Improved Glottic Exposure With the Video Macintosh Laryngoscope in Adult Emergency Department Tracheal Intubations

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On behalf of participating National Emergency Airway Registry (NEAR) Investigators

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Study objective: Glottic visualization with video is superior to direct laryngoscopy in controlled operating room studies. However, glottic exposure with video laryngoscopy has not been evaluated in the emergency department (ED) setting, where blood, secretions, poor patient positioning, and physiologic derangement can complicate laryngoscopy. We measure the difference in glottic visualization with video versus direct laryngoscopy.

Methods: We prospectively studied a convenience sample of tracheal intubations at 2 academic EDs. We performed laryngoscopy with the Karl Storz Video Macintosh Laryngoscope, which can be used for conventional direct laryngoscopy, as well as video laryngoscopy. We rated glottic visualization with the Cormack-Lehane (C-L) Scale, defining “good” visualization as C-L I or II and “poor” visualization as C-L III or IV. We compared glottic exposure between direct and video laryngoscopy, determining the proportion of poor direct visualizations improved to good visualization with video laryngoscopy. We also determined the proportion of good direct visualizations worsened to poor visualization by video laryngoscopy.

Results: We report data on 198 patients, including 146 (74%) medical, 51 (26%) trauma, and 1 (0.51%) unknown indications. All were tracheally intubated by emergency physicians. Postgraduate year 3 or 4 residents performed 102 (52.3%) of the laryngoscopies, postgraduate year 2 residents performed 60 (30.8%), interns performed 20 (10.3%), attending physicians performed 9 (4.6%), and operator experience and specialty were not reported in 4. Overall, good visualization (C-L grade I or II) was attained in 158 direct (80%) versus 185 video laryngoscopies (93%; McNemar’s P<.0001). Of the 40 patients with poor glottic exposure on direct laryngoscopy, video laryngoscopy improved the view in 31 (78%; 95% confidence interval 62% to 89%). Of the 158 patients with good glottic view on direct laryngoscopy, video laryngoscopy worsened the view in 4 (3%; 95% confidence interval 0.7% to 6%).

Conclusion: Video laryngoscopy affords more grade I and II views than direct laryngoscopy and improves glottic exposure in most patients with poor direct glottic visualization. In a small proportion of cases, glottic exposure is worse with video than direct laryngoscopy. [Ann Emerg Med. 2010;56:83-88.]

Please see page 84 for the Editor’s Capsule Summary of this article.

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INTRODUCTION

Background

Visualization of the glottis by direct laryngoscopy requires direct line of sight by alignment of anatomic axes that naturally exist at extreme angles. Video laryngoscopes allow the intubator to see the glottis without such alignment by effectively placing the operator’s eye near the tip of the blade and have provided superior exposure compared with direct laryngoscopes in operating room studies.1,3

Importance

Difficult direct laryngoscopy occurs in 4% to 26% of emergency department (ED) tracheal intubations.4,5 By improving glottic view, video laryngoscopy may improve the probability of successful tracheal intubation in these difficult cases. However, no previous studies have evaluated glottic exposure with video laryngoscopy in the ED, where suboptimal positioning, physiologic compromise, airway secretions, bleeding, and the need for immediate airway intervention more often complicate tracheal
intubation and may obscure the potential benefits of video laryngoscopy.

**Goals of This Investigation**

We sought to determine whether video laryngoscopy improved glottic exposure compared with direct laryngoscopy during ED tracheal intubations.

**MATERIALS AND METHODS**

**Study Design**

In this prospective observational study, we compared glottic exposure with direct laryngoscopy versus video laryngoscopy with the Video Macintosh Laryngoscope System (Karl Storz GmbH and Co. KG, Tuttlingen, Germany). This device has the same shape as a standard Macintosh laryngoscope and therefore can be used for conventional direct laryngoscopy (Figure 1). Image acquisition occurs by an illuminated fiber-optic bundle originating near the distal tip of the blade. This is connected to a charge coupled device video camera, contained in the handle, which relays images to a display screen through a video processor.

**Setting**

The study was performed at 2 urban academic EDs, both Level I trauma and tertiary referral centers with a combined yearly census of 120,000 patient visits. The institutional review boards of both sites approved the study. Emergency medicine attending physicians supervised or performed all laryngoscopies after training in the use of the video laryngoscope with a 30-minute presentation, followed by a 90-minute simulator-based skills session, during which each participant was required to assemble the device, perform laryngoscopy, and intubate with the video screen.

**Selection of Participants**

We enrolled a convenience sample of patients aged 15 years or older and undergoing emergency tracheal intubation from July 2006 to January 2009. Video laryngoscopy was used at the discretion of the emergency medicine attending physician.

**Methods of Measurement**

We assessed glottic exposure by direct laryngoscopy with the blade of the video laryngoscope, with the video screen initially turned away from the operator’s field of view. The intubator obtained his or her best direct view and then, with as little blade movement as possible, assessed glottic exposure as seen on the video screen. The intubator described the glottic view by using

**Editor’s Capsule Summary**

*What is already known on this topic*

Video laryngoscopy is a new, untested technique for emergency department (ED) tracheal intubation.

*What question this study addressed*

Does video laryngoscopy improve glottic view over direct laryngoscopy in ED tracheal intubation?

*What this study adds to our knowledge*

Of 40 patients with poor direct glottic exposure, video laryngoscopy improved the view in 31. Of 158 patients with good direct glottic exposure, video laryngoscopy worsened the view in 4.

*How this might change clinical practice*

In select patients, video laryngoscopy may improve visualization beyond that achieved with direct laryngoscopy. Users should be aware that it occasionally worsens visualization.
the Cormack-Lehane (C-L) grading system (Figure 2). A newer classification system, the Percentage of Glottic Opening scale, exists and has shown better interrater reliability than the C-L grading system. However, we chose C-L over the Percentage of Glottic Opening scale because of its wide recognition and ability to distinguish between very poor laryngoscopic views (C-L grade III and IV airways) in which no portion of the glottic aperture is seen.6-8

Data Collection and Processing

Immediately after the tracheal intubation, operators recorded all visualization data into a secure Web-based form. The intubator also recorded information on patient demographics, indications, medications used, difficult airway attributes, adverse events, and disposition.

Outcome Measures

Our main outcomes were glottic exposure with direct and video laryngoscopy. For analytic purposes, we dichotomized glottic visualizations to “good” (C-L grade I or II) and “poor” (C-L grade III or IV). The distinction is important because previous studies have shown that grade I and II views predict tracheal intubation success.9,10

Primary Data Analysis

We determined the overall proportion of good visualizations for direct and video laryngoscopy, reporting 95% confidence intervals (CIs) for each and using McNemar’s test to assess statistical significance of the difference.11

RESULTS

Characteristics of Study Subjects

During the study period, we enrolled 198 patients. A medical indication was noted for 146 (74%) patients, a traumatic indication for 51 (26%), and no indication for 1 (0.51%). The median age was 52 years (interquartile ratio 40 to 67), and 118 (60%) were men.

Only one method (one combination of medications plus a device) was required in 187 (94%) patients, 2 in 4 (2%) patients, 3 in 5 (3%) patients, 4 in 1 (0.5%) patient, and 5 in 1 (0.5%) patient. The most common initial method chosen was orotracheal intubation with rapid sequence tracheal intubation (191; 96%). A surgical airway (cricothyrotomy) was performed in 1 case (0.5%). Emergency medicine senior residents (191; 96%) performed 102 (52.3%) of the intubations, and intern, 20 (10.3%). Emergency medicine attending physicians performed 9 tracheal intubations (4.6%). Operator experience and specialty were not reported in 4 cases.

Overall, glottic visualization was superior for video laryngoscopy compared with direct laryngoscopy (Table). A grade I or II view was attained in 158 direct laryngoscopies (80%; 95% CI 74% to 85%) versus 185 video laryngoscopies (93%; 95% CI 89% to 96%); McNemar’s P<.0001. Figure 3 divides the cases into good and poor direct views and shows the corresponding video views for these patients. Most (78%) patients with poor glottic exposure on direct laryngoscopy had good exposure on video laryngoscopy. Conversely, few (3%) patients who had good glottic exposure on direct laryngoscopy had poor exposure on video laryngoscopy.

Tracheal intubation was achieved with the study device in all but 6 cases (3%). Two cases had initial grade I video views; however, the telepak display malfunctioned and the image became “still” before tube passage. As a result, both patients required tracheal intubation under direct vision, one with a grade II and the other with a grade III direct view. In one encounter, the operator could not pass the endotracheal tube through the patient’s vocal cords despite a grade I video view, and the patient was subsequently intubated directly with a grade II view. One trauma patient had facial trauma and a fixed neck deformity resulting in grade IV video and direct views and required cricothyrotomy. In the last 2 cases, both ultimately were tracheally intubated with a direct laryngoscope, one had similar direct and video views (grade III for both), and one had a grade III direct yet a grade IV video view. No additional details were recorded.

LIMITATIONS

These results have some important limitations. First, we collected data at 2 academic EDs with interest in airway research. Therefore, our findings may not be applicable to all practice settings. On the other hand, that many of our intubators were trainees means that our study may be more applicable than a study relying on anesthesiologists or senior airway researchers.

Second, we did not verify the direct laryngoscopic view recorded by the intubator, and this could be considered a weakness. However, verification would be difficult in the emergency setting because the observer would have to displace the intubator temporarily, potentially making the “overread” view different from the “original” view.

Our rate of C-L grade III and IV direct laryngoscopies is high compared with that of previous operating room reports,12,13 which may reflect the unselected nature of emergency tracheal intubations and the frequent presence of blood, secretions, distorted anatomy, and cervical spine immobilization in ED versus operating room patients. In addition, the video laryngoscope may have been selected for

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predicted difficult tracheal intubations because of the perception that video technology would be helpful in such cases. Additionally, more than 40% of all tracheal intubations were performed by postgraduate year 1 and 2 residents. Underdeveloped direct laryngoscopy skills may have contributed to the lower number of direct grade I and II views. Finally, if direct laryngoscopy was difficult, and an initial poor view was obtained, the operator may have prematurely abandoned attempts at direct visualization in favor of the video screen. In other words, intubators might have obtained better direct laryngoscopic views if they did not have easy recourse to video laryngoscopy, and this would have biased our study toward poorer direct views.

Another important limitation is that our main outcome measure was a process, rather than an outcome. Although improved glottic view is clearly desirable and can predict tracheal intubation success, it does not guarantee it. Our study compares laryngoscopic views using direct versus video laryngoscopy in ED patients. We found that overall glottic visualization was better with video laryngoscopy than direct laryngoscopy, and in the subset of patients with poor direct views, video laryngoscopy afforded a grade I or II view in nearly 80% of cases.

Video laryngoscopes improve glottic exposure by establishing a viewing point well along the laryngoscope blade, achieving a much better line of sight than can be achieved by the operator’s naked eye. Aside from cost, barriers to the widespread adoption of video laryngoscopy include that emergency physicians are very familiar with direct laryngoscopy and that it is ultimately successful in most cases. Therefore, many practitioners reserve video laryngoscopy for difficult or failed airways and do not consider it an instrument for “routine” use. In our study, although no benefit was observed in 80% of tracheal intubations, use of the video laryngoscope offered substantial benefit in the remaining patients, specifically the potential for immediate rescue in the 20% in whom no portion of the laryngeal inlet was seen. The high visualization rate supports the widespread use of this technique and suggests that video laryngoscopy should have a prominent role in both primary and rescue tracheal intubation efforts in ED patients.

In addition, our laryngoscopists were relatively novice airway managers. Although this may have contributed to our high rate of grade III and IV direct views (see “Limitations”), it suggests that the effort and skill required to obtain an adequate direct view likely are greater than that required for an adequate video view, a fact critically important for operators who do not manage difficult airways frequently. These results also suggest that good views may be obtained more gently and with fewer attempts, reducing airway trauma and improving overall patient safety.

Our findings are consistent with those of an operating room study that reported the rate of difficult laryngoscopy (defined as C-L grade III or IV) and tracheal intubation with approximately 0.5% of medical and 2.5% of trauma tracheal intubations. Our study compares laryngoscopic views using direct versus video laryngoscopy in ED patients. We found that overall glottic visualization was better with video laryngoscopy than direct laryngoscopy, and in the subset of patients with poor direct views, video laryngoscopy afforded a grade I or II view in nearly 80% of cases.

DISCUSSION

A principal factor contributing to difficult and failed tracheal intubation is inability to view the glottic aperture. A closed-claims analysis of poor patient outcomes from respiratory complications during anesthesia revealed that one third of cases were due to difficult laryngoscopy and esophageal intubation, and previous ED studies have shown that failed airways occur in
the Karl Storz Macintosh video laryngoscope compared with direct laryngoscopy. Kaplan et al evaluated 865 patients undergoing general anesthesia with both direct and video laryngoscopy, using the Macintosh video laryngoscope. There were significantly fewer difficult laryngoscopies with video versus direct laryngoscopy (28 versus 128, respectively).

Video laryngoscopy has important educational and quality control implications as well. With video laryngoscopy, supervising physicians and trainees can watch the tracheal intubation unfold throughout the laryngoscopic attempt, allowing real-time guidance and visual confirmation of tube placement. Additionally, many video laryngoscopes can record clips, allowing each institution to create a tracheal intubation library that can support both quality review and further research.

Although the Macintosh video laryngoscope has many desirable qualities, its benefits may only be appreciated in a subset of emergency patients. Most patients are easily intubated with a conventional direct laryngoscope, and when a grade I view is obtained by direct laryngoscopy, it cannot be improved by switching to video laryngoscopy. In addition, we found a small fraction of patients for whom the video view was inferior to the direct view. In 2 of these, fogging and blood obscured the video image, and in 2, no additional details were available. Therefore, in some cases copious secretions and active bleeding might compromise image clarity to the point that direct laryngoscopy would be better than video laryngoscopy, which requires further investigation. Additionally, the video laryngoscope used in our study requires setup time, connecting of 2 cables, steps to reduce fogging, and, in some cases, focusing, which can limit its application in crash airway scenarios, when the need for tracheal intubation is immediate. The next generation of video laryngoscopes (ie, Storz C-MAC) has single-cable configurations for rapid setup and heated lenses that resist fogging. As with any new technology, successful implementation of video laryngoscopy into clinical practice requires a support system to ensure smooth implementation, including plans for secure storage, cleaning, and training. Finally, this technology is expensive compared with direct laryngoscopy and may be unobtainable for small departments with tight operating margins and limited funds.

Video laryngoscopy affords more grade I and II views than direct laryngoscopy and improves glottic exposure in most patients with poor direct laryngoscopic visualization. In a small proportion of cases, glottic exposure is worse with video than direct laryngoscopy.

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Author contributions: CAB served as principal investigator and developed the study concept. CAB and AEB maintained data integrity and site compliance. CAB, DJP, and RMW wrote the article. All authors edited the article. AEB served as primary site investigator at our second center and contributed to study design and article development. DJP performed all database retrievals and performed all statistical analyses. EGL acted as coinvestigator at our second center and contributed to study implementation. RMW created the overall database design and application, as well as the Web-based data entry form, and advised on statistical analyses and reporting of results. CAB takes responsibility for the paper as a whole.

Funding and support: By Annals policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article that might create any potential conflict of interest. See the Manuscript Submission Agreement in this issue for examples of specific conflicts covered by this statement. This study was supported by a research grant from Karl Storz Endoscopy of America (KSEA) for execution of the trial. At each site, KSEA provided 2 video Macintosh laryngoscope blades (sizes 3 and 4), a DCI II video cartridge with cables, and a telepak video display unit.


Reprints not available from the authors.

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REFERENCES


Hospice and Palliative Medicine
The American Board of Internal Medicine (ABIM) will administer the certifying examination in Hospice and Palliative Medicine on November 16, 2010. ABEM diplomates may apply through one of three pathways – ACGME-accredited fellowship training in Hospice and Palliative Medicine, practice, or current certification by the American Board of Hospice and Palliative Medicine, by submitting their applications to ABEM between January 15 and April 30, 2010.

Medical Toxicology
ABEM will administer the certifying examination in Medical Toxicology on November 1, 2010. ABEM diplomates and diplomates of ABMS boards other than the American Board of Pediatrics (ABP) and the American Board of Preventive Medicine (ABPM) may apply to ABEM if they have completed an ACGME-accredited two-year fellowship program in Medical Toxicology. ABEM will accept applications between January 15 and April 15, 2010. Diplomates of ABP or ABPM must submit their applications through ABP and ABPM, respectively.

Sports Medicine
The American Board of Family Medicine (ABFM) will administer the certifying examination in Sports Medicine July 12 – 15, 17, and 19 – 24, 2010. ABFM will also administer the examination to specifically designated candidates December 1 through 4, 2010. Contact ABEM for additional information on the December examination. ABEM diplomates who have completed ACGME accredited fellowship training in Sports Medicine must submit their Sports Medicine applications to ABEM between February 1 and June 1, 2010, if they wish to take the July examination.

Undersea and Hyperbaric Medicine
The American Board of Preventive Medicine (ABPM) will administer the certifying examination in Undersea and Hyperbaric Medicine October 4 through 15, 2010. ABEM diplomates may apply through one of three pathways – ACGME-accredited fellowship training in Undersea and Hyperbaric Medicine, unaccredited fellowship training, and practice-plus-training, by submitting their applications to ABEM between March 1 and June 30, 2010. Application through unaccredited fellowship training and the practice-plus-training pathways will be discontinued as of June 30, 2010.

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