difficult cases. Therefore, this perception may have been influenced by preference for a familiar device. A similar study of experienced pediatric anesthesiologists compared the C-MAC® with a Miller 1 blade to a traditional Miller 1 blade in an infant mannequin with limited neck extension. The use of VL improved glottic exposure (by at least 1 grade using the Cormack-Lehane scales) in 78% of patients, with no difference in time to intubation.  

Literature searches on pediatric VL and difficult airway management in patients resulted in only case reports and series, at this time. Eighteen children with a history of difficult or failed intubation were prospectively recruited and intubation by the anesthesiologist was attempted first using a traditional blade followed by a GlideScope®. Therefore, each patient served as his own control. In this small cohort, the GlideScope® offered improved views over the traditional blade, regardless of external laryngeal manipulation, and without appreciable effect on time to intubation.  

Similarly, 7 patients with identified difficult airways who were undergoing general anesthesia were intubated using the C-MAC®, with first-pass success in 6 of the 7 patients. Finally, several case reports have described the intubation of neonates and children with difficult airways secondary to associated syndromes (including Pierre Robin sequence, Beckwith-Wiedemann syndrome, Treacher Collins syndrome, and Desbuquois syndrome) using a number of different types of VL devices.  

In summary, although large cohorts and comparative trials addressing the difficult airway in pediatrics do not currently exist, early evidence in pediatric patients suggests that VL devices could be beneficial in patients with normal as well as presumed difficult airways. In addition, clinical reviews routinely include the use of VL among their varied recommendations for managing difficult pediatric airways.  

### Video Laryngoscopy In Special Populations  

There exist subsets of patients with potentially difficult intubations in whom VL may be particularly beneficial. These include patients in cervical spine immobilization, neonates, and patients who are undergoing airway management in the prehospital setting.  

### Video Laryngoscopy In Patients With Cervical Spine Immobilization  

For patients with limited cervical spine motion, VL facilitates airway visualization without requiring alignment of the oral, pharyngeal, and laryngeal axes. This is important for 2 reasons: (1) It may improve laryngoscopic view and intubation success in patients who cannot be placed in optimal intubation position, and (2) it may also decrease the forces applied to the spine, limiting the possibility of worsening any existing injury.  

Initial data regarding improved intubation performance and VL for patients with cervical spine immobilization come from adult studies performed in the operating room. A study of 200 adult patients with manual in-line cervical spine stabilization showed that anesthesiologists using the Pentax Airway Scope were less likely to have an obscured view (0% vs 11%), and they had a higher intubation success rate (100% vs 89%). A similar randomized controlled trial of 120 adults with cervical spine immobilization demonstrated that the use of VL devices (GlideScope® and Pentax Airway Scope) was associated with improved view and reduced optimization maneuvers when compared to direct laryngoscopy. Pediatric data on the topic come primarily from 2 previously mentioned studies using simulation with intentionally limited cervical spine movement. Fiadjoe et al were able to demonstrate improved visualization and fewer failed intubations when using the C-MAC® in an infant simulator. Pediatric residents using a GlideScope®, however, did not have higher intubation success rates than residents using direct laryngoscopy in a similar infant simulator.  

Beyond these airway management performance metrics, there are data to support the theoretical decrease in cervical spine motion during intubation using VL. Anesthesiologists using the Airtraq device on adult patients in the operating room had significantly less motion at 3 of 4 cervical segments being studied, with comparable times to intubation when compared to direct Macintosh laryngoscopy. Similarly, a randomized trial using video motion analysis demonstrated a reduction in cervical spine movement when patients with unsecured cervical spines were intubated using the GlideScope®. While this is encouraging, no study, to date, has attempted to measure whether this demonstrated reduction in movement translates into clinically meaningful outcomes, such as a reduction in neurological compromise.  

### Video Laryngoscopy In Neonates  

The position of the larynx changes as children grow older. In the neonatal period, laryngeal structures are the most superior, aligned near the second cervical vertebral body (C2). By adolescence, the larynx has dropped to near the C5-C6 level. This means that
the angle from the base of the tongue to the glottic opening will be the most acute in the youngest patients. Therefore, the wider field of view offered by VL devices may provide a particularly valuable advantage over direct laryngoscopy in neonates.

The largest published study on VL in the neonatal population is a descriptive case series of patients who were successfully intubated using VL. The patients ranged in weight from 530 g to 6795 g. The authors note that VL was used successfully in 5 patients for whom direct laryngoscopy had failed previously. In 6 cases performed by trainees, video assistance prevented the potential need for repeat attempts, and only 3 patients required repeated attempts. In addition, the authors noted the benefit of improved anatomic view as well as the ability to diagnose 1 patient with vocal cord paresis, which they felt would have likely been missed using direct laryngoscopy. A published case report on the use of a Miller 1 VL by an experienced anesthesiologist on a 3-week-old patient with facial abnormalities showed that the grade 3 view obtained by direct laryngoscopy improved to a grade 1 projected view on the screen and resulted in a successful intubation. Given limited data, it is difficult to draw definitive conclusions regarding the use of VL in the neonatal population; however, a number of devices are now available for use in this age group, and emerging experience regarding clinical performance may inform future neonatal practice.

**Video Laryngoscopy In The Prehospital Setting**

Intubation in the prehospital setting can be particularly challenging. Patients may require airway management in suboptimal positions (eg, on the ground), there are limitations to screening for difficult airways, and prehospital clinicians have less required training. The improved views and shorter training times for VL intubation may be particularly valuable in this setting.

A number of studies have provided support for the use of VL for adult patients by a wide array of emergency medicine clinicians. Using mannequins on a stretcher and on the floor, Aziz et al found that VL offered significantly improved glottic views over direct laryngoscopy, particularly in the floor scenario. However, intubation success rates were not different from the direct laryngoscopy group. A helicopter-based emergency medical service reported on the successful intubation of 87 patients using VL, and provided time-based performance metrics related to their experience (including time to best POGO score and tube placement time). Finally, a case series of 80 patients with known complicated airway conditions were all successfully intubated using a C-MAC® device in the prehospital setting, though in 5% of the cases, the device was used as a direct laryngoscope tool rather than as a VL.

Other prehospital studies have compared the use of various VL devices, showing advantages of the APA™ Advance over the GlideScope® in one study, and of the C-MAC® over the King Vision in another. Given the wide array of devices available, the heterogeneity of patient populations, and the varied procedural experience of prehospital clinicians, it is difficult to make a single recommendation regarding VL use in this setting. Furthermore, the patient numbers in this population remain small, relative to the large cohorts in adult emergency medicine. However, as the portability of devices improves, the costs are reduced, and larger prospective trials are performed, increased utilization of VL devices is likely to occur in the prehospital setting.

**Are There Benefits Of One Device Over Another?**

Although comparative trials have been completed, no single device has been shown to have a decided advantage over any other. A small simulation study using adult simulators from the anesthesia setting compared the GlideScope®, C-MAC®, and Airtraq® devices to the Macintosh laryngoscope, and the authors found only subtle differences between the scopes themselves in both difficult and easy airways. However, the Macintosh laryngoscope was consistently found to have the worst view in difficult airways. In adult patients with anticipated difficult airways, C-MAC® and GlideScope® performance was similar with respect to first-pass success and time to intubation, and both were superior to direct laryngoscopy with Macintosh. Mosier et al performed the largest ED-based trial to date that compared intubations using the GlideScope® to those using the C-MAC® in adults. Their results demonstrated first-pass success rates that were similar to prior adult ED literature (82% and 84%, respectively), and, after controlling for multiple confounding factors, there was no significant difference in first-pass success rates between devices.

Although measured outcomes across devices may be similar, it is important to note that nuances exist within the operation of each device that can lead to challenges when used de novo by a clinician. Therefore, the choice of device ultimately is based on availability and the preference and comfort of the clinician.

**Use Of Video Laryngoscopy In Pediatric Patients In The Emergency Department**

**Indications For Use**

VL devices can be utilized in any instance in which endotracheal intubation is required. However, it is critical that operators clearly understand the pro-
procedural nuances and develop familiarity with any device they plan to use in practice. VL can be used as a primary approach, particularly in the context of prehospital and ED care, where clinicians may have less-frequent airway experience and patient screening for intubation difficulty may be challenging. VL may also be useful as a rescue approach. This is based on studies from adult populations in the ED and published anesthesia guidelines, though data supporting this use in the pediatric emergency department are limited at this time.

Contraindications For Use
There are no absolute contraindications to the use of VL in pediatric patients requiring intubation as long as the emergency clinician has experience with the planned device and there is sufficient mouth opening for insertion. Caution should be used with some VL devices in patients with copious blood or secretions in the airway that may obscure the lens and limit visualization.

Video Laryngoscopic Device Review
Currently, 3 VL devices are available for use across the entire spectrum of pediatric ages, from neonates through adolescents.

Storz C-MAC® Video Laryngoscope
The Storz VL (Karl Storz; Tuttlingen, Germany) was initially introduced as a prototype that essentially involved the integration of a fiberoptic-based system into a Macintosh blade. It has evolved into its current form with a similarly shaped blade, but with an electronic module that utilizes semiconductor chip technology, which is less cumbersome than fiberoptic systems. This new technology has improved the C-MAC®’s cost, size, and portability. The C-MAC® is a relatively standard Macintosh or Miller blade attached to a rectangular handle. (See Figure 6.) The tip of the blade holds a video camera that connects to a 7-in LCD (liquid crystal display) monitor or a 2.4-in pocket monitor in the portable version. (See Figure 7, page 11.) The camera lens offers an 80° aperture, allowing for a wide angle of viewing at the tip of the blade, and projects a high-resolution color image onto the monitor. The blades are reusable and come in Miller sizes 0 and 1, Macintosh sizes 2, 3, and 4, as well as a D-Blade with increased curvature for use in adults.

The C-MAC® is unique among VL devices as it allows for use as a VL while simultaneously functioning as a direct laryngoscopic device. This feature situates it well as a tool for instructional teaching and coaching during real-time direct or indirect laryngoscopy. Furthermore, the C-MAC® can create static images or continuous video recording onto a removable secure digital card, allowing for video storage and review. The C-MAC® system utilizes reusable blades that require sterilization between each patient, although a recently released model has disposable blades (currently only available in adult sizes).

Technique
The blade of the C-MAC® laryngoscope is similar to traditional Miller and Macintosh blades. Therefore, the device can be used in the same manner as a direct laryngoscope or indirectly to take advantage of the integrated video system. When using the device as a direct laryngoscopy tool, the flange on the Macintosh blade can be used in a tongue-sweeping maneuver, though recent data suggest that a midline approach may be faster and less likely to result in adverse events. This can be helpful to allow maintenance of direct laryngoscopy skills, with the added advantage of video assistance by another clinician simultaneously watching the screen. This approach may also be favored if the camera lens is obscured by secretions, blood, or vomitus. Although the Miller blade tip is designed to lift the epiglottis directly, while the Macintosh is commonly placed in the vallecula, either blade type can be used with either tip position.

ETT insertion with the direct laryngoscopy approach would mirror clinician preference for direct laryngoscopy, in terms of use of a stylet and shape and degree of bend of the styleted tube. When using the projected video images on the screen primarily, a midline blade insertion technique can achieve an unobstructed glottic view, given the vantage point from beneath the base of the tongue. Tube delivery in this

Figure 6. C-MAC® Video Laryngoscope
A. The C-MAC® video laryngoscope comes with a standard variety of blade sizes including a Miller 1, Macintosh 2, Macintosh 3, and Macintosh 4.
B. The C-MAC® video laryngoscope is structurally similar to standard blades as shown here with a C-MAC® Macintosh size 3 blade (top) compared to a traditional Macintosh size 3 blade (bottom).
Photo used with permission from Israel Green-Hopkins, MD, and Joshua Nagler, MD.
Challenges

For emergency clinicians with experience with direct laryngoscopy, this video device will often seem the most familiar and the least likely to have unexpected challenges. Although the integrated camera allows a wider field of view, the shape of the C-MAC® blades may not provide the same glottic view as a device with increased blade curvature, particularly for superior (sometimes referred to as anterior) airways. As with any video device, obscuration of the camera lens can compromise the projected view. If the projected image is obscured, the blade can be removed and replaced (if a backup is available) or the lens can be cleaned. The final challenge with the C-MAC® is that some emergency clinicians find the larger handle to be challenging compared to the smaller direct laryngoscope handles used in infants, although the blade itself is small, with a height of only 5 mm. (See Figure 8.) Therefore, insertion and manipulation in the mouth should not be compromised.

GlideScope® Video Laryngoscope

The GlideScope® (Verathon Medical; Bothell, WA) has been used in clinical practice since 2003. It has a blade with a 60° curvature, which is substantially more angled than traditional Macintosh blades. (See Figure 9, page 12.) The device is designed to visualize around the anatomic curve of the upper airway, which allows for indirect visualization of the glottic opening without the need to displace the tongue. This is of particular use in airways that are more superior or in patients in whom alignment of the airway axes cannot be performed (eg, patients in cervical spine immobilization). GlideScope® models include the original GVL and newer AVL with advanced video technology that allows image recording, as well as a Ranger model designed for improved portability. The device comes in reusable...
and disposable forms. Figure 10 depicts a disposable form with a light source inserted into a separate molded blade. The GlideScope® line has a full complement of pediatric-sized blades, allowing for use across the entire spectrum of pediatric ages, from neonates through older adolescents. The camera lens is heated to prevent fogging, and it connects to a 3.5-in portable screen or a 7-in LCD screen, depending on the model. (See Figure 11.)

Figure 9. Hyperangulation Of The GlideScope®

The hyperangulated blade of the GlideScope® compared to a traditional Macintosh blade can be ideal for patients with anterior/superior airways.

Photo used with permission from Israel Green-Hopkins, MD, and Joshua Nagler, MD.

Figure 10. Disposable GlideScope® With Attached Light Source

The GlideScope® pictured with its 2-component system of a light source and plastic disposable blade

Photo used with permission from Israel Green-Hopkins, MD, and Joshua Nagler, MD.

Technique

The GlideScope® is inserted along the midline of the mouth, and no sweep of the tongue is required. Care should be taken to watch the blade directly as it enters the initial part of the mouth to ensure no trauma is caused to the lips or dentition. Once the blade is in the mouth, it is gradually moved in the midline along the base of the tongue into the vallecula. Unlike direct laryngoscopy, blade position is achieved by rotating the device around the natural curvature of the tongue and it does not involve direct lifting of the tongue or mandibular block. If poor glottic views are obtained, the view optimization maneuver with the GlideScope® involves rocking the handle toward the clinician performing the procedure, rather than employing the lifting motion used in direct laryngoscopy.

Challenges

Tube delivery can be the most challenging aspect of intubation using the GlideScope®, given the need to advance it around the curve of the airway and then down the initial length of the trachea. Stylets must be used to guide the tube tip up to the glottic aperture. In patients requiring ETTs ≥ size 6.0, the GlideRite® rigid stylet can be used to match the shape of the GlideScope® blade. However, no similar firm stylet currently exists for pediatric-sized tubes.

Figure 11. The GlideScope® And Projection To Its Accompanying Monitor

Photo used with permission from Israel Green-Hopkins, MD, and Joshua Nagler, MD.
Using the most rigid stylet available is recommended. The styled tube should be shaped to match the curvature of the device.

One common mistake is to place the blade tip too close to the glottic opening. Withdrawing the blade slightly and providing more of a “bird’s eye” view will allow more space to maneuver, and it will lessen the angle at which the tube must pass. Just as with blade insertion, the clinician should look directly at the patient when inserting the ETT into the mouth to avoid inadvertent palatal or posterior pharyngeal injury while looking at the screen during tube insertion. This is described as the 4-step technique: (1) Introduce the laryngoscope into the mouth under direct visualization; (2) obtain the best laryngeal view using the projected image; (3) introduce the ETT into the mouth under direct visualization; and (4) intubate using the projected images. Unlike direct laryngoscopy, where passing the ETT down the barrel of the blade can block the direct line of sight, the tube can be passed directly along the curve of the GlideScope® without blocking the clinician’s view. However, presenting the heavily curved ETT from the side may allow easier passage into the hypopharynx.

In other cases, the ETT may be successfully guided into the glottic opening, but cannot be passed smoothly down the length of the trachea. Shaping the ETT to match the scope and passing it along the length of the blade may be helpful.

Importantly, unlike the approach in direct laryngoscopy, attempting to lift the soft tissue is unlikely to be effective with the GlideScope®. If tube passage is difficult, pulling the stylet back 1 to 2 cm after the ETT tip has passed through the vocal cords can prevent the tube from advancing into the anterior wall of the trachea. Alternatively, reverse loading the ETT so its innate curvature is reversed 180° from the curve of the stylet can also be effective. (See Figure 12.) This configuration causes the ETT to project off the stylet in the opposite direction of the stylet curve, helping guide the ETT along the axis of the trachea after passing through the glottic opening. Familiarity with these nuances of the GlideScope® is critical prior to use in patients, and individual training sessions are recommended for emergency clinicians utilizing this device.

**Airtraq Optical Laryngoscope**
The Airtraq (Prodol Meditec, SA; Vizcaya, Spain) is an optical laryngoscope, and it is unique as a single-use, disposable device. The Airtraq is available in sizes from neonatal to adult. By definition, this optical laryngoscope is not a true VL; however, the Airtraq can be connected to a 7-cm external video monitor or a newly available 2.8-in camera hood that utilizes Wi-Fi to project images.
to nearby mobile devices. (See Figure 13.) The laryngoscope has 2 parallel channels: (1) The optical channel containing the prism components to allow indirect viewing, and (2) the guiding channel through which the ETT is advanced. (See Figure 14.) The Airtraq contains a heating system at the light source and the camera to prevent fogging. The device must be turned on for 1 minute for this feature to be fully effective.

**Technique**

Prior to intubation, the ETT should be lubricated with surgical lubricant to assist with delivery through the channel of the device. Similar to the GlideScope®, the Airtraq blade is inserted in the midline of the mouth. The flange on the tip of the blade allows the device to be used to directly lift the epiglottis or rest in the vallecula. The guiding channel allows the operator to advance the ETT once the glottic opening is visualized within the viewfinder or on the camera hood display. As the ETT is channeled, it is not recommended to use a stylet for ETT advancement. Once the ETT has been advanced, the cuff, if used, should be inflated while the device remains in the mouth. The tube is then held stationary while the device is pulled laterally to the left to disengage the ETT from the channel, and the device is removed.

**Challenges**

Identifying airway anatomy after the Airtraq has been inserted fully can sometimes be challenging. Therefore, looking through the viewfinder or at the displayed images as soon as the device has entered the oral cavity can be helpful in allowing progressive visualization of landmarks, and, ultimately, an appropriate device position.

The channel of this device is designed to facilitate tube passage around the curvature of the airway. Multiple sizes are available, and each specifies the range of the ETTs it is designed to accommodate. For example, the size 0 (infant) device will accommodate 2.5 to 3.5 tubes. This range of sizes can potentially avoid difficulty with advancement as described earlier with curved, nonchanneled devices such as the GlideScope®. However, there is, consequently, less ability to guide the tube direction independently of the device position. If the path of the advancing tube does not result in the tip entering the glottic aperture, adjustments must be made to the position of the device. Most commonly, the tube will dive below the arytenoids. While the tendency may be to rock the device backward to aim the tube higher, this is often unsuccessful and risks injury to the upper teeth and lip. Instead, lifting the entire device upward is often the needed adjustment.

**Video Laryngoscopes: Device Selection**

Three VLs are available for use across the entire spectrum of pediatric ages, though there are insufficient data to recommend one specific device over another for use in pediatric emergency care, or even in select clinical contexts. Although some studies have been performed, comparative trials are lacking, and the majority of pediatric data come from simulation-based studies. Decisions regarding device selection are based largely on available resources, personal preference and experience, and cost restrictions. However, attempting to master the nuances of the many available devices for use during a procedure that is performed relatively infrequently may be
problematic. Instead, it is recommended that emergency clinicians gain familiarity with 1 or 2 devices that would be available to be used either primarily or as a back-up approach. Table 1 presents a comparison of the 3 devices discussed.

**Other Nonpediatric Devices**

There are other laryngoscopes that can be used in older children, but they are not sized for the entire spectrum of pediatric ages. The Pentax-AWS is a channeled device like the Airtraq, with video rather than optical components that project to the 2.4-in LCD screen on the device handle. This device has cross-hairs incorporated into the video display to indicate the predicted trajectory of the ETT. There is only a single size adult blade, so use in pediatrics is limited.

King Vision is another curved single-component device with a reusable video display and disposable standard or channeled blades. It is very lightweight and portable, and it is substantially less expensive than other video-equipped devices. Currently, only adult-sized blades are available for this device.

The McGrath® Series 5 offers a very portable device with a handle-mounted 1.7-in display and an angulated blade. Three blade sizes are available, and the camera stick position can be adjusted to change the functional length of the blade, allowing this device to be used in children who are school-aged and older. The McGrath® MAC 2 series offers a design similar to the Series 5, though with a slightly larger screen at 2.4 in, and blades as small as size 2, allowing for use in younger children. The blade is

**Table 1. Comparison Of The Storz C-MAC®, GlideScope®, And Airtraq Laryngoscopes**

<table>
<thead>
<tr>
<th>Device</th>
<th>Specifics</th>
<th>Blade Types</th>
<th>Monitor Types</th>
<th>Benefits</th>
<th>Usage Tips</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storz C-MAC®</td>
<td>Allows video recording and use in a direct and indirect fashion</td>
<td>• Miller 0.1&lt;br&gt;• MAC 2,3,4&lt;br&gt;• Pediatric and adult difficult airway blades (Peds D, Adult D)</td>
<td>• 2.4-in pocket monitor&lt;br&gt;• 7-in LCD monitor</td>
<td>• Equipment and approach similar to direct laryngoscopy, improving familiarity&lt;br&gt;• Allows for direct laryngoscopy with supervision and guidance via shared video image</td>
<td>• Can use midline or right-sided blade insertion (and tongue sweeping) approach&lt;br&gt;• Procedurally similar to direct laryngoscopy&lt;br&gt;• D blades can only be used for indirect laryngoscopy</td>
<td>A significantly larger handle requires familiarity with grip and may crowd the oropharynx in neonates/infants</td>
</tr>
<tr>
<td>GlideScope®</td>
<td>True video laryngoscope with a hyper-angled blade that allows for visualization around the oropharynx curvature</td>
<td>• GVL&lt;br&gt;• AVL (allows recording, sizes: neonate through adolescent/adult for AVL single use; infants through adults for AVL reusable)&lt;br&gt;• Ranger (enhanced portability; GVL 3-4 sizes only)</td>
<td>• 3.5-in portable monitor&lt;br&gt;• 7-in LCD monitor</td>
<td>Hyperangulated blade (60°) facilitates glottic visualization, especially in patients with superior airways</td>
<td>• Midline approach only&lt;br&gt;• ETT must be hyperangled or use available product stylet (unavailable in pediatric sizes)&lt;br&gt;• Blade and ETT introduction should be under direct visualization, then continue movement using video projection</td>
<td>• ETT delivery can be challenging&lt;br&gt;• Requires specific training, as techniques are different from direct laryngoscopy</td>
</tr>
<tr>
<td>Airtraq</td>
<td>Channeled, optical laryngoscope with available pocket video screen</td>
<td>• Infant (0)&lt;br&gt;• Pediatric (1)&lt;br&gt;• Small (2)&lt;br&gt;• Regular (3)&lt;br&gt;Pediatric sizes – disposable only&lt;br&gt;Adult sizes – disposable blades, reusable optics</td>
<td>• Eye-piece attached to every device&lt;br&gt;• 2.8-in camera hood with touch screen</td>
<td>Wi-Fi-enabled camera allows streaming and download/recording capability&lt;br&gt;• Disposable offers potentially less expensive alternative&lt;br&gt;• ETT sizes are depicted on blades, which are color-coded to match the Broselow system</td>
<td>• ETT must be lubricated and preloaded into the channel&lt;br&gt;• Midline approach only&lt;br&gt;• Upward lifting action is used if the ETT is directed below the arytenoids</td>
<td>• ETT delivery can be challenging given the channeled construction&lt;br&gt;• Lubrication is essential, and training is necessary to troubleshoot difficulty with the direction of the ETT</td>
</tr>
</tbody>
</table>

Abbreviations: AVL, Advanced Video Laryngoscope; ETT, endotracheal tube; GVL, GlideScope® Video Laryngoscope; LCD, liquid crystal display.
constructed to be similar to a Macintosh blade and, therefore, this device can be used to perform direct laryngoscopy or VL, much the same as the C-MAC®. New versions of each device, as well as entirely new laryngoscopes, are increasingly becoming available.

### Universal Challenges

#### Device Insertion

Devices with significant curvature (such as the GlideScope® and the Airtraq) are designed to be rotated into place along the natural curvature of the mouth. This is often counterintuitive to emergency clinicians who have extensive experience with direct laryngoscopy where rotating or “rocking” the laryngoscope is discouraged, given the risk of injury to the lips, dentition, and gingiva. Entering the oral cavity of patients with limited mouth opening can also be difficult with larger devices. The Airtraq, for example, has a blade height of 12 mm, while the C-MAC® height is only 5 mm.

#### Endotracheal Tube Insertion

Perhaps the greatest challenge when using VL devices is tube delivery. Studies across a wide array of these devices have consistently shown improved laryngoscopic views. However, guiding the ETT into the projected laryngeal view can be difficult. During direct laryngoscopy, there is a straight line of sight to the glottic opening along which the ETT can be advanced. By definition, therefore, the ETT can also follow in a straight path without anatomic structures causing obstruction. In contrast, VL allows visualization around an anatomic curve, which means the ETT must also be advanced along a curvilinear path rather than directly. Spatially advancing a tube in a straight line under direct visualization may be considerably easier than advancing the tube along a curvature that is only indirectly viewed. This may be particularly challenging in pediatric patients in whom the larynx is more superior, and because smaller ETTs and stylets have less stiffness. Devices such as the Airtraq have attempted to address this difficulty by incorporating a channel for the ETT. However, the ability to make independent adjustments when the tube is not entering the visualized glottic opening requires specific comfort with this device.

Certainly, research supports the challenge of ETT insertion in VL. In a series comparing direct laryngoscopy to a C-MAC®, time to best glottic view was similar in both groups, yet time to tracheal intubation was longer for the VL group. One explanation for this is that the clinician performing the procedure no longer has a direct line of sight and, thus, must utilize the video screen to guide the ETT, supporting the presumption that this 2-dimensional indirect manipulation can be challenging.

#### Adjusting The View

Emergency clinicians performing intubation have often developed strategies for making adjustments to improve laryngoscopic view when using direct laryngoscopy. This may include repositioning the patient, increasing the force applied with the laryngoscope, sweeping the tongue, or applying external laryngeal manipulation. Although there is some overlap, many of the required adjustments when using VL differ from familiar techniques and may be specific to each device. Learning device-specific optimization maneuvers is key to the successful use of VLs.

#### Cautions And Complications With Video Laryngoscopes

As in direct laryngoscopy, intubation failures can occur during VL. Failure in VL can be secondary to anatomic factors specific to the patient or to lens obscuration. While reasons for failure may vary based on the clinical indication or patient characteristics, it is clear that emergency clinicians must always have a back-up airway device or procedure in the event of the failed airway. As the majority of VL devices are designed to be used for indirect visualization, any obstruction to the lens or camera (eg, blood, secretions, emesis) can lead to device failure.

There have been rare instances of worsened glottic exposure with VL use (C-MAC®), and so resorting to direct laryngoscopy may be useful in certain cases. Alternative rescue devices such as extraglottic devices (eg, a laryngeal-mask airway) or notification of additional expert personnel (where available) should be considered prior to attempting endotracheal intubation. Though pediatric data are limited,
data from adults in the operating room have also suggested that GlideScope® failure is most predicted by altered neck anatomy, radiation changes, or airway mass. Caution must be used in extrapolating these data to the pediatric setting, though emergency clinicians should be aware of the possibility of persistent difficulties with intubation despite using a VL device.

While VL devices promote indirect visualization of the glottic opening, their introduction into the mouth still requires care and caution with the delicate oral and pharyngeal tissues. The standard precautions of avoiding blade contact with the teeth should be maintained when using these devices. Pharyngeal wall injury has been reported during VL device insertion. Airway experts and device manufacturers appropriately advise operators to first look into the mouth when inserting the device, then continue with glottic visualization in an indirect manner, while again looking in the mouth to take care with ETT insertion.

Controversies

Slowed Adoption Of Video Laryngoscopy

There are a number of potential reasons why the assimilation of VL into pediatric airway management has been relatively slow. First, the current success rate with direct laryngoscopy is high. That is, although first-pass success may be suboptimal in some circumstances, data suggest that overall success for direct laryngoscopy is very high. In the operating room setting, this number is very near 100%, while in the ED setting, the primary proceduralist is ultimately successful 85% of the time, and overall success rate by any proceduralist is 99%. Therefore, there may be little clinical imperative to change practice with such a high success rate for current approaches. This is coupled with a relative paucity of data to show a definitive benefit in clinical care based on currently available pediatric studies on VL.

Second, VL devices are expensive when compared to direct laryngoscopy devices. Outfitting a pediatric airway system can pose a financial burden, given the need to purchase an entire selection of blade sizes to accommodate all ages and sizes of children. As an example, the cost of a C-MAC® device with a size 3 Macintosh blade is roughly equal to the cost of a complement of the additional pediatric VL blades (Miller 0, Miller 1, and Mac 2). Therefore, budgetary commitments to outfit pediatric needs will be twice that of the cost for similar equipment to be used in adults only. This is further compounded by the relative infrequency of pediatric intubations compared to adult intubations, making the cost per intubation much greater.

Finally, the time and commitment to learn and gain comfort with new technology and equipment can be daunting to established emergency clinicians.

This may be particularly true given the wide array of devices available, the subtle nuances in technique for each, and the relative infrequency with which these skills will be utilized.

Potential Future Directions For Video Laryngoscopy

Airway management with endotracheal intubation has been focused largely on obtaining an optimal view as a route to successful endotracheal intubation. Prior definitions of the difficult airway focused on traits that would lead to inadequate laryngeal view. VL devices have been shown to effectively improve visualization; however, new challenges have now emerged for emergency clinicians. As has been described earlier, substantial challenges when utilizing VL arise not from difficulty with visualization, but rather from difficulties related to ETT delivery and passage, which, in some cases, prolongs time to intubation. In addition, the approaches to difficulties with either visualization or ETT delivery are often significantly different from the familiar techniques utilized with direct laryngoscopy, and there are varying troubleshooting nuances among devices.

Further investigation of the granular characteristics of VL intubation may help determine additional factors that are associated with prolonged, traumatic, or unsuccessful intubations. Such analysis might be particularly helpful in pediatric emergency medicine where intubations are rare and data are lacking.

Education And Quality Assurance Opportunities

Given the rarity of pediatric intubation in the emergency setting and the data suggesting limited training opportunities in pediatric airway management for both trainees and practicing emergency clinicians, VL may fill a niche with regard to training clinicians. Some studies have demonstrated utility of these devices for coaching during simulated and live patient intubations.

Beyond real-time coaching and education, VL devices that allow for continuous recording may also serve as a quality assurance tool. This is a relatively new avenue in pediatric acute care and training, though previous research in ED settings has demonstrated significant value in video review of critical procedures. Academic centers and training programs might consider the development of airway training strategies that utilize VLs in this capacity.

Summary

Intubation is a rare, but critical, procedure in pediatric patients in the emergency medicine setting with risk of significant morbidity and mortality. Airway
management in children offers challenges for emergency clinicians. VL offers the ability to see around laryngeal structures, obviating the need for a direct line of sight, as is required with direct laryngoscopy. There is strong evidence to support improved laryngeal views with VL, although current pediatric data have not shown that this translates into improvements in time to intubation or intubation success rates. Nonetheless, there may be added benefit in using these devices, including a faster learning curve for less-experienced emergency clinicians than direct laryngoscopy, as well as a shared anatomic view to allow supervision and teaching around this high-stakes procedure.

Emergency clinicians caring for children should be aware of the various devices available for use in the pediatric population. The decision to use VL should be made based largely on availability and provider preference. However, clinicians should use only the devices on which they have been trained and feel competent, as nuances of technique exist for each. Over time, emerging experience and data will better inform the role of VL in pediatric emergency medicine.

Case Conclusions

The 8-year-old boy required inline stabilization during intubation for airway protection and due to his altered mental status. You were concerned that the inability to position his head and neck due to the potential for cervical spine injury could make direct laryngoscopy difficult, particularly for the less-experienced emer-

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### Risk Management Pitfalls In Video Laryngoscopy In Pediatric Patients
(Continued on page 19)

1. “Passing the ETT using a GlideScope® is no different than when using a direct laryngoscope.”
The increased curvature of the blade of the GlideScope® is designed to provide optimal viewing around the curve of the airway toward anterior/superior airways. Passing an ETT around this same curved path can be challenging, particularly in children, as there is no commercially available rigid stylet to guide the tube. To overcome this challenge, use the stiffest stylet available, and bend the tube to match the shape of the blade. To facilitate tube passage once the tip has passed the vocal cords, withdraw the stylet slightly to prevent the tube from advancing into the anterior tracheal wall and allow it to travel down the length of the tracheal lumen.

2. “VL devices are too large to be used in neonates. I would only use direct laryngoscopy in this age group.”
Although there are no large comparative trials on the use of VL in neonates, case reports and series have shown success in this age group. Becoming comfortable with the size of the blades and the technique for use in this population requires experience. However, many devices (including the C-MAC®, GlideScope®, and Airtraq) have blade sizes designed for use in children of all ages, including neonates. For emergency clinicians with training, these devices can offer the same advantages as in older pediatric patients and adult patients. Emergency clinicians who are comfortable with airway management in this age group and with VL may safely use VL in neonates.

3. “The VL screen went blank as I was preparing to intubate.”
Although VL offers technical advantages, like any equipment, there is a risk of malfunction. All electronic connections from the blade to the screen, as well as the power source, should be checked to ensure proper function. It is also important to have a back-up intubation plan in place.

4. “I am most familiar with adult-sized blades, so I will plan to use them when I intubate children.”
Each of the VL devices reviewed here has a range of different-sized blades to be used based on the age and size of the child. Just as with direct laryngoscopy, choosing appropriately sized equipment is key to success with this procedure. Use of incorrectly sized equipment may compromise procedural success and can be potentially harmful to the patient.

5. “Our ED is looking to purchase every available VL device for use in pediatrics so that we have a device for every circumstance.”
Although each VL device may have some advantage in different clinical circumstances, gaining and maintaining proficiency in many devices can be challenging, particularly if they are not used frequently. For emergency clinicians committed to being prepared to use each, it is important to have sufficient training and frequent practice opportunities. If these opportunities do not arise in the ED, then maintenance of skills using either simulation or dedicated time in an operating room or other controlled setting can be valuable.
emergency medicine fellow. You took the opportunity to demonstrate GlideScope® use to the trainee. While in-line stabilization was maintained, the GlideScope® was introduced into the mouth in the midline, and the hyper-angulated blade was easily guided around the curve of the tongue, providing a complete glottic view. You bent an ETT with a stylet to match the curve of the blade and passed it through the glottis. You pulled the stylet back 2 cm and passed the tube into the trachea. The position was confirmed by end-tidal CO₂ and chest x-ray.

The first attempt at intubation of the 5-year-old patient with seizure disorder was performed by a resident using the C-MAC® VL with a Macintosh 2 blade. After the patient was appropriately placed in sniffing position, the resident used the scope to look directly at the patient while you viewed the projected image on video guid-

ance. Although the resident reported a grade 1 view, you immediately recognized on the video that he was passing the tube into the esophagus. You identified the correct anatomy on the screen for the resident, and the resident adjusted his approach to guide the tube into the glottic opening above. The use of the VL allowed you to coach the trainee through the procedure and ensure success.

The 2-year-old girl had an anticipated difficult airway due to her congenital malformations. You considered the variety of devices you had available and felt that you had the most familiarity with the Airtraq. A back-up plan was articulated, and additional personnel were made available, if needed. You intubated the patient with the Airtraq and achieved a grade 2 view with easy passage of the lubricated ETT that was steadily advanced through the channel of the device into the visualized glottic opening.

The patient was in a motor vehicle crash and arrived in cervical spine immobilization with a hard collar. Is it safe to use a VL in this patient?” VL can be used safely in trauma patients and may offer the additional advantage of providing an improved glottic view without the need to move the head and neck. It should be noted, however, that, in some cases blood, secretions, or vomit may obscure the camera lens.

“I had trouble sweeping the tongue to the left when using the GlideScope®.” The GlideScope® is designed for indirect laryngoscopy only, and, therefore, there is no need to sweep the tongue. Unlike direct laryngoscope blades, the GlideScope® blade does not have a flange to control the tongue. Instead, it is recommended that the device should be inserted in the midline until the glottic structures are visualized.

“I have an Airtraq available in my difficult airway cart. I have never tried it before, but I will use it as my rescue device with my next crash intubation.” Although some use video and optical devices as back-up or rescue devices, emergency clinicians should only use equipment on which they have been trained and feel comfortable. There are nuances to the technique for each device, and the opportunity to learn these is not during a difficult or crash airway. Becoming familiar with the devices that are available in a given clinical environment and the circumstances in which it might be used is paramount for anyone who might be emergently managing a child’s airway.

“The patient has bronchiolitis and copious oral secretions. Is that a contraindication to using VL?” Secretions, vomitus, or blood can cover the camera lens and compromise visualization. Although this is not an absolute contraindication to the use of VL, preparations such as suction, gauze to wipe the camera, and back-up blades may be helpful. In addition, availability of a device that allows for direct visualization (either a C-MAC® or a traditional laryngoscope) may help obviate the risk of reliance on an indirect (camera) view.

“I did not use VL because of the risk of lip or dental trauma.” There is a tendency to look at the image in the viewfinder or on the projected screen when using VL, which can result in advertent lip or dental injury when the VL is being introduced or adjusted in the oral cavity. To mitigate this risk, emergency clinicians should proceed in the following order: (1) Look in the mouth as the VL blade is inserted past the dentition; (2) then look at the screen to guide movement of the blade tip; (3) then, again directly visualize the ETT as it enters the mouth; and (4) return to the VL screen view to guide final indirect positioning of the tube.
References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study will be included in bold type following the references cited in this paper, as determined by the author, will be noted by an asterisk (*) next to the number of the reference.


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**CME Questions**

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1. The tongue and tonsils are relatively small in children, leading to an easier direct line of sight during traditional laryngoscopy.
   a. True
   b. False

2. During direct laryngoscopy, alignment of which of the following axes is required to obtain an adequate view?
   a. Oral, cervical, and laryngeal
   b. Cranial, cervical, and pharyngeal
   c. Oral, pharyngeal, and laryngeal
   d. Oral, laryngeal, and tracheal

3. Available data from adult emergency medicine literature has demonstrated which of the following with respect to VL relative to direct laryngoscopy?
   a. The ability to obtain an improved view
   b. Higher rates of first-pass success
   c. Similar or decreased frequency of complications
   d. A and B
   e. A, B, and C
4. Available data from pediatric anesthesia literature have demonstrated which of the following with respect to VL relative to direct laryngoscopy?
   a. The ability to obtain an improved view
   b. Higher rates of first-pass success
   c. Similar or decreased frequency of complications
   d. A and B
   e. A, B, and C

5. As seen in much of the literature, the prolonged time to intubation during VL relative to direct laryngoscopy seen may be secondary to:
   a. The inability to obtain a satisfactory view
   b. Difficulty with indirect tube passage
   c. The extra force required for VL
   d. Focusing on the screen too long when passing the tube

6. Patients with cervical spine immobilization may benefit from VL intubation because:
   a. The operator may obtain a better view
   b. The operator is less likely to cause movement of the cervical spine
   c. The operator may require fewer optimization maneuvers
   d. A and B only
   e. All of the above

7. Absolute contraindications to the use of VL in pediatric patients include:
   a. Blood or secretions in the airway
   b. Facial trauma
   c. Cervical spine immobilization
   d. Neonates
   e. None of the above

8. The C-MAC® VL is unique because:
   a. It is structurally similar to conventional blades, both MAC and Miller.
   b. It has a similar handle to conventional blades.
   c. It is reusable.
   d. None of the above

9. VL devices used in an indirect laryngoscopy fashion should be inserted via the
   a. Midline
   b. Right side
   c. Left side
   d. Either side

10. To date, there have been no instances in the literature of laryngoscopic view obtained by VL that is worse than that obtained with direct laryngoscopy.
    a. True
    b. False

Coming Soon In Pediatric Emergency Medicine Practice

Acute Management Of Inhaled Foreign Bodies In Pediatric Patients

While much is known about the management of inhaled foreign bodies, it remains a significant risk to young children, affecting thousands every year. There is a substantial amount of literature on the topic in otolaryngology and surgery; however, there is limited emergency medicine literature addressing inhaled foreign bodies. This review discusses the etiology, pathophysiology, diagnosis, and management of inhaled foreign bodies. For the purposes of this review, inhaled foreign bodies will refer to foreign bodies (both organic and inorganic) located in the posterior nasopharynx, larynx, trachea, and bronchi. The focus will be on risk factors and clinical clues to the diagnosis, as well as emergent management of inhaled foreign bodies.

Use Of Diagnostic Ultrasound In The Emergency Department To Assess Conditions In Pediatric Patients

Performing a diagnostic ultrasound at the point of care in the emergency department can answer focused clinical questions in a rapid manner. Over the last 20 years, the use of ultrasound in the emergency department has become a core requirement in emergency medicine residencies and some pediatric emergency medicine fellowships. In the pediatric setting, the growth has been slower, but there is increasing demand for these studies, given the absence of ionizing radiation with ultrasound. This review focuses on the current evidence for the most common indications for diagnostic ultrasound. Evidence in the pediatric setting is presented, or extrapolated from adult literature where pediatric evidence is scarce. The limitations of diagnostic ultrasound in the emergency department as well as current trends, controversies, and future directions are discussed.
SPECIAL ANNOUNCEMENT

The New Pediatric Emergency Medicine Practice Mobile App—Available August 1, 2015!

Mobile-optimized content from Pediatric Emergency Medicine Practice, powered by AgileMD, will enable you to instantly search our entire publication library—so you have access to hundreds of topics on your mobile device at the point of care.

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