Conversion of Emergent Cricothyrotomy to Tracheotomy in Trauma Patients

Peep Talving, MD, PhD; Joseph DuBose, MD; Kenji Inaba, MD; Demetrios Demetriades, MD, PhD

Objectives: To review the literature to determine the rates of airway stenosis after cricothyrotomy, particularly as they compare with previously documented rates of this complication after tracheotomy, and to examine the complications associated with conversion.

Data Sources: We conducted a review of the medical literature by the use of PubMed and OVID MEDLINE databases.

Study Selection: We identified all published series that describe the use of cricothyrotomy, with the inclusion of the subset of patients who require an emergency airway after trauma, from January 1, 1978, to January 1, 2008.

Data Extraction: Only 20 published series of cricothyrotomy were identified: 17 retrospective reports and 3 prospective, observational series.

Data Synthesis: Considerable variance in methods and follow-up periods were noted between examinations. Published experiences documented the results of 1134 total patients for whom cricothyrotomy was performed, including 368 trauma patients who underwent emergent cricothyrotomy. The rate of chronic subglottic stenosis among survivors after cricothyrotomy was 2.2% (11/511) overall and 1.1% (4/368) among trauma patients for follow-up periods with a range from 2 to 60 months. Only 1 (0.27%) of the 368 trauma patients in whom an emergent cricothyrotomy was performed required surgical treatment for chronic subglottic stenosis. Although the literature that documents complications of surgical airway conversion is scarce, rates of severe complications of up to 43% were reported.

Conclusions: Cricothyrotomy after trauma is safe for initial airway access among patients who require the establishment of an emergent airway. The prolonged use of a cricothyrotomy tube, however, remains controversial. Although no study to date has demonstrated any benefit of routine conversion to tracheostomy, considerable deficiencies in existing studies highlight the need for further investigations of this practice.

Arch Surg. 2010;145(1):87-91

The early establishment of a patent and secure airway, in either the field setting or the emergency department, is a basic tenet of trauma care. Endotracheal intubation remains the initial airway of choice for trauma patients with a decreased Glasgow Coma Scale score or airway or ventilatory compromise and can be achieved with a high degree of success in most cases. During recent years, the laryngeal mask airway and double-lumen tube (Combitube; Tyco-Kendall Healthcare Products, Mansfield, Massachusetts) have also gained popularity because of their simplicity and demonstrated effectiveness in both pre-hospital and in-hospital settings. The establishment of a surgical airway, however, remains indicated for those patients in whom these initial adjuncts fail to provide adequate airway access or for those patients with severe facial or neck injuries that preclude the insertion of an endotracheal tube. Cricothyrotomy, which can be rapidly and successfully performed in both field and hospital settings by a variety of trained professionals, has been widely advocated as the initial surgical airway of choice in these emergent situations.

Among patients who require a cricothyrotomy and survive their initial injuries, many may require the prolonged use of a surgically created airway. Traditional surgical teaching has dictated that a cricothyrotomy tube placed for emergency purposes should be converted to a tracheotomy tube within 72 hours in these patients primarily because the prolonged use of this airway access is thought to be associated with a prohibitive risk of subglottic stenosis. Although this practice continues to be advocated by contemporary authors, the literature on which this assumption is primarily based is now...
older than 80 years. A growing body of more contemporary literature has suggested that the risk associated with the prolonged use of a cricothyrotomy tube, particularly that of airway stenosis, may be much lower than previously believed. The risk of conversion, although less well examined, may also be associated with underappreciated risk. The aims of the present review are to review the literature to determine the rates of airway stenosis after cricothyrotomy, particularly as they compare with previously documented rates of this complication after tracheotomy, and to examine the complications associated with conversion.

### METHODS

We conducted a search of the medical literature using the keyword cricothyrotomy in PubMed (http://www.pubmed.gov; accessed May 6, 2008), a service of the National Library of Medicine of the National Institutes of Health and OVID MEDLINE databases. A total of 153 publications that pertain to cricothyrotomy were identified. A consensus panel of 3 reviewers (P.T., J.D., and K.I.) reviewed each study and their references to extract all studies that addressed open cricothyrotomy in human patients who require airway access (Table 1). Twenty studies were identified and analyzed to abstract the following data: patient population type, nature of cricothyrotomy tube placement, clinical outcomes, and follow-up. An additional subgroup of trauma patients was also identified for examination (Table 2).

### RESULTS

Twenty published series and studies were identified. Seventeen of these consisted of retrospective reports, and 3 were prospective, observational series. Considerable variance in methods and follow-up among these investigations was noted. In these reports, 1134 total cricothyrotomies were documented, with 511 survivors available for follow-up (Table 1). Follow-up periods ranged overall from 2 to 60 months, with a mean of 16 months. Chronic subglottic stenosis was documented in 11 of 511 overall survivors (2.2%). Surgical intervention to correct stenosis was required in 7 of the 511 survivors (1.4%).

Among trauma patients, 452 cricothyrotomies were performed. Adequate documentation that these procedures were performed for emergent airway access was available in 368. The overall rate of chronic subglottic stenosis in this setting was 0.9% (4/452) and 1.1% (4/368) when cricothyrotomy was used to establish emergent airway access. Only 1 of 368 trauma patients (0.27%) required surgical treatment for chronic subglottic stenosis after emergent cricothyrotomy for trauma (Table 2).

The examination of complications directly related to conversion to tracheotomy was limited to only 2 identified case series consisting of 15 total patients. The overall complication rate from these 2 reports was 53.3% (8/15), with a mortality rate of 28.6% in 1 series.

### COMMENT

In the late 19th century, Chevalier Jackson began to establish surgical airway operative techniques as standardized procedures. During his investigations, he conducted extensive examinations of the complications associated with the performance of these interventions. In a 1921 publication, he reported on a series of 200 cases of subglottic stenosis after the surgical creation of
airways. Among these cases, Jackson determined that 30 of the lesions were secondary to laryngeal inflammation and cartilage necrosis owing to diphtheria or other causes of inflammation. Of the remaining 170 patients with subglottic stenosis, 158 (92.9%) had undergone cricothyrotomy. After noting that the preponderance of patients with subglottic stenosis had a history of cricothyrotomy, he concluded that the use of this type of surgical airway was associated with a prohibitive risk of stenosis compared with tracheotomy. Largely on the basis of the report by Jackson, surgical dogma that advises against elective cricothyrotomy and supports the practice of early conversion to tracheotomy after emergent cases gained widespread acceptance. Even today, authors continue to recommend adherence to these principles to avoid the risk of subglottic stenosis after cricothyrotomy.11

Several subsequent examinations, however, have refuted the findings of Jackson. Brantigan and Grow32 were among the first to challenge the dogma against cricothyrotomy in 1976. These investigators reported their experience with the use of elective cricothyrotomy in 655 cardiovascular patients, without a single subglottic stenosis in their series. In our review of reports that followed, we identified 20 series with similar findings. From 20 studies we noted a chronic subglottic stenosis rate of 2.2% among survivors of hospitalization for follow-up periods that ranged from 2 to 60 months. In the largest of the prospective series of cricothyrotomy, Sise et al20 documented only 2 cases of subglottic stenosis after the use of this airway approach among 76 critically ill patients. Both of the patients with stenosis in this report were adolescent trauma patients. Each underwent cricothyrotomy only after complications associated with antecedent endotracheal intubation. As Weymuller and Cummings14 have previously shown, the performance of cricothyrotomy after previous endotracheal intubation is known to be associated with stenosis rates in excess of 30%.

In a prospective, observational study, François and colleagues35 however, total complication rates of 42% were noted after tracheotomy in a large population of pediatric patients, which suggests that any surgical manipulation of the pediatric airway may be likely to predispose patients to stenosis and other airway complications. The explanation for this, as Parrilla and colleagues34 found that the severe suprastomal stenosis (grade II, >50% of the lumen) was present in 19.2% of patients via endoscopy at a mean follow-up of 75 days.

In addition to the risk of chronic subglottic stenosis, several other concerns that pertain to the prolonged use of a cricothyrotomy tube have also been proposed. Even among advocates of the technique, concerns that pertain to the use of this form of surgical airway for children and adolescents have been voiced. In another prospective, observational study of 146 patients who underwent either open or dilatational tracheotomy, Koitschev and colleagues34 found that the severe suprastomal stenosis (grade II, >50% of the lumen) was present in 19.2% of patients via endoscopy at a mean follow-up of 75 days.

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Cricothyrotomies</th>
<th>No. With Emergent Airway Established</th>
<th>No. With Chronic SGS</th>
<th>No. Operated On</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>McGill et al,14 1982</td>
<td>26</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Miklus et al,1989</td>
<td>19</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Spalte and Joseph,1990</td>
<td>19</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Boyle et al,1993</td>
<td>69</td>
<td>69</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Sise et al,1984</td>
<td>40</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>II</td>
</tr>
<tr>
<td>DeLaurier et al,1990</td>
<td>31</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Salvino et al,1993</td>
<td>30</td>
<td>30</td>
<td>2</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Hawkins et al,1995</td>
<td>66</td>
<td>66</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Jacobson et al,1996</td>
<td>47</td>
<td>47</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Gillespie and Eisele,1999</td>
<td>10</td>
<td>10</td>
<td>Not stated</td>
<td>Not stated</td>
<td>III</td>
</tr>
<tr>
<td>Isaacs,2001</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Rehm et al,2002</td>
<td>36</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>Wright et al,2003</td>
<td>46</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>III</td>
</tr>
<tr>
<td>François et al,2003</td>
<td>9</td>
<td>Not stated</td>
<td>Not stated</td>
<td>Not stated</td>
<td>II</td>
</tr>
<tr>
<td>Total No. (%)</td>
<td>452</td>
<td>368/452 (81.4)</td>
<td>4/452 (0.9)</td>
<td>1/4 (25.0)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: See Table 1.
phagia. It has been hypothesized that injury to the cricothyroid muscle may contribute to alterations in vocal tenor and phonation. Although human data are lacking, animal studies have failed to demonstrate electromyographic or muscle morphologic changes after prolonged use of a cricothyrotomy tube. In addition, this sequel may not be unique to this particular form of surgical airway. Walts and colleagues, in a report on the follow-up of 58 survivors of tracheotomy for respiratory failure after cardiovascular surgery, noted that 24% of patients reported voice changes. The true incidence of alterations in voice after cricothyrotomy is unknown. The patients reported voice changes. The true incidence of age.40,41 Although the prolonged use of an emergently placed airway tube may predispose patients to alterations of deglutination, the particular risk of cricothyrotomy for this morbidity, compared with that of tracheotomy or orotracheal intubation, has not been defined. The risk of conversion itself has not been well established but is most certainly a concerning entity. In an examination by Wright et al,28 investigators found that, among 8 patients who underwent conversion, complications occurred in 5 (62.5%). They also noted that patients who underwent conversion required a significantly greater subsequent length of hospital stay compared with their counterparts who had continued use of their cricothyrotomy tube for airway access. In another report by Altman and colleagues,31 of 7 patients (43%) who underwent conversion at a mean of 6.1 days experienced severe complications, which resulted in 2 deaths and 1 patient with permanent neurologic impairment.

Unfortunately, the existing literature that pertains to routine conversion of cricothyrotomy to tracheotomy may raise more questions than it answers. Although the aforementioned figures are interesting, they are based largely on retrospective studies and class III studies that used mixed methods and uncontrolled patient selection. The type and size of endotracheal cannula used are also poorly documented or highly variable among existing investigations. Given that the diameter and materials of cannula involved may affect the type and rate of subglottic stenosis, the absence of this information is significant.

The diagnosis of subglottic stenosis among these studies is, unfortunately, also not universally well documented. The methods and indications for evaluation of stenosis are unclear. Follow-up procedures are highly variable and poorly documented, with no standardization. Once diagnosed, the optimal modality and timing for treatment are, likewise, not defined. The percentage of patients who require surgical correction of stenosis is also questionable because confounding comorbidities may preclude consideration for such procedures in many patients.

Because of the lack of evidence that supports mandatory conversion of emergently established cricothyrotomy to a subsequent surgical or percutaneous tracheotomy, a prospective, randomized validation of this practice is warranted. The primary end point of such trial should be designed to evaluate clinically significant subglottic stenosis that requires treatment as evaluated by endoscopic examination of the larynx, vocal cords, and trachea before intensive care unit discharge and decannulation and during the postdecannulation follow-up. Secondary end points would include complications associated with the second procedure, such as tracheoinnominate fistula, incidence of aspiration and pneumonia, acute respiratory failure owing to inadvertent decannulation, tracheoesophageal fistula, chronic dysfunction of the vocal cords, deglutination abnormalities, and voice alterations. Other important end points would be markers of efficacy, such as length of stay in the intensive care unit and the hospital, time to decannulation, and cost analysis. Given the small number of emergently established cricothyrotomies at a single institutional level, a multi-institutional trial is necessary to validate the practice.

In conclusion, several class III studies have suggested that there is no benefit associated with conversion of cricothyrotomy to tracheotomy. Conversely, no existing literature supports the routine use of this practice. In the absence of adequate evidence on which to base practice, however, the role of routine conversion of emergent cricothyrotomy to tracheotomy remains a matter of contention. Prospective investigation designed to settle this debate is warranted.

Accepted for Publication: January 14, 2009.

Correspondence: Joseph DuBose, MD, Los Angeles County and University of Southern California Medical Center, 1200 N State St, Room IPTN123, Los Angeles, CA 90033-4525 (jjd3c@yahoo.com).

Author Contributions: Study concept and design: Talving, DuBose, Inaba, and Demetriades. Acquisition of data: Talving, DuBose, and Inaba. Analyzing and interpreting data: Talving, DuBose, and Inaba. Drafting of the manuscript: Talving, DuBose, and Inaba. Critical revision of the manuscript for important intellectual content: Inaba and Demetriades. Study supervision: Demetriades.

Financial Disclosure: None reported.

REFERENCES

8. Jacobson LE, Gomez GA, Sobieray RJ, Rodman GH, Solotkin KC, Misinski ME.