A Comparison of Two Open Surgical Cricothyroidotomy Techniques by Military Medics Using a Cadaver Model

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Study objective: The CricKey is a novel surgical cricothyroidotomy device combining the functions of a tracheal hook, stylet, dilator, and bougie incorporated with a Melker airway cannula. This study compares surgical cricothyroidotomy with standard open surgical versus CricKey technique.

Methods: This was a prospective crossover study using human cadaveric models. Participants included US Army combat medics credentialed at the emergency medical technician–basic level. After a brief anatomy review and demonstration, participants performed in random order standard open surgical cricothyroidotomy and CricKey surgical cricothyroidotomy. The primary outcome was first-pass success, and the secondary outcome measure was procedural time.

Results: First-attempt success was 100% (15/15) for CricKey surgical cricothyroidotomy and 66% (10/15) for open surgical cricothyroidotomy (odds ratio 16.0; 95% confidence interval 0.8 to 326). Surgical cricothyroidotomy insertion was faster for CricKey than open technique (34 versus 65 seconds; median time difference 28 seconds; 95% confidence interval 16 to 48 seconds).

Conclusion: Compared with the standard open surgical cricothyroidotomy technique, military medics demonstrated faster insertion with the CricKey. First-pass success was not significantly different between the techniques. [Ann Emerg Med. 2014;63:1-5.]

Please see page 2 for the Editor's Capsule Summary of this article.

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INTRODUCTION

Background

Traumatic airway obstruction has been responsible for 1.8% of combat-related deaths in recent conflicts.[1] Surgical cricothyroidotomy rates in the military out-of-hospital setting, in which penetrating and explosion-related trauma predominate, are double that of the civilian emergency medical services setting.[2] The face and anterior neck are not typically covered with protective armor, resulting in an increased likelihood of upper airway structural injury and the need for surgical cricothyroidotomy.

The majority of US military medics are trained at the emergency medical technician (EMT)–basic level. While outside the scope of US civilian EMT-basic training, surgical cricothyroidotomy is an essential battlefield medical skill. Although all medics learn standard open surgical cricothyroidotomy, the first opportunity to perform the procedure on a patient is usually under combat conditions. The surgical cricothyroidotomy failure rate for medics in Iraq and Afghanistan is 33%.[2] Other reported complications include bleeding, incorrect anatomic placement, mainstem intubation, and damage to associated airway structures.[2,3]

Importance

Although numerous surgical cricothyroidotomy techniques have been described, the optimal approach remains unknown, especially in the out-of-hospital setting.[4] Ideal properties for surgical cricothyroidotomy include a rapid, simple technique easily performed in out-of-hospital conditions. In addition, the technique must be easily learned and retained by minimally trained health care providers.

Goals of This Investigation

In this cadaveric study, we compared surgical cricothyroidotomy first-attempt success rates and procedural speed, using conventional open versus a new CricKey surgical cricothyroidotomy technique.

MATERIALS AND METHODS

Study Design and Setting

We conducted a prospective randomized crossover study comparing standard open with CricKey-assisted surgical cricothyroidotomy by US Army combat medics. This study was approved by the San Antonio Military Medical Center's institutional review board. Informed consent was obtained from each participant before their inclusion in the study.

Editor's Capsule Summary

What is already known on this topic

Surgical cricothyroidotomy is a difficult procedure seldom performed by most clinicians.

What question this study addressed

Are success rates higher and insertion speed faster with CricKey-assisted cricothyroidotomy than with standard "open" technique?

What this study adds to our knowledge

In this controlled human cadaver crossover trial of 15 military medics, insertion times were faster with CricKey-assisted cricothyroidotomy than with open technique. There were 3 failures with open technique and none with the CricKey.

How this is relevant to clinical practice

The CricKey offers an alternate approach to surgical cricothyroidotomy.

Selection of Participants

Participants were volunteer US Army medics assigned to the emergency department (ED) of a large military hospital (San Antonio Military Medical Center, Ft. Sam Houston, TX). Entry-level military medics are trained to the EMT-basic level. They receive additional training above the EMT-basic level on supraglottic airway insertion and surgical cricothyroidotomy.

Army medics currently receive 2 hours of classroom instruction on surgical cricothyroidotomy, followed by 5 hours of airway laboratory training encompassing at least 12 to 15 surgical cricothyroidotomy practice repetitions on a manikin (Simulaids Critical Airway Management Trainer Model 68454, Saugerties, NY). All airway training is completed on plastic manikins. Entry-level medics do not have the opportunity to conduct airway procedures on live patients, cadavers, or animal models. Medics are required to successfully perform open surgical cricothyroidotomy in less than 60 seconds on the Simulaids airway training manikin.

We included medics with current EMT-basic certification. We excluded individuals who had previously performed open surgical cricothyroidotomy on a human cadaver or patient.

Interventions

The 2 surgical cricothyroidotomy techniques tested in this study were standard open surgical cricothyroidotomy and CricKey-assisted surgical cricothyroidotomy. The standard open surgical technique taught to US Army medics uses a number 10 scalpel, tracheal hook, and 6.0 cuffed endotracheal tube (Figure 1).

The CricKey technique is based on the shape and curvature of Levitan's fiber optic scope[5] (Figure 2). The CricKey introducer

STANDARD OPEN SURGICAL TECHNIQUE STEPS

Equipment: #10 scalpel, tracheal hook, 6.0 endotracheal tube (ETT), 10cc syringe

Steps for standard surgical cricothyroidotomy:

1. Identify cricothyroid membrane (CTM) between the cricoid cartilage and thyroid cartilage.
2. Grasp and hold trachea, stabilizing the airway.
3. Make a vertical skin incision down to the CTM using a #10 scalpel.
4. Dissect the tissues to expose the membrane.
5. Make a horizontal incision through the CTM.
6. Maintain the opening in the CTM with the scalpel handle.
7. Secure the opening with a tracheal hook and remove the scalpel handle.
8. Insert a cuffed 6.0 endotracheal tube no more than 3 cm into the opening.
9. Inflate the cuff with 10 cubic centimeters (cc) of air.
10. Connect bag valve mask and check for breath sounds bilaterally.

CRICKEY TECHNIQUE STEPS

Equipment: #10 scalpel, CricKey, cuffed Cook-Melker 5.0 airway, 10cc syringe

Steps for CricKey surgical cricothyroidotomy:

1. Identify the cricothyroid membrane between the cricoid cartilage and thyroid cartilage.
2. Grasp and hold trachea, stabilizing the airway.
3. Make a vertical skin incision down to the cricothyroid membrane using a #10 scalpel.
4. Dissect the tissues to expose the membrane.
5. Make a horizontal incision through the CTM.
6. Insert the CricKey with the Melker airway
7. Confirm placement by feeling the tracheal rings, and looking for skin tenting.
8. Remove the CricKey leaving the airway in place.
9. Inflate the cuff with 10 cc of air.
10. Connect bag valve mask and check for breath sounds bilaterally.

Figure 1. Standard surgical cricothyroidotomy and CricKey-assisted surgical cricothyroidotomy instructions provided to subjects.

is curvilinear, with an overall length of 19 cm, an anteriorly directed distal tip, and a diameter of approximately 5 mm. The introducer is designed to guide insertion of a 5.0 cuffed Melker cricothyroidotomy airway cannula (Cook Critical Care, Bloomington, IN). The CricKey combines the functions of a tracheal hook, stylet, dilator, and bougie when incorporated with the Melker airway.

Participants received a 5-minute slide presentation reviewing the appropriate airway anatomy. The standard and CricKey surgical cricothyroidotomy techniques were then demonstrated by one investigator while another investigator read aloud the steps listed in Figure 1. Total instruction time was approximately 15 minutes. The participants then practiced each technique 5 times, as recommend by Wong et al[6] on an airway manikin.

After the practice sessions, subjects were allowed to familiarize themselves with available airway equipment. All equipment was unpackaged and preassembled. The participants then performed surgical cricothyroidotomy on a human cadaver, using either the standard open or CricKey technique. Once participants were in the laboratory, no interaction was allowed until the conclusion of their timed procedure.

Figure 2. CricKey.

Randomization of surgical cricothyroidotomy technique was assigned by participant order, with odd-numbered participants performing the CricKey technique first and even-numbered participants performing the standard technique first. Each participant then performed the alternate technique on a second cadaver. Each cadaver in the study received only 1 surgical cricothyroidotomy.

The study was conducted from September 2011 to May 2012 at 2 medical education facilities in the San Antonio, TX, area that use human cadavers for medical training. Cadavers were made available for this study after their use in other educational activities. No cadaver with evidence of neck surgery, morbid obesity, or abnormal neck anatomy was used in the study.

Outcome Measures

The primary outcome measure was first-pass success at cannulating the trachea. The secondary outcome was procedural time from first incision to first ventilation through a bag-valve-mask device.

Successful placement was confirmed by the bilateral rise and fall of the chest and the presence of breath sounds on auscultation. If placement was uncertain, a gum elastic bougie was inserted through the airway to confirm intratracheal placement by tactile feedback. For purposes of this study, a separate "attempt" was recorded if the tube was removed and another insertion made through a new incision or if a placed tube was completely removed and reinserted through the same incision. In the case of multiple attempts, elapsed time was continued until the medic indicated he or she was finished with the attempt.

Primary Data Analysis

No previous studies were available to guide the estimation of effect size or SD. A priori analyses showed that 78 cadaver models and 34 subjects would be required to detect a 30% difference in success rates, and 14 subjects would be required to detect a 50% difference in first-pass success rates. We also estimated that 15 subjects would be required to detect a 0.8 SD difference in procedural speed. Because of the limited number of available cadavers, we designed the study to use 15 subjects and 30 cadavers.

First-pass success rates were compared with a univariable odds ratio and 95% confidence interval. We compared elapsed insertion times with the Wilcoxon signed-rank test. Calculations were performed with SAS (version 9.2; SAS Institute, Inc., Cary, NC).

RESULTS

Fifteen participants completed the protocol. The medics reported an average of 2.5 years of experience. Three participants had previously performed open surgical cricothyroidotomy on an animal model.

First-pass success was 100% (15/15) for CricKey and 66% (10/15) for open surgical cricothyroidotomy (odds ratio 16.0; 95% confidence interval 0.81 to 326). Two participants required multiple attempts to place the airway in the standard open surgical cricothyroidotomy group. Three participants in the standard open surgical cricothyroidotomy group failed to cannulate the airway. One participant placed the airway into the esophagus. Two others placed the airway into the soft tissue of the neck (Table).

By the Wilcoxon signed-rank test, elapsed procedure time was faster for CricKey than open surgical cricothyroidotomy (median difference 28 seconds; interquartile range 16 to 48 seconds).

LIMITATIONS

Although other open surgical cricothyroidotomy techniques exist such as the bougie-aided cricothyroidotomy,[7] we believed that it was more important to assess the CricKey against the standard technique currently used by US Army out-of-hospital providers. Both surgical cricothyroidotomy techniques involve different steps and different pieces of equipment. Each surgical cricothyroidotomy airway cannula has different characteristics, which may have affected ease of insertion.

Cadavers used in this study had easily discernible neck anatomy and may not be comparable to battlefield patients sustaining traumatic injury to the face or neck. Cadaver characteristics such as demographics, age at death, height, weight, neck circumferences, and cricothyroid membrane measurements were not recorded.

Rather than auscultation, confirmation of surgical cricothyroidotomy success and tracheal injury could have been improved with access to fiber optic bronchoscope visualization.[8] Other similar studies used trained anatomists to dissect tissues to determine airway placement and to assess complications such as tracheal injury. We did not have access to an anatomist and did not assess for tracheal injury.

DISCUSSION

In this cadaveric study, we found CricKey surgical cricothyroidotomy to be faster than open surgical cricothyroidotomy. Although we did not have enough enrolled subjects to formally

Table. Cricothyroidotomy procedure time, success, and number of attempts.

	Standard Cricothyroidotomy			CricKey Thyroidotomy			
Subject	**Time, Seconds**	**Number of Attempts**	**Successful**	**Time, Seconds**	**Number of Attempts**	**Successful**	**Time Difference, Seconds**
1	51	1	Yes	44	1	Yes	7
2	50	1	Yes	31	1	Yes	19
3	38	1	Yes	35	1	Yes	3
4	82	1	No	34	1	Yes	48
5	185	3	Yes	31	1	Yes	154
6	62	1	Yes	38	1	Yes	24
7	49	1	Yes	36	1	Yes	13
8	70	1	No	41	1	Yes	29
9	65	1	Yes	37	1	Yes	28
10	94	1	Yes	38	1	Yes	56
11	49	1	Yes	33	1	Yes	16
12	66	1	Yes	31	1	Yes	35
13	93	2	Yes	28	1	Yes	65
14	68	1	No	32	1	Yes	36
15	54	1	Yes	31	1	Yes	23
Median (IQR)	65 (50–82)			34 (31–38)			28 (16–48)
Mean (95% confidence interval)	72 (52–91)			35 (32–37)			37 (17–57)

IQR, interquartile range.

differentiate first-pass success rates, they seemed to demonstrate greater ease of surgical cricothyroidotomy insertion with the CricKey.

The CricKey has design features that may provide key advantages over open surgical cricothyroidotomy. The CricKey introducer combines the functions of a tracheal hook, bougie, and dilator into a single unit. When the tip of the CricKey is inserted into the cricothyroid membrane, it provides the ability to lift and manipulate the trachea while securing the opening into the cricothyroid membrane. This maneuver is similar to that performed with a tracheal hook in the standard surgical cricothyroidotomy technique.

Once inserted, the semirigid CricKey introducer provides tactile feedback as is contacts the tracheal rings. Each of the subjects reported appreciating the tactile feedback of the tracheal rings when using the CricKey. Although a standard bougie can be used to assist open surgical cricothyroidotomy, the length (70 cm) is excessive for this application, and there is a chance no vibrations will be felt if the coudé tip is pressed against the membranous trachea. Unlike standard surgical cricothyroidotomy, the CricKey also provides visual feedback by skin tenting if the device is placed incorrectly into the subcutaneous tissue.

The 2 surgical cricothyroidotomy techniques use different size tubes. We compared a 6.0 endotrachael tube and the 5.0 Melker because they provide equivalent minute ventilation.[9] The Melker 5.0 tube is short (9 cm), fairly rigid, and specifically fabricated for insertion through the cricothyroid membrane. In contrast, a 6.0 ETT is flexible and is more difficult to direct through the cricothyroid membrane into the trachea. The excessive length of conventional ETTs also make them difficult to secure. Previous studies report a 15% incidence of right mainstem intubation when an ETT is used for surgical cricothyroidotomy.[2,3]

Surgical cricothyroidotomy is a rarely performed yet potentially lifesaving procedure. A variety of surgical cricothyroidotomy techniques have been advocated yet none has been proven superior. We believe the CricKey surgical cricothyroidotomy technique incorporates a number of features that simplify surgical cricothyroidotomy execution and skill acquisition. The medics in this study were able to learn the CricKey technique with minimal training. Thus, application in the ED by physicians or by civilian paramedics should be possible. Further evaluation of the CricKey in the combat and clinical settings is warranted to fully appreciate the differences suggested by this study.

Compared with their performance with the standard open cricothyroidotomy technique, military medics demonstrated faster insertion using the CricKey. First-pass success was not significantly different between techniques. The CricKey may provide a feasible alternate approach to surgical cricothyroidotomy.

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Author contributions: RLM and AF conceived the study and designed the trial. MCN prepared the documentation and submitted the study to the institutional review board. RLM, MCN, DCS, and SB supervised the conduct of the trial and data collection. MCN and DCS supervised recruitment of participants and managed the data, including quality control. RLM provided statistical advice on study design and MCN analyzed the data. RLM drafted the article, and all authors contributed substantially to its revision. RLM takes responsibility for the paper as a whole.

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