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Cricothyroidotomy for elective airway management in critically ill trauma patients with technically challenging neck anatomyChristina G Rehm¹, Sandra M Wanek², Eliot B Gagnon³, Slone K Pearson⁴ and Richard J Mullins⁵¹Associate Professor of Surgery, Oregon Health & Science University, Portland, Oregon, USA²Critical Care Fellow, Oregon Health & Science University, Portland, Oregon, USA³Senior Medical Student, Oregon Health & Science University, Portland, Oregon, USA⁴Senior Research Assistant, Oregon Health & Science University, Portland, Oregon, USA⁵Chief Trauma/Critical Care, Oregon Health & Science University, Portland, Oregon, USACorrespondence: Christina G Rehm, rehmc@ohsu.edu

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Abstract**Introduction** To assess the value of elective cricothyroidotomy for airway management in critically ill trauma patients with technically challenging neck anatomy.**Materials and methods** A retrospective chart review of patients admitted to the Trauma Service at a Level I Trauma Center who underwent cricothyroidotomy for elective airway management over a 40-month period from January 1997 to April 2000. Comparison was made with a cohort of Trauma Service patients who received a tracheostomy.**Results** Eighteen patients met study criteria, and an unpaired *t* test revealed significance ($P < 0.05$) for age only. There was no difference with Injury Severity Score, number of days in the intensive care unit, number of days requiring ventilation post procedure or number of days intubated prior to procedure. The major difference was the more technically challenging neck anatomy in the patients undergoing cricothyroidotomy. Five out of 18 patients undergoing cricothyroidotomy died prior to discharge and two out of 18 died after discharge from complications unrelated to their airway. Two out of 18 patients undergoing tracheostomy died prior to discharge from complications unrelated to their airway. For a period of 1 week–15 months (average, 5.5 months), notes in subsequent clinic appointments were reviewed for subjective assessment of wound healing, breathing and swallowing difficulties, and voice changes. One patient with a cricothyroidotomy required silver nitrate to treat some granulation tissue. Otherwise, no complications were identified. Telephone interviews were conducted with eight of the 11 surviving cricothyroidotomy patients and nine of the 16 surviving tracheostomy patients. One tracheostomy patient required surgical closure 3 months after discharge; otherwise, the only noted change was minor voice changes in three patients in each group. All six of these patients denied that this compromised them in any way.**Conclusion** Elective cricothyroidotomy has a low complication rate and is a reasonable, technically less demanding option in critically ill patients with challenging neck anatomy requiring a surgical airway.**Keywords** airway, cricothyroidotomy, tracheotomy, trauma

Introduction

Long-term airway management is a complex problem, and the subject of unresolved controversy. The literature suggests that translaryngeal intubation, considered the standard initial airway support [1], may be associated with a higher incidence of infectious complications, with longer weaning times from the ventilator, and with damage to the trachea and laryngeal structures. Translaryngeal intubation is tenuous and uncomfortable compared with a surgical airway when used long term, which is defined as beyond 7 days [1–5].

Surgical access to the airway directly in the anterior neck decreases or completely avoids these complications. The standard surgical approach has been defined as an anterior tracheotomy through the second or third tracheal ring after Jackson's articles from 1909 and 1921 [6,7]. The advent of the percutaneous technique has virtually simplified this to a routine bedside procedure that even nonsurgeons perform with ease and good results. However, the narrow margin for technical error and the need to provide an airway within minutes have led to the introduction of the approach through the cricothyroid membrane, the most superficial portion of the airway in the midsection of the anterior neck. This approach is technically much easier and faster, and thus cricothyroidotomy has found its place as the standard emergency airway in situations when translaryngeal intubation cannot be achieved.

It has been long taught that cricothyroidotomies could only serve as a temporary solution because of feared harm to the larynx and the vocal cords, and that they needed to be changed to a standard tracheostomy possibly within hours, but certainly within days. This was not always feasible in unstable and critically ill patients, and it was unexpectedly found that long-term cricothyroidotomy was tolerated without a high incidence of negative sequelae [8,9].

Trauma surgeons at Oregon Health & Science University have carried this concept one step further. They have electively employed cricothyroidotomy in patients with challenging neck anatomy, in whom a standard elective tracheostomy could not be performed safely for long-term airway management, neither percutaneously nor with direct open dissection.

Materials and methods

A query of the trauma registry of a Level I Trauma Center was performed: all patients who underwent cricothyroidotomy for elective airway management from January 1997 to April 2000, a 40-month period, were identified as the study group. All patients were already endotracheally intubated, with all intubations occurring within 24 hours of admission, and prolonged ventilator dependence was anticipated and was the indication for a surgical airway in all patients. A comparison group was comprised of patients receiving tracheostomies. This group was selected by matching each of the cricothyroidotomy patients with the most recent patient prior to them receiving a tracheostomy.

The sole intent of introducing a comparison group was to provide information about our standard of care airway management for critically ill trauma patients with ventilator dependence during the study period. The standard of care was a standard tracheostomy through the second or third tracheal ring either percutaneously or open, according to the surgeon's preference, at the bedside in the intensive care unit (ICU). Furthermore, this was intended to equally represent potential changes in patient composition and management philosophy. Data abstracted from the patients' records were the Injury Severity Score, derived from AIS 90, the length of stay in the ICU, ventilator days, body mass index, significant anatomy, complications and death.

All patients were cared for and all procedures were performed by a group of five full-time trauma surgeons with added qualifications in critical care. Patients were followed beyond hospital discharge for subjective assessment of wound healing, breathing, and swallowing difficulties and voice changes. The available followup clinic chart notes were reviewed 1 week–15 months (average, 5.5 months) post discharge, and telephone interviews were conducted 12–24 months (average, 30 months) post discharge. These interviews were conducted by the authors, with the sole purpose of inquiring about negative sequelae from the surgical airway.

Results

The Oregon Health & Science University trauma registry identified 18 patients as the study group and selected 18 comparison patients. An unpaired *t* test confirmed that the cricothyroidotomy group was older than the comparison patients ($P < 0.05$).

There was no difference in Injury Severity Score, ICU length of stay, and ventilator days before or after the surgical airway procedure (Table 1). There was a significant difference in body mass index between the two groups. The cricothyroidotomy group had an average body mass index of 30, compared with an average of 20 in the tracheostomy group. The sole indication to choose a cricothyroidotomy over a standard tracheostomy was a technically challenging neck anatomy. These patients were morbidly obese and possessed other complicated anatomical challenges: very short necks, abundant pendulous submental adipose tissue, and the larynx positioned in the thoracic inlet rather than the neck proper, resulting in intrathoracic placement of the trachea virtually in its entire length. These challenges of individual anatomy were often coupled with the inability to favorably manipulate the neck position due to spine trauma. There were no patients with a challenging neck anatomy in the comparison (tracheostomy) group.

All cricothyroidotomies were performed open, and all procedures were carried out at the bedside in the ICU. Cannula #6 (inner diameter, 6 mm) and cannula #8 (inner diameter, 8 mm) were used for cricothyroidotomies and for tracheo-

Table 1

Patient characteristics							
	Age (years)	ISS	Days intubated prior to procedure	Vent days post procedure	ICU length of stay	Deaths prior to discharge	Deaths post discharge
Cricothyroidotomy (<i>n</i> = 18)	59.8 (27–89)	26 (5–43)	7.4 (0–19)	17.2 (8–48)	23.2 (8–48)	5	2
Tracheostomy (<i>n</i> = 18)	44.6 (16–75)	28 (10–45)	6.6 (0–20)	10.4 (1–20)	19.2 (4–60)	2	0

ISS, Injury Severity Score; ICU, intensive care unit.

stomies, respectively. There was no significant procedure time difference between the tracheostomy and the cricothyroidotomy because of the more challenging neck anatomy in the latter group. There were five inhospital deaths and two deaths after discharge from the 18 patients in the study group, compared with two inhospital deaths and no deaths after discharge in the tracheostomy group. None of the deaths in either group were airway related.

Wound healing, voice changes, and breathing or swallowing difficulties were assessed when reviewing clinical followup notes. There was only one complication identified in this retrospective fashion. One patient with a cricothyroidotomy required silver nitrate application for abundant granulation tissue.

Telephone interviews with eight of the 11 surviving cricothyroidotomy patients and with nine of the surviving 16 tracheostomy patients showed that one tracheostomy patient required surgical closure 3 months after discharge. The only other sequela reported was minor voice changes in three patients in each group. All six of these patients denied this compromised them in any way (Table 2).

There was not a single case of subglottic stenosis in either group. No patient was endotracheally intubated beyond 21 days prior to placement of the surgical airway (Table 1).

Discussion

Translaryngeal intubation is the mainstay for temporary airway management. Early experience demonstrated that prolonged translaryngeal intubation was associated with irreversible damage to laryngeal and vocal cord structures. In the 1950s and early 1960s, surgeons therefore began converting translaryngeal intubation to a tracheostomy after a short period of time, thereby bypassing and sparing the larynx. The later development of better tube designs with high-volume, low-pressure cuffs allowed for an increase in the duration of translaryngeal intubation, with a decrease in associated incidence and severity of damage to the larynx and the trachea [2]. Additional support for this approach was provided by studies citing the procedural dangers of tracheostomy placement and chronic subglottic stenosis as a perceived end result from this operation [6,7].

Table 2

Follow-up telephone interviews assessed wound healing, voice changes, breathing or swallowing difficulties

	Available survivors	Surgical closures of persistent stomas	Minor voice changes
Cricothyroidotomy	8/11	0	3
Tracheostomy	9/16	1	3

The American College of Chest Physicians published guidelines for artificial airways in patients receiving mechanical ventilation in a consensus paper in 1989 [1]. They suggested translaryngeal intubation for mechanical ventilation of less than 10 days, and they recommended tracheostomy in patients with the need for an artificial airway exceeding 21 days. Good evidence in the form of prospective data for this practice is lacking to date [2,3]. Undisputed benefits of tracheostomies are that they facilitate transfer from the ICU setting, they improve oral care and they allow the patient to speak and eat while on ventilatory support [1].

Tracheostomy is no longer the formidable procedure historically described. Better anesthesia, pre-existing airway control with translaryngeal intubation and the advent of the percutaneous method with commercially available standardized kits have made this feared procedure rather commonplace, routinely performed at the bedside away from the formal operating room environment. This procedure can nevertheless turn into a virtual nightmare with high morbidity and mortality very quickly. Loss of an airway, and with it the loss of adequate gas exchange, results in irreversible brain damage within minutes. There is a narrow window for technical error due to the delicate nature of the airway and its close proximity to the esophagus and major vascular structures. It may become a formidable task in patients with demanding neck anatomy: morbid obesity, a short neck, overhanging submental fat, or the position of the larynx in the sternal notch with virtual intrathoracic placement of the entire length of the trachea. This can be confounded by the inability to place the patient in the favored 'sniff position' due to spine trauma or significant degenerative joint disease (Figs 1 and 2).

Figure 1



Candidate for elective cricothyroidotomy: morbid obesity; no neck; pendulous overhanging tissue; thyroid cartilage positioned in sternal notch.

The alternative to a tracheostomy provides technically easier and direct access to the trachea. This procedure is known as a 'coniotomy' or 'cricothyroidotomy' and was popular before the 1900s [10]. Cricothyroidotomy is a faster, simpler and less bloody procedure, and fewer instruments are required in comparison with a tracheostomy. Its ease has been depicted in the fact that "it can be performed in a restaurant with a jack knife and the barrel of a pen for a tube" (restaurant tracheostomy) [11].

The conus elasticus or cricothyroid membrane is the most superficial portion of the airway. Easily palpated, it is usually only covered by skin and sparse subcutaneous fat. Only rarely is there an overlying thyroid isthmus remnant or a significant branch of the jugular venous system. This lends to the technical simplicity and shortened procedural time of the cricothyroidotomy.

The two classic articles by Jackson in 1909 and 1921 condemned cricothyroidotomy and 'high tracheostomy' as the major cause of chronic subglottic stenosis [6,7]. These two landmark articles defined the principles of the proper procedural technique for what is now known as the standard tracheostomy through the second or third tracheal ring. Jackson was able to substantially reduce mortality, so that his negative view of cricothyroidotomy was accepted undisputed for decades. But times have changed, and the patient population requiring a surgical airway has changed. The primary indications in Jackson's days were primary airway problems: infections, tumors, swelling, and edema. Today, long-term respiratory failure with ventilator dependence or an inability to clear secretions predominates. There is no primary acute laryngeal pathology, as pointed out by Brantigan and Grow in

Figure 2



Candidate for elective cricothyroidotomy: morbid obesity; acute multilevel spine trauma; no neck; pendulous overhanging tissue; thyroid cartilage positioned in sternal notch.

a re-examination of Jackson's papers [11,12]. Brantigan and Grow conclude that the incidence of subglottic stenosis in Jackson's era could have been related to the inflammatory process coupled with poorly performed procedures rather than to the cricothyroidotomy procedure itself. Their vast experience with elective cricothyroidotomy in postoperative cardiac patients convincingly supports this point. It is corroborated by a followup study from O'Connor *et al.* [13], who also prefer this approach over the traditional tracheostomy in their patients to protect their median sternotomy wounds from contamination. Further support comes from the trauma literature [8,9,14] where emergency cricothyroidotomies were maintained without conversion to a formal tracheostomy with low morbidity.

We have also found this to be our preferred elective surgical airway in a subset of patients with very special needs: the already described morbidly obese, and short neck or no neck patients, often coupled with an inability to favorably manipulate the cervical spine. Surgical access to the infralaryngeal trachea becomes an insurmountable technical challenge, even when attempted percutaneously. Cricothyroidotomy was performed in these challenging patients at the bedside in the ICU by experienced surgeons with added qualifications in critical care without perioperative complications. All deaths were due to the underlying illness. All surviving patients came to successful decannulation. There was no single incidence of the feared subglottic stenosis at followup. The literature offers a plausible explanation for this: all the cricothyroidotomies were performed within 20 days of translaryngeal intubation, as recommended by the American College of Chest Physicians [1]. As described even with newer endotracheal tubes, trauma to laryngeal and subglottic structures occurs with ulceration and

Key messages

- Cricothyroidotomy is recommended for elective airway management in patients with challenging neck anatomy
- A surgical airway should be considered in any patient with ventilator dependence exceeding 21 days
- The cricothyroidotomy should be performed by an experienced surgeon who is familiar with local anatomy, the potential complications, and the strategies with which to avoid them

inflammation, and the degree of damage correlates with the duration of intubation [5]. This constitutes nothing but the modern equivalent to Jackson's described acute laryngeal disease. It is therefore not surprising that more recent papers report a high incidence of subglottic stenosis if cricothyroidotomy is performed after prolonged intubation [4,5,13]. Jackson's original dogma has therefore not lost its validity today; his reasoning has to be interpreted correctly.

Our experience shows that elective cricothyroidotomy is a valuable, safe alternative surgical airway in the technically challenging patient. The decision to perform cricothyroidotomy has to be made early, however, and an experienced surgeon very familiar with the local anatomy should carry out the procedure.

It cannot be emphasized enough that this is not the technically easy, low-risk surgical access to the airway as discussed earlier, which is life saving when the airway cannot be secured any other way in an emergency situation, in patients with normal neck anatomy, in whom trachea and larynx are palpated easily. The technical challenges of the local anatomy in the described subset of patients require a surgeon very familiar with this area, who knows how to avoid technical complications such as creating false passages, bleeding from engorged veins, and premature loss of the endotracheal tube, just to name the most common and the most dangerous. The surgeon also has to be prepared to recognize and correct these complications as soon as they occur.

Competing interests

None declared.

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