A Standing-order Protocol for Cricothyrotomy in Prehospital Emergency Patients

Evadne G. Marcolini, MD, John H. Burton, MD, Jay R. Bradshaw, EMT-P, Michael R. Baumann, MD

Abstract

Objective. To study utilization, indications, and outcomes associated with the use of a statewide, emergency medical services (EMS) standing-order protocol for cricothyrotomy. **Methods.** A statewide EMS database was queried for patients who received cricothyrotomy under a standardized, standing-order protocol. Patient EMS and hospital records were reviewed in a defined sequence with information recorded on a standardized collection form. **Results.** EMS records included eight years of practice with 1.5 million patient encounters. For each year studied, approximately 540 emergency medical technicians (EMTs) were certified to perform cricothyrotomy. State EMS providers performed a collective mean of eight cricothyrotomy procedures per year (range, 1–17), for a total of 68 cricothyrotomies performed within the eight-year period. Hospital records were available for review in 61 patients. Fifty-six patients received cricothyrotomy by open surgical incision, six by needle with jet ventilation, and one by both methods. Categorization of cricothyrotomy patients as trauma or medical was 61% trauma and 39% medical. Thirty-six patients (59%) were in cardiac arrest on EMS arrival and 12 patients (20%) died during transport. Thirteen trauma patients (21%) were admitted with eight patients surviving to discharge (13%). The neurologic impairment at time of hospital discharge was severe in four, moderate in two, and minimal or none in two patients (3%). **Conclusion.** A considerable percentage of cricothyrotomy procedures were performed on patients with non-trauma-related diagnoses in this investigation describing a standing-order EMS protocol for cricothyrotomy. The majority of patients undergoing cricothyrotomy with this protocol were in cardiac arrest at the time of cricothyrotomy, with a small minority of patients surviving to hospital discharge and fewer surviving neurologically intact. **Key words:** cricothyrotomy; emergency medical services; endotracheal intubation.

PREHOSPITAL EMERGENCY CARE 2004;8:23–28

Received May 23, 2003, from the University of Vermont School of Medicine (EGM), Burlington, Vermont; the Department of Emergency Medicine (JHB, MRB), Maine Medical Center, Portland, Maine; and Maine Emergency Medical Services (JRB), Augusta, Maine. Revision received August 19, 2003; accepted for publication August 22, 2003.

Supported by grants from the Maine Medical Center Research Institute and the University of Vermont School of Medicine.

Address correspondence and reprint requests to: John H. Burton, MD, Department of Emergency Medicine, Maine Medical Center, 22 Bramhall Street, Portland, ME 04102. e-mail: <burtoj@mmc.org>.
doi:10.1197/S1090-3127(03)00277-6

For more than 20 years, emergency medical services (EMS) practice protocols have included cricothyrotomy as an invasive procedure of last resort to secure the airway of the most critical of prehospital patients when intubation attempts have been unsuccessful.[1–3] In some EMS systems, other airway procedures such as multilumen airway or laryngeal mask airway are available and may provide a less invasive method of securing an airway after failed intubation attempts.[4–7]

Previous studies have investigated surgical cricothyrotomy utilization by prehospital personnel with online medical control in trauma patients as well as cricothyrotomy utilized by flight nurses and physicians.[8–12] We are unaware of any previous investigation that has described a standing-order EMS cricothyrotomy protocol for patients with trauma and medical diagnoses. The objective of this study was to describe the utilization, indications, and outcomes associated with the use of a statewide, EMS standing-order protocol for cricothyrotomy.

Methods

Study Design

The study was a retrospective health records survey of EMS records from January 1, 1993, through December 31, 2000. The Maine Medical Center Research Institute Institutional Review Board (IRB) for Research on Human Subjects approved the study.

Population and Setting

The Maine state EMS system is primarily a rural EMS system with advanced life support (ALS) and basic life support (BLS) personnel. Approximately 200,000 annual patient encounters occur in this system.

The state of Maine has a population of 1.3 million with census of 41.3 persons per square mile. Prehospital resources include an air ambulance service in the state in addition to ground-based EMS services. Typical ground-based transport times vary greatly throughout the state and include prehospital ground transport times up to two hours given the number of Maine hospitals relative to the geographic state size. Additionally, the mountainous topography of Maine frequently presents communication challenges for EMS providers contacting hospital-based medical control via radio and cell phone. This challenging environment

is recognized by EMS participants as a provocation for the maintenance of standing-order EMS practice protocols, particularly for potentially lifesaving procedures such as cricothyrotomy.

Prehospital providers document all EMS patient encounters on standardized data collection sheets. These data collection sheets are entered into a health records database and maintained by the state Health Information Center (HIC). The data entered include demographics, presumed injury type or illness, vital signs, physical assessment, and prehospital patient interventions and management.

The EMS run report directs the prehospital provider to classify prehospital diagnosis and assessment as either trauma or medically related. This descriptor is further subclassified by the EMS provider. Subclassifications for trauma patients include multisystem trauma, isolated head injury, burn, soft tissue injury, fracture, or other. Medical encounters are subclassified as cardiac, poisoning/overdose, respiratory, behavioral, diabetic, seizure, cerebrovascular accident, obstetrics/gynecology, cardiac arrest, or other.

For prehospital airway management, the database includes indicators for the endotracheal intubation procedure and providers' self-assessments of intubation success. Prehospital personnel do not describe the total number of endotracheal intubation attempts per patient encounter. Additionally, the provider level of licensure is not described in the database. Detection of all prehospital cricothyrotomies is accomplished via an individual checkbox on the EMS run report for attempted cricothyrotomy, which is to be checked regardless of success of procedure. Additionally, the narrative section of the run report includes a description of patient care, including all procedures.

Maine EMS providers treat patients according to statewide, standardized treatment protocols applicable to all prehospital personnel. A Medical Direction and Practice Board consisting of a physician medical director from each of the state's six EMS geographic regions as well as the state physician medical director administer these protocols. The state protocols in effect during the study period included treatment protocols specific to chief complaints (e.g., chest pain) in addition to diagnosis (e.g., asthma).

No neuromuscular-blocking agents or induction agents were available to ground transport EMS personnel during the study period. In 1998, an air medicine flight program began operations in the state and included these agents as well as laryngeal mask airways or cricothyrotomy for difficult airway management. Protocol indications for intubation included respiratory arrest, adult coma, seizure, and the unconscious patient with ventricular fibrillation, ventricular tachycardia, wide complex tachycardia, asystole, and pulseless electrical activity.

During the study period, no alternative devices existed in Maine airway management and patient treatment protocols (e.g., laryngeal mask airway or Combitube) for ground EMS personnel. The state EMS protocols have included the use of cricothyrotomy as a standing-order direction since 1988.

The standing-order direction (no online medical control required) for cricothyrotomy existed for those patients whom EMS providers believed required an airway intervention and were unable to undergo successful bag–valve–mask ventilation or endotracheal intubation. The indications for this procedure include respiratory arrest, with or without obstruction, when other EMS provider maneuvers to secure a definitive airway are unsuccessful. This indication has been maintained in the Maine EMS practice protocols to allow the prehospital provider substantial latitude in deeming the appropriateness and necessity of an emergent cricothyrotomy for any prehospital patient with trauma or medically related illness.

The cricothyrotomy component of the Maine paramedic curriculum consists of didactic presentation and live intubations or mannequin training. The state EMS protocol allows for application of cricothyrotomy only by providers at the paramedic level of licensure. The teaching component does not specify a method to be used by the provider for cricothyrotomy. Methodologies for cricothyrotomy technique include transverse or horizontal incision with placement of a Shiley (Mallinckrodt, Inc., Hazelwood, MO) or endotracheal tube.[1–3,13,14]

All Maine-licensed paramedics are eligible to perform cricothyrotomy. Paramedic-level licensure renewal requires continuing education credit in airway management as well as participation in a skill laboratory with cricothyrotomy review and self-assessment.

Study Measurements and Key Outcome Variables

The state EMS database was queried for all patients who underwent a prehospital cricothyrotomy procedure during the defined study period. Data reviewed included the number of providers licensed with the state EMS office as eligible to perform cricothyrotomy during each study year, number of cricothyrotomy attempts performed annually in the EMS system, and provider self-reported cricothyrotomy success rates. Descriptors of patients undergoing cricothyrotomy included patient age, gender, prehospital diagnosis, and other treatments rendered during the prehospital encounter. Hospital records for cricothyrotomy patients were reviewed at the EMS destination hospital for each patient.

A study investigator (EGM) reviewed patient EMS and hospital records in a defined sequence. This

sequence involved identification of study subjects from the Maine EMS database, gathering and reading EMS run reports, requesting and review of hospital records, and collection of investigational information into a standardized study database. The investigational database was derived with variables defined by the study investigators before the initiation of data collection. All EMS run reports and hospital records were entered into the database as they were received. Specific coding rules for the investigation database were predefined in a database manual. Missing data were accounted for by specific coding within the database.

All documentation of successful cricothyrotomy placement was interpreted from narrative description in the EMS run report or hospital records. Paramedic-confirmed success implies that within the narrative of the EMS run sheet, the paramedic describes a functioning cricothyrotomy. Physician-confirmed success implies that the physician describes a functioning cricothyrotomy within the narrative of the emergency department chart or other hospital record.

Given the latitude inherent in the Maine EMS indications for prehospital cricothyrotomy as well as the retrospective limitations of investigational data, the study investigators elected not to categorize the appropriateness of the performed cricothyrotomies except as noted in the manuscript. Rather, the investigators have chosen to communicate descriptive information and categorization of the procedures performed.

For the purposes of this study, patient outcomes were graded with regard to neurologic outcome by an investigator-defined, nonvalidated categorization. Given the retrospective nature of the study and the limited and variable neurologic data available for review, the investigators elected not to categorize neurologic outcome via a more complete or validated scheme (e.g., NIH Stroke Scale). Definitions for the neurologic categorizations of patients are as follows: (1) "severe": patient is unable to resume independent living; (2) "moderate": patient is able to resume independent living, although with major restrictions to daily functions; and (3) "minimal or none": patient is able to resume independent living with minimal or no impairment of functions.

ANALYTICAL METHODS

All state EMS database patient information, within the investigation period, was extracted into a study patient database, Microsoft Excel 97 (Microsoft Corp., Redmond, WA). Measurements are reported using descriptive statistics. Selected continuous variables are reported as mean ± standard deviation (SD). The software package used for data collection and analysis was SPSS 11.0 (SPSS Inc., Chicago, IL).

RESULTS

Cricothyrotomy Encounters, Providers, and Patients

Patient prehospital encounters during the study period are shown in Figure 1. The mean number of patient encounters was 167,000 per year. Eight of the reported cricothyrotomies were considered duplicates because they were reported on two separate run sheets by different responding EMS services for the same call.

Each year, a mean of eight cricothyrotomy procedures was recorded in the Maine EMS database (range, 1–17/yr). The last three years of study revealed the largest annual number of cricothyrotomies (range, 11–17), whereas the initial five-year period documented 1–6 annual procedures. The investigators were unable to identify any rationale accounting for this utilization trend.

For each year studied, approximately 540 EMS providers were certified to perform cricothyrotomy. Within the eight-year investigation period, 51 of the 540 eligible providers attempted cricothyrotomy (range, 1–5 cricothyrotomy procedures per cricothyrotomy provider). Forty-nine providers were observed to have performed between one and two procedures each during the study period. One provider documented three procedures with another identified in five

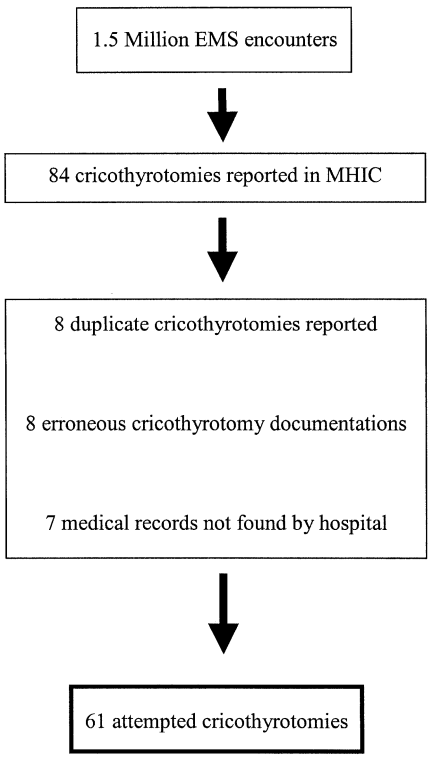

FIGURE 1. Emergency medical services (EMS) cricothyrotomy activity during the study period, 1993–2000. MHIC = Maine Health Information Center.

procedures. These last two providers were EMS providers who worked for a number of EMS organizations during the investigational period, primarily urban-based services/populations. The investigators did not identify any apparent inappropriateness for patient selection in the cricothyrotomy application by these two individuals.

The mean age of cricothyrotomy subjects was 46 ± 14 years (range, 14–85 yr). Documentation of gender revealed cricothyrotomy patients to be 62% male and 38% female. Forty-four percent of cricothyrotomy patients were transported to one of the three state-designated trauma centers with the remainder transported to one of 16 smaller hospitals.

Trauma and medical categorization of cricothyrotomy patients included 37 (61%) patients with trauma-related injuries and 24 (39%) with medical diagnoses. The trauma injuries/mechanisms and medical diagnoses for cricothyrotomy patients are summarized in Table 1. Patients with airway obstruction included two with food-related obstructions and two with obstructions from objects not specified in the medical records. Nineteen (31%) patients sustained closed head injury with no findings of facial trauma documented on the EMS run report or hospital records. Patients with gunshot wounds included three with substantial facial trauma and one with excessive blood in the airway.

TABLE 1. Medical Diagnoses and Trauma Mechanisms for Cricothyrotomy Patients during the Study Period, 1993–2000 (n = 61)

	No.	Percent of Total
Medical patients (n = 24)		
Cardiac arrest	9	14.8
Respiratory arrest	4	6.5
Airway obstruction	4	6.5
Seizure	2	3.3
Drowning	1	1.6
Carbon monoxide poisoning	1	1.6
Stroke	1	1.6
Anaphylaxis	1	1.6
Hypothermia	1	1.6
Total	24	39.3
Trauma patients (n = 37)		
Closed head injury		
Motor vehicle crash	9	14.8
Motorcycle crash	4	6.5
Fall	2	3.3
Car vs. pedestrian	1	1.6
Car vs. bicycle	1	1.6
Snowmobile crash	1	1.6
Hit by falling tree	1	1.6
Total	19	31.1
Facial trauma		
Motor vehicle crash	7	11.5
Motorcycle crash	3	4.9
Tire explosion	1	1.6
Total	11	18.0
Penetrating injury		
Gunshot wound to head	4	6.5
Knife wound to neck	1	1.6
Total	5	8.2
Unspecified trauma	2	3.4

Cricothyrotomy Procedures

Ninety percent of patients received cricothyrotomy by open surgical incision. Six cricothyrotomy procedures (10%) were performed by needle and jet ventilation (two trauma and four medical patients), including one who had an attempted needle cricothyrotomy followed by open surgical incision. This patient, a 12-year-old motor vehicle crash victim with facial trauma, had unsuccessful sequential prehospital attempts at bag–valve–mask, oral intubation, needle cricothyrotomy, and surgical cricothyrotomy. In the hospital, an endotracheal tube was placed through the prehospital surgical opening. This patient survived to the operating room, although not to discharge.

Cricothyrotomy Patient Outcomes

The 13 patients surviving to hospital admission received a cricothyrotomy subsequent to trauma-related injury. The neurologic categorization of patients discharged from the hospital is presented in Figure 2 with patient case details summarized in Table 2.

Cricothyrotomy Success Rates and Complications

The prehospital provider reported cricothyrotomy success in 54 (89%) patients and cricothyrotomy failure in seven patients. Of the 54 cricothyrotomy patients

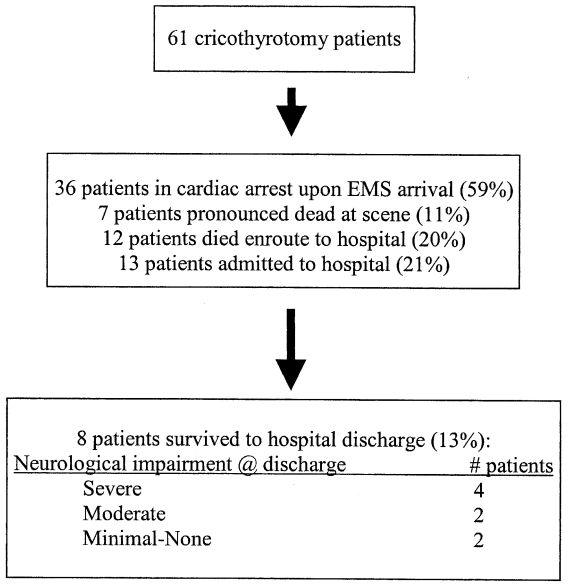

FIGURE 2. Outcomes for emergency medical services (EMS) patients who underwent cricothyrotomy during the study period, 1993–2000.

TABLE 2. Case Details of Cricothyrotomy Patients Who Survived to Hospital Discharge during the Study Period, 1993–2000

Patient No.	Age (yr)	Gender	MOI	Injuries	Neurologic Impairment at Discharge
1*	75	Male	GSW to head	Facial trauma airway obstructed	None
2	51	Female	MVC	Facial lacerations clenching	Moderate
3*	53	Male	Tree fell on patient	Head/eye wounds posturing/clenching	Moderate
4*	22	Male	Vehicle rollover ejected driver	Closed head injury facial edema tracheal deviation	Severe
5*	18	Male	MVC	Closed head injury	Severe
6*	19	Male	MVC	Closed head injury	Severe
7*	26	Male	MVC	Facial trauma	Severe
8*	47	Male	Snowmobile crash	Facial trauma laryngeal edema	Moderate

*Successful cricothyrotomy.
MOI = method of injury; GSW = gunshot wound; MVC = motor vehicle crash.

reported as having cricothyrotomy success, seven were not transported to the hospital and were pronounced dead at the scene. All patients with paramedic-reported cricothyrotomy failure were transported to the hospital.

For the patients reported by EMS providers as successful cricothyrotomy encounters and transported to the hospital (47 patients), physicians documented five as not functional on arrival to the respective emergency department and 32 were confirmed in the records as successful. Hospital physicians failed to document an assessment of the prehospital cricothyrotomy in ten patients.

Complications of cricothyrotomy procedures documented by paramedics included continuous bleeding at the site in eight patients. None of these patients required blood transfusion for the cricothyrotomy incision blood loss. Blood in the trachea was reported by the prehospital provider in three patients. An aborted cricothyrotomy attempt occurred with one patient, a 51-year-old woman. This patient was a belted driver in a high-speed motor vehicle crash. She was reported to have agonal respirations at the scene, but became combative during surgical cricothyrotomy attempt. The cricothyrotomy attempt was aborted, direct pressure was applied to the wound, and the patient was transported to the hospital.

DISCUSSION

Cricothyrotomy is commonly accepted as appropriate and necessary for airway management in critical patients with substantial facial trauma or in medical patients with an obstructed airway.[1–3] Previously published investigations have been limited to surgical cricothyrotomy in trauma patients.[8–11] We were unable to identify previous investigations encompassing cricothyrotomy for both medical and trauma patients, and those associated with a standardized, standing-order protocol. Our investigation also appears to report the largest cohort of cricothyrotomies performed by prehospital personnel (Table 3).

We found that a large number of cricothyrotomies were performed on medical patients. This finding raises the question of whether the procedure was being utilized in patients who could have otherwise been ventilated by bag–valve–mask or other alternate airway adjuncts until hospital arrival. The lack of survival in medical cricothyrotomy patients implies a lack of utility for cricothyrotomy in this setting. However, the small sample size of medical cricothyrotomy patients limits this observation. As stated, we were unable to identify previous investigations addressing the utility of prehospital cricothyrotomy to allow comparison with our findings.

We noted that a large number of cricothyrotomy patients were in cardiac arrest on initiation of the cricothyrotomy procedure. This observation has been reported in previous investigations.[8–11] This observation may reflect the injury severity inherent in many EMS cricothyrotomy patients. We did not assess cricothyrotomy patient outcome relative to injury severity to address this question. Additionally, the

TABLE 3. Characteristics of Prehospital Cricothyrotomy Investigations

	Jacobson[8]	Fortune[9]	Gerich[10]	Robinson[11]	Marcolini
Publication date	1996	1997	1998	2001	2004
Years studied	5	5	5	12	8
Method of study	Retrospective	Retrospective	Prospective	Retrospective	Retrospective
Geographic area	Urban metro	Urban metro	Flight region	Flight region	Statewide
Medical providers studied	P	P, I	MD, FP	MD, RN	P, FP
Total no. of cricothyrotomy patients	50	56	8	8	61
Medical trauma indications	T	T	T	T	M, T
Surgical/needle	S	S	S	S	S, N
Survival to hospital discharge	19 (38%)	15 (27%)	1 (13%)	not reported	8 (13%)

P = ambulance-based paramedic; I = ambulance-based emergency medical technician; FP = flight paramedic; RN = flight nurse; MD = flight physician; M = medical indications; T = trauma indications; S = surgical cricothyrotomy; N = needle cricothyrotomy.

sequence of cardiac arrest as occurring before or after the cricothyrotomy procedure in the prehospital setting was difficult to discern given the descriptive nature of the patient records.

Survivors to hospital discharge in this investigation appeared to be trauma patients with predominantly isolated blunt head, face, or neck injuries. The neurologic impairment of survivors was considerable, with only two patients surviving with little or no impairment. As stated for all EMS cricothyrotomy patients, the poor outcome associated with cricothyrotomy survivors may be a reflection of expected outcomes for this subset of critical patients. The importance of the role of cricothyrotomy is difficult to determine in a population of patients with heterogeneous injuries.

Previously published prehospital cricothyrotomy success rates, self-reported by EMS providers, have ranged from 62% to 100%.[8–11] In this investigation, we found comparatively high success rates when similarly defined by paramedic-reported success. Given the retrospective nature of this study, information regarding the physician's assessment of the cricothyrotomy was not always available. Because EMS run reports and hospital records do not require documentation of cricothyrotomy procedure success, paramedic-reported success as well as physician-reported success depended on the subjective quality of the provided narrative.

Limitations

Limitations of this study include chart review and identification methodology. We identified patient charts by using the name and date of service from EMS run reports, identified from the Maine HIC data input. As a result of this limited information, a small number of the hospital records were not available for review. Consequently, information on long-term complications was limited by the availability of hospital records.

Legibility and interpretation of narrative reports were limitations of EMS data. Most of the qualitative medical information (method, indications, number of attempted intubations, complications, and success) was derived from the narrative portion of the EMS run report. Hospital records were also inconsistent in providing information such as success of cricothyrotomy placement and were subject to interpretation of narrative information.

Given the standing-order cricothyrotomy protocol and retrospective nature of this report, it is unclear whether patients could have been ventilated adequately with bag–valve–mask or other devices until hospital arrival. Similarly, the impact of alternate airway devices not available during the study period cannot be assessed.

CONCLUSION

In this investigation describing a standing-order EMS protocol for prehospital cricothyrotomy, the majority of patients were in cardiac arrest at the time of cricothyrotomy with a small percentage surviving to hospital discharge and fewer ($< 1\%$) surviving neurologically intact. A considerable percentage of cricothyrotomy procedures was performed on patients with nontrauma-related diagnoses. All cricothyrotomy patients who survived to hospital discharge had trauma-related injuries. No cricothyrotomy patient with medical-related EMS encounters survived to hospital discharge.

The authors thank Jeri Kahl for her assistance with record retrieval and EMS run report analysis. The assistance of many individuals throughout Maine's hospitals, particularly those in emergency services and medical records, who assisted with medical record retrieval is gratefully acknowledged.

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