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Brief Reports

EMERGENT SURGICAL AIRWAY: COMPARISON OF THE THREE-STEP METHOD AND CONVENTIONAL CRICOTHYROIDOTOMY UTILIZING HIGH-FIDELITY SIMULATION

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☐ **Abstract—Background: Surgical airway creation has a high potential for disaster. Conventional methods can be cumbersome and require special instruments. A simple method utilizing three steps and readily available equipment exists, but has yet to be adequately tested. Objective: Our objective was to compare conventional cricothyroidotomy with the three-step method utilizing high-fidelity simulation. Methods: Utilizing a high-fidelity simulator, 12 experienced flight nurses and paramedics performed both methods after a didactic lecture, simulator briefing, and demonstration of each technique. Six participants performed the three-step method first, and the remaining 6 performed the conventional method first. Each participant was filmed and timed. We analyzed videos with respect to the number of hand repositions, number of airway instrumentations, and technical complications. Times to successful completion were measured from incision to balloon inflation. Results: The three-step method was completed faster (52.1 s vs. 87.3 s; $p = 0.007$) as compared with conventional surgical cricothyroidotomy. The two methods did not differ statistically regarding number of hand movements (3.75 vs. 5.25; $p = 0.12$) or instrumentations of the airway (1.08 vs. 1.33; $p = 0.07$). The three-step method resulted in 100% successful airway placement on the first attempt, compared with 75% of the conventional method ($p = 0.11$). Technical complications occurred more with the conventional method (33% vs. 0%; $p = 0.05$). Conclusion: The three-step method, using an elastic bougie with an endotracheal tube, was shown to require fewer total hand movements, took less time to complete, resulted in more successful airway placement, and had fewer complications compared with traditional cricothyroidotomy. Published by Elsevier Inc.**

☐ **Keywords—cricothyroidotomy; cricothyrotomy; three-step; simulation; training**

INTRODUCTION

Emergent surgical airway management is crucial to the survival of many patients. Oral endotracheal intubation, although preferred, is not always possible. Severe facial injury, laryngeal and soft tissue swelling of the neck, obesity, and provider inexperience can preclude correct placement of endotracheal tubes via oral or nasal intubation (1). When this classic, "can't intubate, can't ventilate" situation occurs, there is an immediate need to pursue surgical airway management by performing cricothyroidotomy. Although approximately 1% of emergency airway management requires a surgical airway, if performed incorrectly or in an untimely manner, death is almost certainly imminent (2).

Conventional methods of surgical airway creation require multiple steps and specialized equipment. These methods involve a variety of blunt and sharp dissection techniques, self-retaining retractors and a trachea hook to elevate the airway into view of the provider. Once dissection is complete and the cricothyroid membrane

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has been divided, typically a small tracheostomy tube is inserted and secured.

To decrease complexity of the procedure, several commercially available kits have been developed to simplify the process (3–6). Several kits utilize percutaneous needle insertion, followed by wire-guided passage of a tube (4,6,7). Others employ a needle with a preloaded cannula that can be passed into the trachea, and some kits use detection devices to identify the posterior wall of the larynx (4,5). Devices are even available that can be carried on a keychain (8). Although the efficiency of these methods is variable, all require specialized equipment and result in increased costs.

To address cost and equipment concerns, we have adopted a simplified approach previously described by MacIntyre et al., requiring only three major steps (three-step method): incision, bougie placement, and endotracheal tube placement over the bougie (9). This method utilizes readily available inexpensive equipment, consisting of a #10 scalpel, gum elastic bougie, and a size 6.5 endotracheal tube.

The goal of this study was to test the three-step method in comparison with conventional cricothyroidotomy, utilizing high-fidelity simulation. We hypothesized this streamlined method would result in faster, more efficacious placement of surgical airways.

METHODS

Twelve experienced flight nurses and paramedics were filmed performing the conventional cricothyroidotomy and the three-step method on the METI® ECS® simulator (CAE Healthcare, Montreal, Quebec). Six participants first performed the conventional method, and the remaining participants performed the three-step method first. The two groups then performed the other method. Each provider had extensive prior training performing the conventional method, and each had attended at least two previous training sessions within the preceding year.

The conventional method involved the following steps. A horizontal incision was made over the anterior neck and a hemostat was used to spread the incision. Next, a self-retaining retractor was introduced into the wound. A hook was used to elevate the trachea. Then a horizontal incision was made through the cricothryoid membrane and a spreader was used to open the cricothyroidotomy. A size 6 tracheostomy tube was then inserted, balloon inflated, and connected to a bag valve mask. Before performing the conventional cricothyroidotomy, each provider received standardized training, which included a short didactic lecture, briefing regarding the simulator, and a demonstration of the technique.

Before performing the 3-Step Method, participants underwent a standardized training module with a lecture, simulator briefing, and demonstration of the technique. First, a vertical incision was made from the base of the thyroid cartilage to above the sternal notch. A transverse incision was made through the membrane. Next, a bougie was passed into the defect, and a size 6.5 endotracheal tube was then passed over the bougie. The balloon was inflated and tube connected to a bag valve mask. No dissection was performed. Retractors and trachea hooks were not used.

Participants were filmed performing each procedure. We measured the time from incision to balloon inflation. Techniques were then analyzed by two independent reviewers. No discrepancies were identified between the reviews. The number of hand repositions, airway instrumentations, complications, and successful airway placements were recorded.

Institutional internal review board approval was issued before the study. Statistical analysis was performed using Student's *t*-test.

RESULTS

The three-step method resulted in shorter completion times (52.1 s vs. 87.3 s; $p = 0.007$) as compared with conventional surgical cricothyroidotomy. Using the three-step method, providers were able to place the definitive airway 100% of the time on first attempt, and 75% of those were correctly placed by the conventional method ($p = 0.11$). The two methods did not differ statistically regarding efficiency of motion and number of hand movements (3.75 vs. 5.25; $p = 0.12$) and instrumentations of the airway (1.08 vs. 1.33; $p = 0.07$). No complications occurred during the three-step method; however, the conventional method resulted in a 33% complication rate ($p = 0.05$) (Table 1). Complications included two trachea hooks remaining lodged within the airway and participant injuries related to the hook. One participant suffered an injury while using a scalpel.

DISCUSSION

This study showed the novel three-step method of performing a surgical airway could not only be taught using the high-fidelity simulator and a brief lecture, but could also result in better performance. The three-step method outperformed conventional cricothyroidotomy in all areas studied.

Conventional cricothyroidotomy has been challenged by multiple techniques in recent years with mixed results (3,5–7,10). Commercially available kits have shown variable rates of successful airway placement from 20% to 100% (3,6,7). Methods utilizing standard surgical instruments have also been tested. A study by Schober et al. showed a method using scissors improved rates of