Is Video Laryngoscope-Assisted Flexible Tracheoscope Intubation Feasible for Patients with Predicted Difficult Airway? A Prospective, Randomized Clinical Trial

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BACKGROUND: Failed intubation may result in both increased morbidity and mortality. The combination of a video laryngoscope and a flexible tracheoscope used as a flexible video stylet may improve the success rate of securing a difficult airway. We tested the hypothesis that this combination is a feasible way to facilitate intubation in patients with a predicted difficult airway in that it will shorten intubation times and reduce the number of intubation attempts.

METHODS: We conducted a randomized, prospective trial in 140 patients with anticipated difficult airways undergoing elective or urgent surgery. After insertion of video laryngoscope, patients were randomly assigned to either having their tube placed with the use of a preformed stilet (control group) or with a flexible tracheoscope (intervention group). The primary outcome measures were time to successful intubation and number of intubation attempts.

RESULTS: The number of intubations requiring 2 or more intubation attempts was similar in the 2 groups (14% control vs 13% intervention, P = 1.0); the number of patients requiring 3 or more intubation attempts was not significantly different (8.6% control vs 1.4% intervention, P = 0.12). Distribution for time to intubation also did not differ between the control (median of 66 seconds, interquartile range 47–89) and the intervention group (median of 71 seconds, interquartile range 52–100; P = 0.35). In the control group, 4 patients, all with cervical spine pathology, had the trachea intubated successfully with the video laryngoscope plus flexible tracheoscope after 3 failed attempts with video laryngoscope and rigid stylet. For these 4 patients, time from the decision to change the intubation method to successful intubation with a flexible tracheoscope was 36 ± 14 seconds. Overall success probability for cervical spine patients was 100% (20/20) in the intervention group and 80% (16/20) in the control group, with an exact 95% confidence interval for the difference of 1.4% to 44%, P = 0.04.

CONCLUSIONS: Flexible tracheoscope-assisted video laryngoscopic intubation is a feasible alternative to video laryngoscope only intubation in patients with predicted difficult airways. A flexible tracheoscope used in combination with video laryngoscope may also further increase the success rate of intubation in select patients with a proven difficult airway, particularly when in-line stabilization is required. (Anesth Analg 2014;118:1259–65)

Both predicted and unanticipated difficult airways may pose a challenge to tracheal intubation via direct laryngoscopy. Failed tracheal intubation may harm the patient and may result in both increased morbidity and mortality.1,2 The use of flexible fiberoptic bronchoscopes (FOB) to facilitate difficult intubation is recommended for management of a difficult airway.3,4 In the last decade, video-assisted tracheal intubation tools such as video laryngoscopes (VLS) have been developed. A VLS is a plastic or metal laryngoscope that incorporates a light-sensitive chip on the distal aspect of the blade. In many studies, VLS assures improved laryngeal visualization compared with a regular laryngoscope; however, it does not guarantee endotracheal tube placement.5,6 To facilitate tracheal intubation, rigid or malleable stylets can be used along with a VLS, but their form cannot be changed during the intubation procedure.7,8 Occasionally, intubation will fail even with a VLS despite the use of rigid or malleable stylets, because stylets cannot be actively positioned during the intubation process.7 Thus, the operator may visualize the glottis but may be unable to pass the tube through the vocal cords.9

A possible way to increase the success rate of intubation is the use of a flexible tracheoscope that allows active positioning, similar to a stylet that can be maneuvered during the intubation process. One of these tracheoscopes has been designed as a flexible, disposable plastic scope that incorporates a high-resolution video camera with a light emitting diode (LED) light at its flexible tip and has an attached
Video Laryngoscope-Assisted Tracheoscope

monitor (aScope®, Ambu Inc., Glen Burnie, MD); this scope is less expensive and less time-consuming to set up compared with a FOB. However, the use of flexible tracheoscopes or FOB for the purpose of tracheal intubation may be difficult without an adjunct device to assure an airspace proximal to the laryngeal opening. Some authors have suggested that a VLS would be an ideal tool for this purpose.

Consequently, the combination of the VLS and a flexible tracheoscope used as a flexible video stylet may further improve the success rate in difficult intubation scenarios. Various case reports have described this method.\(^{11-13}\) In addition, a recent report demonstrated successful intubation using a VLS along with a rigid, optical stylet (Bonfils).\(^ {14}\) The technique of combining a VLS with a flexible bronchoscope was also reported for difficult airways in patients with laryngeal pathology.\(^ {15}\)

However, no systematic comparison has been made between video laryngoscopy with rigid stylet versus video laryngoscopy with flexible tracheoscope using successful tracheal intubation as the main outcome. We therefore tested the hypothesis that a combination of a video laryngoscope with a flexible tracheoscope used as a maneuverable stylet is a preferred procedure to facilitate intubation in patients with a predicted difficult airway in that it will shorten duration of intubation and reduce the number of intubation attempts. The aim of the study was to determine whether the technique of combining a VLS with a flexible tracheoscope increases the rate of successful tracheal intubation.

**METHODS**

We conducted a prospective, randomized trial in patients with anticipated difficult airways. The study was registered at ClinicalTrials.gov (NCT01215695) and was conducted under Good Clinical Practice Guidelines. The Human Studies Committee at the University of Louisville and the University of Louisville Hospital Research Integrity Office approved this study. All subjects or their legal representatives signed a written informed consent. The study was designed as a parallel 2-arm, randomized-controlled trial comparing VLS with rigid stylet (control) versus VLS with flexible tracheoscope (treatment) for tracheal intubation.

We enrolled 140 patients scheduled for elective or urgent surgery under general anesthesia with endotracheal intubation. Patients were aged 18 to 81 years with ASA physical status I to III. Inclusion and exclusion criteria are given below.

**PROTOCOL**

Preoperatively, 1 anesthesiologist who was not involved in either laryngoscopy or tracheal intubation evaluated the patient’s airway. This evaluation focused on identification of inclusion criteria for the study. Any one of the following criteria was used for inclusion:

- A thyromental distance <6 cm or a sternomental distance of <12 cm
- Oropharyngeal view: modified Mallampati scale of 3 or 4
- Abnormal upper teeth: loose or protruding upper teeth or partially missing upper incisors or canines
- Impaired temporomandibular joint mobility: interincisor gap <38 mm and inability to move the lower teeth in front of the upper teeth, or ankylosis with limited mouth opening
- Limited neck movement: inability to extend and flex neck >90° from full extension to full flexion or presence of cervical spine pathologies and fractures (e.g., C-collar in place)
- History of difficult laryngoscopy or intubation
- Body Mass Index (BMI) >35 kg/m\(^2\)
- History of obstructive sleep apnea diagnosed by polysomnography.
- Neck circumference larger than 40 cm in females and 43 cm in males measured at the thyroid cartilage.

We classified the oropharyngeal view according to the modified Mallampati classification\(^ {16}\): class I = soft palate, fauces, uvula, and pillars seen; class II = soft palate, fauces, and uvula seen; class III = soft palate and base of uvula seen; and class IV = soft palate not visible. The examination to determine oropharyngeal class was performed with the aid of a flashlight. The patients were in a semisitting position with the tongue fully protruding.

Patients were included if at least 1 predictor of difficult intubation was identified. Patients were excluded if they required an awake intubation (as determined by the attending anesthesiologist) or had a full stomach, hiatus hernia, or history of severe gastroesophageal reflux disease. Likewise, patients with known larynx or pharynx pathology (e.g., tumor, abscess) were excluded.

The subject’s head was placed on an anesthesia pillow (Devon, Coviden, Mansfield, MA) before induction. After 3 minutes of oxygen administration by mask, anesthesia was induced with fentanyl (1–2 μg/kg), propofol (2–4 mg/kg), succinylcholine (0.5–1 mg/kg), or rocuronium (0.6 mg/kg). Laryngoscopy was performed after full muscle relaxation, which was confirmed with a nerve stimulator (train-of-4:0–1). For visualization of the larynx, a VLS (GlideScope®, Verathon Medical, Bothell, WA) was used with a No. 3 blade for women and a No. 4 blade for men. If the patient’s neck was in a C-collar, the front portion of the C-collar was removed, and manual in-line axial stabilization was applied. No manipulation on the neck (no sniffing position) was performed, and no cricoid pressure was applied during the intubation process. The patient’s neck was kept in neutral position during the intubation procedure in all study patients at all times.

All patients had tracheal intubation with a VLS. Patients were randomly assigned to either having their endotracheal tube placed with use of a preformed rigid stylet shaped to match the curvature of the blade of the VLS (control group) or with a flexible tracheoscope (aScope®) (intervention group). The randomization was stratified as to whether patients were categorized as predicted difficult airway or had cervical spine pathologies and fractures (C-collar in place). Randomization was based on computer-generated codes that were maintained in sequentially numbered opaque envelopes.

In both groups, the epiglottis was visualized under indirect vision on the video screen of the VLS. If the patient was randomized to the control group, the intubation was...
performed using an endotracheal tube (size 7 in women, size 8 in men) loaded onto a rigid, preformed stylet. In the intervention group, a flexible tracheoscope, loaded with an endotracheal tube (size 7 in women, size 8 in men), was inserted into the mouth and subsequently underneath the epiglottis and was advanced to the carina under indirect visualization. The endotracheal tube was then advanced over the flexible tracheoscope. After tracheal intubation, the respiratory circuit was connected, and ventilation was confirmed with capnography and auscultation. If intubation failed after 3 attempts regardless of the group assignment, the patient’s trachea was intubated using the alternative method. If both methods were to fail, the plan was to awaken the patient and prepare for an awake intubation.

Three attending anesthesiologists performed all intubations: a single anesthesiologist performed all intubations in the control group, while 2 anesthesiologists performed the procedure in the intervention group. All 3 anesthesiologists had an average of 12 years of difficult airway management experience.

MEASUREMENTS
The primary outcome measures were the number of intubation attempts and time (in seconds) from visualization of the vocal cords to successful intubation. Time from visualization of the vocal cords to successful intubation exceeding 120 seconds was considered a difficult or failed intubation. Secondary outcomes consisted of failure to intubate, episodes of oxyhemoglobin desaturation as measured by pulse oximetry (< 90% O₂), ease of intubation, and neck movement during the intubation process.

Preoperative Assessment
Each patient’s age, sex, weight, height, BMI, and ASA physical status were recorded. Standard anesthesia monitoring consisted of electrocardiogram, pulse oximetry, capnography, noninvasive arterial blood pressure monitoring, and temperature measurements.

Post-Induction Assessment
Intubation time was measured by an independent investigator and defined as the time from insertion of the VLS through the upper and lower incisors, visualization of the epiglottis, to the intubation of the trachea, which was verified by the presence of end-tidal CO₂. Times were divided into total time to intubation and time between successful visualization of the glottis and verified intubation. If the time from visualization of the vocal cords to successful intubation exceeded 120 seconds, this was considered a “difficult intubation” and was recorded as such.

Removal of the VLS constituted a failed intubation attempt. More than 3 attempts were regarded as failure of intubation. If failure to secure the airway occurred with the VLS and flexible tracheoscope, then conventional difficult intubation protocols approved by the hospital were to be implemented. Interim bag and mask time, if needed, was not included in the intubation time.

The laryngeal view was obtained by VLS and graded according to the method described by Cormack and Lehane, although this method was originally developed for direct laryngoscopy. Grading was done as follows: grade I (full view of the glottis), grade II (glottis partly exposed, anterior commissure not seen), grade III (only epiglottis seen), or grade IV (epiglottis not seen). A grade of I or II was considered to represent easy laryngoscopy and a grade of III or IV to represent difficult laryngoscopy. Ease of intubation was also recorded using a visual analogue scale (0–100) of perceived difficulty by the intubator.

One observer video recorded the patient’s neck during the entire intubation process from a view perpendicular to the neck axis. Fifteen patients in the control group and 11 patients in the intervention group could not be recorded for logistic reasons (camera not readily available). An otherwise unrelated observer watched the video recordings and graded the neck movement during the intubation process. Neck movement was classified subjectively by a single observer as Grade 0 = no neck movement, Grade 1 = minimal neck movement, Grade 2 = moderate neck movement, and Grade 3 = severe neck movement.

DATA ANALYSIS
Sample size analysis: a between-group difference of 10 seconds to successful intubation was considered to be clinically significant in our study, because such a difference was equivalent to a 25% change from the average intubation time of 40 seconds. Accordingly, per our a priori assessment, to detect a reduction of 10 seconds to successful intubation, 126 patients were required with 80% power at a 2-tailed significance level of 0.05. We therefore enrolled 140 patients. We stratified randomization for patients with cervical spine pathology (40 patients) and patients with any other predictive factor of difficult airway (100 patients).

Statistical analyses were performed using SPSS statistics version 20 and R version 3.0.1 (IBM Corp., Armonk, NY). Associations between treatment assignment and categorical variables were analyzed using Fisher’s exact test or the χ² test as appropriate. Confidence intervals (CIs) for the difference in success rates between the 2 groups were calculated using an exact method. Comparison of time to intubation between study groups was done using the Kolmogorov-Smirnov test for differences between 2 distributions. Differences in the mean, median, and tail (75th and 90th percentiles) of the 2 distributions were further assessed based on a nonparametric approach using the bootstrap percentile method for CIs (95% for mean/median and 99% for 75th/90th percentiles) and the permutation test for statistical significance. Other continuous data were compared between the 2 study groups using Student’s t test. Results were considered statistically significant when P < 0.05.

RESULTS
Morphometric data and predictive indices for difficult intubation are presented in Tables 1 and 2. There were more women than men patients in the control group, though the difference was not statistically significant. Eight patients had a history of difficult intubation in the intervention group, while there were none in the control group (P = 0.006). In contrast, BMI was significantly higher in the control group (P = 0.04).
All patients’ tracheas were intubated successfully. The number of patients requiring 2 or more intubation attempts was nearly identical in both groups (14% control vs 13% aScope, \( P = 1.0 \)), and the number of patients requiring 3 or more intubation attempts was not significantly different in the control and intervention groups (8.6% control vs 1.4% intervention, odds ratio = 6.4, 95% CI, 0.75–301), \( P = 0.12 \).

The distribution of time to successful intubation did not differ between the groups (\( P = 0.35 \), Fig. 1). Mean, median, and interquartile range (IQR) for time to intubation were 97, 66, and 47 to 89 seconds in the control group and 92, 71, and 52 to 100 seconds in the intervention group. Neither the mean (difference [intervention–control] = −5 seconds, 95% CI, −32 to 19 seconds), \( P = 0.71 \) nor the median (difference = 5 seconds, 95% CI, −7 to 28 seconds), \( P = 0.51 \) were significantly different between the 2 groups. As a further follow-up, we compared the 75th percentiles (intervention 100 seconds vs control 89 seconds, 99% CI for difference −39 to 56 seconds, \( P = 0.30 \)) and 90th percentiles (intervention 167 seconds vs control 176 seconds, 99% CI for difference −209 to 92 seconds, \( P = 0.88 \)). Neither one was significantly different between the 2 groups. Distributions in time from visualization of the vocal cords to intubation were similar in both groups: 46 seconds (IQR 37 to 68 seconds) in the control group and 47 seconds (IQR 37 to 74 seconds) in the intervention group (\( P = 0.88 \)). Patients with a time interval between visualization and successful intubation of >120 seconds were analyzed as a subgroup. There were 9 patients in the control group versus 3 patients in the intervention group in whom successful intubation took longer than 120 seconds (\( P = 0.13 \)). In the control group, 4 patients could not be intubated with the VLS and the rigid stylet alone. After 3 failed attempts with the VLS and rigid stylet, the flexible tracheoscope was added to the procedure, and all patients’ tracheas were intubated successfully. For these 4 patients, time from the decision to change intubation method to successful intubation with a flexible tracheoscope was 36 ± 14 seconds. There was no visible trauma from failed intubations that could have potentially affected the videoscope view.

### Table 1. Morphometric Data and Predictive Indices for Difficult Intubation

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 70)</th>
<th>Intervention (n = 70)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years, mean ± SD</td>
<td>45 ± 13</td>
<td>46.5 ± 14</td>
<td>0.5*</td>
</tr>
<tr>
<td>Females (%)</td>
<td>37 (53)</td>
<td>27 (39)</td>
<td>0.13b</td>
</tr>
<tr>
<td>Classified by ASA class I/II/III/IV</td>
<td>2/32/35/1</td>
<td>2/38/28/2</td>
<td>—</td>
</tr>
<tr>
<td>Thyromental distance &lt;6 cm</td>
<td>12</td>
<td>8</td>
<td>0.47b</td>
</tr>
<tr>
<td>Sternomental distance &lt;12 cm</td>
<td>13</td>
<td>14</td>
<td>1.0b</td>
</tr>
<tr>
<td>Modified Mallampati grade 3 and 4</td>
<td>24</td>
<td>31</td>
<td>0.30b</td>
</tr>
<tr>
<td>Interincisor distance &lt;38 mm</td>
<td>0</td>
<td>3</td>
<td>0.24b</td>
</tr>
<tr>
<td>Obstructive sleep apnea</td>
<td>7</td>
<td>12</td>
<td>0.32b</td>
</tr>
<tr>
<td>Presence of large anterior incisors</td>
<td>1</td>
<td>0</td>
<td>1.0b</td>
</tr>
<tr>
<td>Neck movement &lt;35°</td>
<td>0</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Cervical spine pathologies and fractures</td>
<td>20</td>
<td>20</td>
<td>—</td>
</tr>
<tr>
<td>History of difficult airway</td>
<td>0</td>
<td>8</td>
<td>0.006b</td>
</tr>
<tr>
<td>Body Mass Index (BMI) ≥35</td>
<td>41</td>
<td>28</td>
<td>0.04b</td>
</tr>
<tr>
<td>Neck circumference &gt;40 cm in females/&gt;43 cm in males; combined</td>
<td>24/28; 52</td>
<td>16/32; 48</td>
<td>0.57b</td>
</tr>
<tr>
<td>Categorized by 1/2/3/4/5/6 predictors for difficult intubation</td>
<td>12/26/24/7/1/0</td>
<td>18/19/22/6/4/1</td>
<td>0.39b</td>
</tr>
</tbody>
</table>

Data presented as number of subjects unless otherwise noted.

*Student’s \( t \) test.

bFisher’s exact test. For number of intubation attempts the number of subjects requiring a change of technique were grouped together with the number of subjects requiring 3 attempts.

cStudent’s \( t \) test.

### Table 2. Time to Intubation, Number of Intubation Attempts, and Ease of Intubation by Study Group

<table>
<thead>
<tr>
<th></th>
<th>Control group (n = 70)</th>
<th>Intervention group (n = 70)</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubation time in s; median (IQR range)</td>
<td>66 (47–89)</td>
<td>71 (52–100)</td>
<td>0.35*</td>
</tr>
<tr>
<td>Time in s from visualization of vocal cords to intubation; median (IQR range)</td>
<td>46 (37–68)</td>
<td>47 (37–74)</td>
<td>0.88*</td>
</tr>
<tr>
<td>Number of subjects grouped by intubation attempts, no. (%)</td>
<td>60 (86)</td>
<td>61 (87)</td>
<td>0.09b</td>
</tr>
<tr>
<td>1</td>
<td>4 (6)</td>
<td>8 (11)</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>2 (3)</td>
<td>1 (1)</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>4 (6)</td>
<td>0</td>
<td>—</td>
</tr>
<tr>
<td>Number of subjects requiring change of technique</td>
<td>32 (46)</td>
<td>26 (37)</td>
<td>0.09b</td>
</tr>
<tr>
<td>1</td>
<td>30 (43)</td>
<td>25 (36)</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>8 (11)</td>
<td>17 (24)</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2 (3)</td>
<td>—</td>
</tr>
<tr>
<td>Ease of intubation (100-mm Visual Analog Scale); mean ± SD</td>
<td>36 ± 23</td>
<td>39 ± 25</td>
<td>0.5*</td>
</tr>
<tr>
<td>Episodes of deoxygenation &lt;90%; (%)</td>
<td>6 (8.5)</td>
<td>4 (6)</td>
<td>0.75*</td>
</tr>
<tr>
<td>Number of patients with neck movement rated as none/mild/moderate/severe</td>
<td>8/38/8/1</td>
<td>5/38/16/0</td>
<td>0.20*</td>
</tr>
</tbody>
</table>

*Kolmogorov-Smirnov test.

bFisher’s exact test.

cStudent’s \( t \) test.
When the cervical spine pathology patients were compared separately, intubation performance for the intervention group was 100% (20/20), while for the control group, it was 80% (16/20). The exact 95% CI for the difference in proportions was (0.014 to 0.440), suggesting that the success probability for cervical spine pathology patients is between 1.4% and 44% higher in the intervention group relative to the control group.

The operators rated ease of intubation as similar in the 2 groups. No complications were encountered. Events of arterial deoxygenation as measured by pulse oximetry of <90% were encountered in 6 patients in the control group and in 4 patients in the intervention group (P = 0.75). Neck movement as observed by an independent observer was not significantly different between the groups (P = 0.20).

**DISCUSSION**

In this study, we compared intubation success using VLS either with a rigid stylet (control group) or with a flexible tracheoscope (intervention group) in patients with anticipated difficult airways. We found no statistically significant difference in time to intubation or in the number of intubation attempts between the 2 methods even when the patient’s neck was kept in neutral position during the process of intubation with no sniffing position allowed. In addition to comparing mean and median intubation times between the 2 methods, we additionally evaluated whether intubation times at the extremes of the distribution (75th and 90th percentiles) were longer in one group relative to the other. The 99% CI for the difference in the 75th percentile (intervention–control) was (−39 to 56 seconds), indicating that it is highly unlikely that the differences in intubation times at the 75th percentile exceed 1 minute.

The combination of VLS with a flexible tracheoscope is feasible but may not be necessary in most difficult intubations. VLS (with rigid stylet) has been shown to significantly increase the success rate of intubations in potentially difficult airways. However, there may be occasional cases in which intubation may fail with VLS with a rigid stylet. Moore et al. showed a success rate of 96% in morbidly obese patients. In another recent study, patients with predicted difficult airway were successfully intubated with VLS in 93% of cases on first attempt. In the emergency room environment, VLS was superior to direct laryngoscopy with respect to reducing the number of esophageal intubations. Jeon et al. presented an alternative to VLS with rigid stylet. They compared VLS with rigid stylet with VLS with a forceps-guided tube exchanger in patients with a semirigid cervical collar and showed similar success rates of intubation of 93% vs 94%.

In our study, we found 4 patients who could not be intubated with VLS and rigid stylet. These patients’ tracheas were subsequently intubated successfully using the alternative method that included a flexible tracheoscope. All 4 patients had cervical spine pathology and underwent intubation with in-line stabilization, which may have rendered intubation more difficult. Interestingly, these patients did not have any other predictor of difficult airway.

As a secondary analysis, >120 seconds were needed for successful intubation in 9 patients in the control group compared with only 3 in the intervention group. Though not statistically significant, these data suggest that a combination of a VLS with a flexible tracheoscope is a feasible way to facilitate intubation in a subset of patients with a
predicted difficult airway and may show an advantage over the use of VLS with rigid stylet in select patients.

A single-use flexible tracheoscope was used in this study (aScope®). It can be maneuvered in a similar way as a reusable bronchoscope; it allows visualization of the glottis and the trachea and could even be used to verify the correct position of the endotracheal tube in the trachea.22 However, a comparative study showed worse optical performance compared with a reusable fiberoptic bronchoscope.24 Thus, we relied on end-tidal CO₂ as evidence for correct placement of the tube in our study. We can speculate that this may have extended the process of the intubation by a few seconds in the intervention group.

A flexible tracheoscope that is disposable has the further advantage of being readily available and can be used with only minimal setup time in case of emergent, unforeseen difficult airway. The flexible tracheoscope must be disposed of after use in 1 patient. Of note: combining VLS with a flexible tracheoscope requires 2 anesthesia providers, one to hold the VLS in place and the second person to proceed with the actual intubation with the flexible tracheoscope. The use of this method may be precluded if no capable assistance is available to the anesthesiologist.

Our study has several limitations. First, in our screening process, we enrolled every patient with at least 1 factor for a potential difficult airway. Single factors such as history of difficult intubation and increased BMI were significantly different in the 2 patient groups. Thus, patients were heterogeneous with respect to factors associated with difficult intubation. However, the overall number of factors was similar in the 2 groups.

Second, we stratified patients in groups with or without cervical spine morbidity to assure that we would get the same number of cervical spine pathology subjects in both groups. Although screening was very thorough and all patients’ necks were kept in neutral head position without external manipulation on the larynx during the process of intubation, we only had patients to convert to the intervention group who were enrolled with cervical spine pathology. The results may suggest that the method of combining a VLS with a flexible tracheoscope may be particularly helpful in a patient population with cervical spine pathology.

Neck movement and external manipulation on the larynx often facilitate glottis view25 and intubation. In our study, intubation was not facilitated by either method. This may explain our somewhat longer intubation times. In addition, it may not reflect the routine intubation process in patients with predicted difficult airways without cervical spine pathology. However, facilitation with such methods may not be necessary when using VLS with either a rigid stylet or a flexible tracheoscope. Inadvertent minimal to moderate neck movement may be encountered in most patients as shown in our dataset. Just by opening the mouth, mild neck movement may occur.

Third, only 3 experienced attending anesthesiologists performed all tracheal intubations. Handling a flexible tracheoscope has a learning curve similar to maneuvering a fiberoptic bronchoscope for difficult intubations.26 For novice users, the combined method may not prove successful, and the failure rate for intubation in patients with difficult airways may be higher.

Last, it should be noted that various optical stylets are available aside from VLS and flexible tracheoscopes. These include the Bonfils fiberscope27 or the Shikani optical stylet.28 In this study, we have chosen to use a VLS as the primary device to visualize the glottis. Consequently, no comparison can be made among the different instruments with respect to visualization and rate of successful intubation.

In summary, we evaluated a method for tracheal intubation in patients with difficult intubation that combined a VLS with a flexible tracheoscope. Although there was no statistically significant difference in time to successful intubation or in intubation attempts compared with the use of a VLS with a rigid stylet, 4 patients, all with cervical spine pathology, could only be successfully intubated with the combined method. In addition, overall success probability for cervical spine patients was 100% (20/20) in the intervention group, and 80% (16/20) in the control group, with a 95% CI for the difference between 2% and 42%.

A flexible tracheoscope used in combination with VLS may further increase the success rate of intubation and speed the intubation process in patients with a proven difficult airway, particularly in cervical spine pathology, when manual in-line axial stabilization is required. Although this method was not specifically tested in emergent airway management, it may also be considered a rescue approach, if and when other methods fail to secure an unanticipated difficult airway, even if an adequate glottis view can be achieved with a VLS.

DISCLOSURES

Name: Rainer Lenhardt, MD.
Contribution: This author helped design and conduct the study, analyze the data, and write the manuscript.
Attestation: Rainer Lenhardt has seen the original study data, reviewed the analysis of the data, approved the final manuscript, and is the author responsible for archiving the study files.

Name: Mary Tyler Burkhart, MD.
Contribution: This author helped conduct the study and analyze the data.
Attestation: Mary Tyler Burkhart has reviewed the analysis of the data and approved the final manuscript.

Name: Guy N. Brock, PhD.
Contribution: This author helped analyze the data and performed statistical analysis.
Attestation: Guy N. Brock has reviewed the analysis of the data and approved the final manuscript.

Name: Sunita Kanchi-Kandadai, MD.
Contribution: This author helped conduct the study.
Attestation: Sunita Kanchi-Kandadai has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

Name: Rachana Sharma, MD.
Contribution: This author helped conduct the study and analyze the data.
Attestation: Rachana Sharma has seen the original study data, reviewed the analysis of the data, and approved the final manuscript.

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REFERENCES


