Teaching the surgical airway using fresh cadavers and confirming placement nonsurgically☆☆

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Abstract

Study Objective: To determine if teaching cricothyrotomy with fresh cadavers improves confidence with neck anatomy, patient positioning, procedural steps, and familiarity with a cricothyrotomy kit.

Design: Prospective pre- and post-educational.

Setting: University medical center.

Subjects: 16 anesthesiology residents, one certified registered nurse-anesthetist (CRNA), and 8 medical students.

Measurements: Subjects received workshop training with a PowerPoint presentation followed by an instructional video. Subjects then performed cricothyrotomy during supervision on cadavers. The comfort levels of 25 subjects before (pre) and after (post) the workshop were assessed using a 7-point Likert scale. Correct placement of the cricothyrotome was confirmed with visualization of the carina fiberoptically.

Main Results: There was a significant increase (P < 0.001) between pre- and post-training comfort levels in identification of neck anatomy, surgical landmarks, and patient positioning (pre, 2.60 ± 1.56; post, 5.64 ± 1.22; mean ± SD); use of cricothyrotomy kit (pre, 1.72 ± 1.22; post, 5.52 ± 1.26), and surgical steps (pre, 1.76 ± 1.17; post, 5.52 ± 1.26). In 24 of 25 attempts (96% success rate), correct placement of the cricothyrotome was confirmed by visualization of the carina fiberoptically.

Conclusions: A didactic workshop followed by performance of cricothyrotomy on fresh human cadavers may improve both physician and non-physician anesthesiology care providers’ confidence in performing cricothyrotomy.

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1. Introduction

Endotracheal intubation is a very common procedure that is performed both in and out of the hospital setting. However, in some patients, even the most skilled clinicians experience difficulty in performing endotracheal intubation. The reported incidence of “unable to intubate, unable to ventilate” cases requiring emergency surgical airway varies between 2.5 per 10,000 cases to 0.5 per 10,000 cases [1]. The surgical airway remains the final option on all failed airway algorithms [2], but two surveys from the United Kingdom and United States indicate that anesthesiologists lack formal training in performing the surgical airway [3,4]. Although there are different forms of surgical airway [5], cricothyrotomy is perhaps the most safe and effective [6,7], with a reasonably low complication rate and high success rate compared with other surgical techniques [8,9]. Cricothyrotomy is difficult to teach on actual patients due to the limited number of patients requiring cricothyromies in most clinical settings, and the obvious ethical problems of performing a percutaneous cricothyrotomy in the elective setting.

Although the use of fresh cadavers to teach invasive airway skills has been documented previously, investigators in the past have resorted to surgical dissection of the neck in cadavers in order to confirm correct placement of the surgical airway [8,10]. We maintain that confirmation of correct placement of the surgical airway while teaching cricothyrotomy procedures on cadavers is extremely important. We propose that proper placement of the cricothyrotome may be confirmed endoscopically by visualization of the carina using a 2.8 mm fiberoptic bronchoscope passed through a three mm commercially available cricothyrotome.

There are several methods to teach surgical cricothyrotomy to clinicians, but the three most common techniques are the standard surgical technique, the catheter-over-needle (eg, Rusch QuickTrach; Teleflex Medical, Research Triangle Park, NC, USA) technique, and the wire-guided cricothyrotomy technique [11]. Although ventilation can be established within the same time frame with any of the above techniques [12], wire-guided cricothyrotomy is the preferred technique by emergency [11] and anesthesia physicians [13]. This is mainly because the wire-guided technique is similar to placement of vascular access lines by the Seldinger technique [14]. For this reason, we elected to use the Melker Emergency Cricothyrotomy Catheter Set with cuff (Cook Critical Care, Bloomington, IN, USA), a wire-guided cricothyrotomy catheter set, to teach cricothyrotomy.

We tested the hypothesis that participating in a cricothyrotomy workshop improves confidence among participants, which will translate to a successful demonstration of the wire-guided cricothyrotomy technique on the first attempt while performing a surgical airway on fresh cadavers. We also planned to confirm correct placement of the cricothyrotome in the trachea using a fiberoptic bronchoscope.

2. Materials and methods

The University of Louisville Human Studies Committee approved this study, and subjects gave their written, informed consent to participate in the study. All subjects completed a pre-workshop questionnaire rating their comfort level of their knowledge of neck anatomy, surgical landmarks, surgical steps, patient positioning, and the cricothyrotomy kit. Subjects rated their comfort level using a 7-point Likert scale, in which 1 = very uncomfortable and 7 = very comfortable. Participants were also requested to document the number of surgical airways performed previously, either with dilation percutaneous tracheostomy or cricothyrotomy.

Participant instruction included a 15-minute PowerPoint presentation (Microsoft, Redmon, WA, USA) about the indication, anatomy, patient positioning, and steps involved in wire-guided cricothyrotomy and how to confirm the correct position of the cricothyrotome in the trachea. This was followed by a 5-minute instructional video about performing cricothyrotomy (Cook Critical Care).

Subjects then performed cricothyrotomy on cadavers with a Melker Emergency Cricothyrotomy Catheter Set with cuff using the Seldinger [14] technique with the direct supervision of an experienced anesthesia faculty member. Subjects extended the neck of the cadaver by placing a role under the shoulders. After identification of neck structures, subjects made a 2-centimeter vertical incision with a scalpel in the skin overlying the cricothyroid membrane. For subsequent uses, 2-inch plastic tape (3M Scotch Brand 471; 3M, Inc., St. Paul, MN, USA) was applied to the cadaver’s neck to simulate the skin. An 18-gauge needle attached to a syringe was inserted through the incision, through the underlying cricothyroid membrane, and into the trachea at a 45° angle in a caudal direction. Air was aspirated into the syringe to confirm placement in the trachea. Once confirmed, the syringe was removed and a guide wire was inserted through the needle. The needle was removed over the wire, and the dilator-airway assembly was advanced over the guide wire into the trachea. Finally, the dilator and guide wire were removed, leaving the Melker cricothyrotome in place. Correct placement of the surgical airway was confirmed with a 2.8mm STORZ fiberoptic bronchoscope (Karl Storz GmbH & Co. KG, Tuttlingen, Germany) passed through the Melker cricothyrotome to allow visualization of the carina. If the carina was not visualized, the fiberoptic bronchoscope was introduced orally through the vocal cords, guided by a Williams Airway Intubator (SunMed, Inc., Largo, FL, USA). The position of the cricothyrotome was visualized and noted. Four cadavers were used to teach 25 learners. After each attempt – before the next subject made his or her attempt – plastic tape was re-applied to the cadaver’s neck to give a consistency comparable to skin overlying the cricothyroid membrane [15].

Immediately after the workshop was complete, subjects completed a post-workshop questionnaire identical to the
pre-workshop questionnaire, rating their comfort level with knowledge of neck anatomy, surgical landmarks, surgical steps, patient positioning, and the cricothyrotomy kit.

SPSS software version 17.0 (SPSS, Chicago, IL, USA) was used to analyze quantitative data. Descriptive statistics included frequency, mean, and standard deviation (SD). Changes in subjects’ perceptions of comfort, as captured in the pre- and post-workshop Likert-scaled data, were analyzed using the Wilcoxon signed-rank tests. All P-values were two-tailed. Owing to the multiple testing of the Likert scale items, statistical significance was set at $P \leq 0.01$.

3. Results

Thirteen anesthesiology residents, one certified registered nurse-anesthetist (CRNA), three interns, and 8 medical students consented to participate in this study. Of our 25 participants, 23 reported that they had never been in a situation requiring cricothyrotomy for definitive airway on a patient, and 24 reported no previous procedural experience using the Seldinger technique for cricothyrotomy. Analysis of the entire sample showed a significant increase between pre- and post-workshop comfort level as measured on a Likert scale (Table 1). Average scores of comfort level for the identification of neck anatomy, surgical landmarks, and patient positioning increased twofold. In addition, scores of participants’ comfort in use of the cricothyrotomy kit and knowledge of the surgical steps increased more than threefold.

Because cricothyrotomy is an advanced airway management skill, it was possible that including medical students’ and first-year residents’ perceptions might have skewed our results. Therefore, we re-analyzed our data after omitting the data obtained from medical students and interns. The analysis again showed similar statistically significant increases in participants’ confidence of their knowledge of neck anatomy, surgical landmarks, patient position, and surgical steps; and use of a cricothyrotomy kit.

Correct positioning of the cricothyrotome was confirmed fiberoptically in 24 of 25 attempts (96% success rate). In one case, we were unable to identify the carina when the fiberoptic scope was introduced into the trachea through the cricothyrotome. In this case, the fiberoptic scope was introduced orally guided by a Williams airway intubator and the position of the cricothyrotome was visualized above the cords. On a subsequent attempt, the subject was able to place the cricothyrotome correctly into the trachea.

4. Discussion

The present study shows that a systematic teaching approach in a workshop setting, using didactic instruction followed by proper supervision of hands-on implementation, improves the confidence of health care providers in performing a cricothyrotomy. Unfortunately, it is difficult to teach surgical airway procedures in the normal elective clinical setting. The emergency surgical airway is still a fairly rare occurrence, and the focus on re-establishing the airway supersedes that of instruction. In the clinical setting, most patients requiring surgical airway are in cardiac arrest prior to the procedure and hence have poor outcomes [16-18]. Scrase and Woollard [5] indicated that if we exclude this subset of patients from the analysis, the survival rate after surgical airway in a failure-to-intubate situation is 34% to 75%, with 9% to 34% having good neurological outcome [16]. Hence, evidence supports the teaching of cricothyrotomy to doctors, nurses, and paramedics.

Although the incidence of “cannot intubate, cannot ventilate” is low, a surgical airway remains the final option in these patients. The use of the Esophageal-Tracheal-Combitube (Covidien, Mansfield, MA, USA) and Laryngeal Mask Airways (LMA North America, Inc., San Diego, CA, USA) in the difficult airway are recognized [19,20]; however, successful placement of these devices is not always guaranteed [21]. This situation makes teaching and mastering the surgical airway a matter of paramount importance for anesthesia care providers.

<table>
<thead>
<tr>
<th>Question</th>
<th>Assessment time</th>
<th>Likert Scale (% of participants marking within range) $^a$</th>
<th>Mean (SD)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>How comfortable are you identifying the anatomy, surgical landmarks, and patient positioning for cricothyrotomy?</td>
<td>Pre</td>
<td>64% 24% 12%</td>
<td>2.6 (1.6)</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Post</td>
<td>8% 8% 84%</td>
<td>5.6 (1.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How comfortable are you with the use of a cricothyrotomy kit?</td>
<td>Pre</td>
<td>84% 12% 4%</td>
<td>1.7 (1.2)</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Post</td>
<td>8% 12% 80%</td>
<td>5.5 (1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How comfortable are you with the surgical steps of cricothyrotomy?</td>
<td>Pre</td>
<td>88% 8% 4%</td>
<td>1.8 (1.2)</td>
<td>≤0.001</td>
</tr>
<tr>
<td>Post</td>
<td>8% 12% 80%</td>
<td>5.5 (1.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$ Likert Scale: 1 = most uncomfortable, 7 = most comfortable. Data for the Likert scale are given as the percentage of participants who scored their comfort level at 1-3 (uncomfortable), 4 (neutral), or 5-7 (comfortable).
The 96% success rate for correct placement of the cricothyrotome on the first attempt in our study is similar to that previously reported by Chan et al. [22] but higher than what has been reported elsewhere [11,12]. We believe that the detailed didactic instruction of surgical airway steps and neck anatomy, familiarity with the surgical airway instruments, and supervision by an expert faculty member may have been responsible for the 96% success rate of our participants. We hope that such knowledge and hands-on experience reduces complication rates during future procedures when it comes to performance on patients [23,24].

We acknowledge that practice on fresh human cadavers does not necessarily reflect the experience in live patients. Fresh cadavers do not bleed, nor do they form hematomas that might distort neck anatomy and thus make surgical cricothyrotomy very challenging for the care provider. However, cadavers are the closest simulation model that accurately reproduces the anatomy and spatial relationship of the cricothyroid membrane to the rest of the airway. The use of only 4 cadavers for 25 learners may not have been satisfactory to assure that all learners recognized the anatomical structures. The plastic tape to replace the skin may not provide the same feeling to learners as real skin. If this study is repeated, a greater cadaver-to-learner ratio is desirable.

One limitation of the current study is that we did not measure the body mass index (BMI) of the 4 cadavers. A decreased patient BMI might have rendered the surgical airway procedure easier for our participants and thus improved our success rate. Increased BMI impedes orotracheal intubation, especially when associated with larger neck circumference [25].

Another limitation of the current study is that we did not measure how long participants took to perform surgical cricothyrotomy on their first attempt. In the setting of working with cadavers, participants were not under pressure and there was no time limit to insert a surgical airway. However, real airway emergencies requiring cricothyrotomy have significant time pressure. This sense of time pressure and urgency may increase complication rates and lower success rates on patients [15,23]. Reducing elapsed time to insert a surgical airway is important in the clinical setting so as to prevent hypoxic brain injury. Future studies or workshops should measure time to perform surgical airway on the first or any attempt.

We showed that a fiberoptic bronchoscope may be used to confirm correct placement of the cricothyrotome in a cadaver by visualization of the carina nonsurgically. This method is quick and reliable compared with surgical dissection, but it does not identify any associated injuries to the surrounding structures as surgical dissection can. Nonetheless, the aim of performing cricothyrotomy in the emergency situation is to place the cricothyrotome into the trachea and provide oxygen to the patient’s lungs. Using the fiberoptic bronchoscope in our study was sufficient to confirm that a proper airway was established.

We conclude that patient care providers who deal with airway management, such as anesthesiologists, CRNAs, intensive care physicians, emergency rooms physicians, and emergency medical technicians, should attain skill in surgical cricothyrotomy and maintain this skill. A workshop for teaching wire-guided cricothyrotomy to clinicians greatly increased participant confidence with this procedure. Participants showed a success rate of 96% on the first attempt.

References


