An Analysis of Battlefield Cricothyrotomy in Iraq and Afghanistan

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ABSTRACT

Objective

Historical review of modern military conflicts suggests that airway compromise accounts for 1–2% of total combat fatalities. This study examines the specific intervention of pre-hospital cricothyrotomy (PC) in the military setting using the largest studies of civilian medics performing PC as historical controls. The goal of this paper is to help define optimal airway management strategies, tools and techniques for use in the military pre-hospital setting.

Methods

This retrospective chart review examined all patients presenting to combat support hospitals following pre-hospital cricothyrotomy during combat operations in Iraq and Afghanistan during a 22-month period. A PC was determined "successful" if it was documented as functional on arrival to the hospital. All PC complications that were documented in the patients' record were also noted in the review.

Results

Two thirds of the patients died. The most common injuries were caused by explosions, followed by gunshot wounds (GSW) and blunt trauma. Eighty-two percent of the casualties had injures to face, neck or head. Those injured by gunshot wounds to the head or thorax all died. The largest group of survivors had gunshot wounds to the face and/or neck (38%) followed by explosion related injury to the face, neck and head (33%).

Pre-hospital cricothyrotomy was documented as successful in 68% of the cases while 26% of the PC's failed to cannulate the trachea. In 6% of cases the patient was pronounced dead on arrival without documentation of PC function. The majority of PC's (62%) were performed by combat medics at the point of injury. Physicians and physician assistants (PA) were more successful performing PC than medics with a 15% versus a 33% failure rate. Complications were not significantly different than those found in civilian PC studies, including incorrect anatomic placement, excessive bleeding, air leak and right main stem placement.

Conclusions

The majority of patients who underwent PC died (66%). The largest group of survivors had gunshot wounds to the face and/or neck (38%) followed by explosion related injury to the face, neck and head (33%). Military medics have a 33% failure rate when performing this procedure compared to 15% for physicians and physician assistants. Minor complications occurred in 21% of cases. The survival rate and complication rates are similar to previous civilian studies of medics performing PC. However the failure rate for military medics is three to five times higher than comparable civilian studies. Further study is required to define the optimal equipment, technique, and training required for combat medics to master this infrequently performed but lifesaving procedure.

Background

Historical review of modern military conflicts suggests that airway compromise accounts for 1–2% of total combat fatalities.[1,2] One recent autopsy study examining United States military casualties sustained in recent operations in Iraq and Afghanistan showed that eighteen cases or 1.8% of 982 deaths were found to have airway compromise as the likely primary cause of death.[3] Though airway related battlefield mortality is low compared to hemorrhage, the impact of airway related morbidity due to inadequate oxygenation and ventilation in the military pre-hospital setting remains undefined, and may in fact be where advances in airway management in the field holds its greatest promise. Untreated hypoxemia is not only directly detrimental to the casualty, but

also contributes to the lethal triad of acidosis, hypothermia and coagulopathy.

Airway compromise in the civilian pre-hospital setting is most often a result of cardiac and respiratory arrest in elderly patients due to pulmonary or cardiovascular disease. In the civilian trauma setting, pre-hospital airway management is most often required for patients involved in motor vehicle accidents suffering from predominantly blunt trauma.[4]

While causes of and requirements for pre-hospital airway management may differ between the civilian and military pre-hospital settings, no studies to date have examined these differences. Airway management in the military pre-hospital setting is still conceptualized and taught using commonly accepted civilian tools and algorithms such as those in Advanced Trauma Life Support and Advanced Cardiac Life Support courses. This study examines the specific intervention of pre-hospital cricothyrotomy in the combat setting over a 22-month period, the only study of this nature to date.

This study will examine injury patterns, success rates, frequency, outcomes, and complications associated with pre-hospital cricothyrotomy in the military setting compared to historical controls in the civilian literature. The goal of this paper is to help define optimal airway management strategies, tools and techniques for use in the military pre-hospital setting.

Methods

Study Design

This is retrospective chart review examining all patients who presented to combat support hospitals following prehospital cricothyrotomy during combat operations in Iraq and Afghanistan from September 2007 until July 2009.

Data Collection and Processing

The Joint Theater Trauma Registry (JTTR) is used to collect, store, and analyze battlefield casualty data for the Department of Defense incorporating data through the entire continuum of care from the point of injury through long term rehabilitative care.[5] The JTTR was queried for prehospital cricothyrotomy from September 2007 thru July 2009. Versions of the JTTR prior to September 2007 did not have pre-hospital cricothyrotomy as an ICD-9 Coded procedure that could be queried from the database.

The initial JTTR query produced 11,492 trauma admissions during the study period including 80 patients who were coded as having a pre-hospital cricothyrotomy (PC). This list was then used to gain access to the patients' scanned medical record generated at the time of their injury. Examination of medical records revealed three patients with redundant medical records from different medical facilities and five cases that were erroneously coded with no evidence of cricothyrotomy either attempted or performed. From the original query, 72 patients met inclusion criteria for PC.

Once the medical records were obtained, data were abstracted into a Microsoft Excel Spreadsheet by a single un-blinded abstractor (the author RM). Data fields and definitions are included in Table 1.

Patient outcomes, success rates, and complications were compared with historical controls. We selected the four largest civilian PC studies where PC was performed by medics in ground ambulance systems. We excluded smaller studies and those examining more advanced providers, i.e., air ambulance services.

Results

Characteristics of Study Subjects

Of the 72 cases that met inclusion criteria the vast majority were adult males in the U.S. military with an average age of 25 years while the second largest group was the Iraqi and Afghan military casualties. Demographics are shown in Table 2.

Main Results

Two thirds of the patients died. The most common injuries were caused by explosions, followed by gunshot wounds and blunt trauma (Table 4). Eighty-two percent of the casualties had injures to face, neck or head. Those injured by gunshot wounds to the head or thorax all died. The largest group of survivors had gunshot wounds to the face and/or neck (38%) followed by explosion related injury to the face, neck and head (33%) (Table 5).

Fourteen percent of the procedures were performed for failure to intubate after rapid sequence induction (RSI) by a physician or PA.

Pre-hospital cricothyrotomy was documented as successful in 68% of the cases while 21% of the PC's failed to canulate the trachea. In 6% of cases the patient was pronounced dead on arrival without documentation of PC function (Table 3). The majority of PC's (62%) were performed by combat medics at the point of injury. Physicians and physician assistants (PA) were more successful performing PC than medics with a 15% versus a 33% failure rate (Table 6).

Complications are shown on Table 7 and include incorrect anatomic placement, excessive bleeding, air leak

Table 1 Data Elements

Data Field	Definition
Country of injury occurrence	☐ Iraq ☐ Afghanistan
Patient affiliation	☐ American ☐ Local ☐ NATO
Branch of service	☐ Army ☐ Marine ☐ Navy ☐ Air Force ☐ Police ☐ Civilian
Gender	☐ Male ☐ Female
Age	☐ No exact age given ☐ Adult ☐ Pediatric
Injury type	☐ Battle ☐ Non-battle
Mechanism of injury	
Penetrating injury	☐ Gunshot wound ☐ Explosion
Blunt	☐ Motor vehicle crash ☐ Fall ☐ Assault ☐ Aircraft crash
Burns	
Provider level	☐ Medic ☐ Physician assistant ☐ Physician
First recorded Glasgow coma score (GCS)	
Injury description	
CPR initiated	☐ Yes ☐ No
Prehospital rapid sequence intubation (RSI) medications	Documented use of a sedating agent: ☐ Etomidate ☐ Versed ☐ Morphine ☐ Fentanyl
	Documented use of a paralytic agent: ☐ Succinylcholie ☐ Rocuronium ☐ Vecuronium
Intubation or airway attempts prior to cricothyrotomy	☐ Documented attempts at ETI ☐ Placement of a laryngeal mask or supraglottic airway
Complications from airway placement	☐ Documented failed airway ☐ Right main stem intubation ☐ Incorrect anatomical placement ☐ Damage to adjacent structures related to airway placement ☐ Excessive hemorrhage ☐ Prolonged hypoxia ☐ Malfunctioning airway
Successful placement of the cricothyrotomy	Placement and function documented on arrival at hospital
Cricothyrotomy technique	☐ Open surgical ☐ Percutaneous ☐ Cuffed tube vs uncuffed tube
Cause of death source	Death certificate

and right mainstem placement. In one instance an unconscious patient with a closed head injury awoke and removed the airway during transport.

Limitations

Our study has several limitations. JTTR data, like civilian trauma registries, are not population-based. Data are abstracted retrospectively from patients' medical records. Primary documentation of care at the point of injury is lacking in the vast majority of combat casualties.[6] Therefore, much of the data for this study came from the trauma flow sheet started by hospital personnel upon the patient's arrival, using what was reported from the field by flight medics or by verbal report, and then recorded onto the trauma flow sheet. The frequency of battalion aid station documentation was somewhat better. Currently, no system of pre-hospital documentation exists that reliably captures into the medical record medical care from the point of injury, during helicopter evacuation, or from forward resuscitation at a forward surgical team or aid station—even after a decade of war.

Discussion

This is the only study of pre-hospital cricothyrotomy in the combat setting that we are aware of. Table 8 compares this study with civilian studies.[7-10] This procedure is infrequently performed in the civilian setting at a rate of 0.32–0.36% of trauma admissions. It is infrequently performed in the military setting as well. However we found 0.62% of all military trauma admissions in this

Table 2

DEMOGRAPHICS	N
Age Range 5 to 50 years of age	
Pediatric patients: ages 5–14	4
Adult Patients	68
Male	69
Female	3
Iraq	59
Afghanistan	13
PATIENT CLASSIFICATION	
U.S. Military	29
Host Nation Military	22
NATO Military	1
U.S. Civilian	1
Host Nation Civilian	19
TOTAL	72

Table 3

CRICOTHYROTOMY RESULT	N	%
Cric successful	49	68
Not successful	19	26
Unknown (patients DOA)	4	6
TOTAL	72	100

Table 4

MECHANISM OF INJURY	N	%
Gunshot wounds	28	38
Motor vehicle crash	4	5
Fall	3	4
Burns	2	3
Motorcycle crash	2	3
Assault	1	2
Helicopter crash	1	2
Unknown mechanism	1	2
TOTAL	72	100

study had a PC, a rate nearly double that found in the civilian setting.

Unlike civilian emergency medical services (EMS) agencies, all combat medics and other pre-hospital providers such as battalion medical officers (physicians' assistants and primary care physicians) are trained to perform PC. There are no studies that have examined the frequency or success rate of the procedure in the combat setting. Adams et al. report that PC accounted for 5.8% of all patients with advanced airway interventions presenting to combat support hospitals in Iraq, on par with civilian PC rates that represent between < 1% to 10% of pre-hospital airway interventions.[11]

Table 5

	Total Injured		Survivors	
OUTCOME BY INJURY	N	%	N	%
Explosion Related Injuries				
Face, head or neck wounds	24	33	8	33
Chest and or abdominal	2	3	1	4
wounds	3	4	2	8
Altered LOC	1	1	0	0
Facial burn				
Gunshot Wounds				
GSW to face and/or neck	14	19	9	38
GSW to the head	12	16	0	0
GSW to the chest	2	3	0	0
Blunt Injury				
Closed Head Injury	7	10	3	13
Severe polytrauma	5	7	0	0
Burns				
Facial Burn	2	3	1	4
TOTAL	72	100	24	100

The most common injuries associated with PC in this study were:

1. From facial or neck trauma and burns, presumably for relief of a primary airway obstruction (56% of cases);
2. Casualties with severe injuries without primary airway injury, to include isolated GSWs to the head (16%), penetrating trauma to the thorax (6%) severe polytrauma (7%), closed head injury (10%) and loss of consciousness following explosions (4%); and
3. In the event that the provider cannot intubate or ventilate following sedation and paralysis during attempted RSI at the aid-station (14%).

Outcomes in this study are similar to other civilian studies. The vast majority of patients who underwent PC died. Those with GSWs to the head, to the chest, or severe polytrauma all died. In these cases PC was likely performed for resuscitation when a definitive airway could not be established (first responders unable to perform RSI, trismus, intact gag reflex, etc) as the primary lethal injury was not airway-related. The largest group of survivors were those with GSWs to the face and/or neck followed by those with explosion-related injuries to the face, neck, and head. These patients were most likely to have a mechanical obstruction from disruption of normal airway anatomy that benefitted from PC and reestablishing effective ventilation.

Success rates in this military population were lower than those described in studies of civilian pre-hospital providers (Table 8). We found a 21% overall failure, with 33% of the PCs performed in the field by medics who failed to canulate the airway. Physicians and physician

Table 6

OUTCOME: Aid Station vs Field	Number of PCs Performed %	Number of Survivors %	Successful	Failed	Unknown Result
Battalion Aid Station	27 (38%)	10 (37%)	21 (77%)	4 (15%)	2 (7%)
Field	45 (62%)	14 (31%)	28 (62%)	15 (33%)	2 (4%)

Table 7

COMPLICATIONS	N	%
Right Main Stem Bronchi Placement	6	8
Excessive Bleeding	4	5
Incorrect Anatomical Location	3	4
Air leak through mouth	1	2
Patient Awoke and Removed Airway	1	2
TOTAL	15	21

assistants in the aid station were somewhat better with a 15% failure rate.

While there are differences in the success rates in the military versus civilian setting, it is important to highlight differences in training, as they are not directly equivalent. Civilian pre-hospital providers performing PC in the United States are all trained to the paramedic level at a minimum. Military medics in the U.S. Army are trained to the Emergency Medical Technician-Basic level. They undergo additional training in PC using standard plastic manikins or "airway heads." They do no clinical rotations with the anesthesia service or in the emergency department, nor do they have access to a cadaver lab or live-tissue training methods during their initial training. Civilian EMS systems with high advanced airway management success rates routinely include intensive clinical and laboratory training as a mandatory part of their paramedic training programs[12-14] whereas the military medic may encounter their first opportunity to place an advanced airway in a real patient while they are under fire in combat.

There is also a similar discrepancy in comparing physicians and PAs working in a forward aid-station against civilian studies. Most forward deployed medical officers are primary care providers. Some have completed only an internship and are awaiting a residency selection. The military physician assistant was historically an experienced former enlisted combat medic is now more likely not to have had any prior experience as a medic. All deploying providers are required to attend a week of additional medical training focused on combat medicine where they are trained in airway management techniques including RSI and PC. This training is at best a "just in time" familiarization of airway management. Comparing these success rates to the civilian setting where cricothyrotomy performed by physicians is most often in an emergency department resuscitation bay where trained emergency physicians, trauma surgeons, and anesthesia staff are close at hand would likewise not be equitable.

Complications related to PC in this study were not significantly different than those previously described in the civilian setting. These complications included, but were not limited to, incorrect anatomical placement, bleeding, air leaks, and right mainstem placement.[7-10]

The military training standard for PC is the open surgical technique using a scalpel, a tracheal hook and most commonly a standard 6.0mm cuffed endotracheal (ET) tube. While commercial kits are becoming more available (H&H Associates, North American Rescue Products, Tactical Medical Solutions), these have not been universally adopted due to their expense and availability compared to the ubiquitous availability of ET tubes and a conventional scalpel.

In this study we found 8% of the PCs were emplaced in the right mainstem bronchus. This is not a surprising finding, and can be attributed to using regular cuffed ET tubes in an improvised fashion while performing a PC during battlefield conditions. A high frequency of right main stem intubation with PC in the civilian setting has been observed as well with conventional ET tubes.[8]

Enlisted military medics and relatively junior physicians and physician assistants are the providers most likely to care for patients forward of the combat support hospital. These providers often do not have the ability, the equipment, drugs, or the training to perform RSI on the battlefield. Even if it were feasible, paralyzing a patient to manage an airway in the context of a single medic, multiple casualties and ongoing combat operations is inherently problematic. Previous studies suggest that patients with severe trauma who tolerate intubation or superglottic airway placement without sedation have a very high mortality rate[17,18] and that battlefield airway death is often related to trauma to the face and neck causing airway obstruction and hemorrhage into the airway.[3] In this study, the majority of PC's were performed on patients with trauma to the face and neck. Given these circumstances, we suggest cricothyrotomy as the primary

Table 8 Comparison to Civilian Studies

	Spaite (10)	Jacobson (7)	Fortune (8)	Marcolini (9)	Mabry
Publication Date	1990	1996	1997	2004	2012
Years Studied	2	5	5	8	22 months
Method of Study	Retrospective	Retrospective	Retrospective	Retrospective	Retrospective
Geographic Area	Urban metro	Urban metro	Urban metro	Statewide	Iraq, Afghanistan
Total Trauma Patients	Not provided	14,772	15,686	Not provided	11,492
% of Patients with PC	Not provided	0.32%	0.36%	Not provided	0.62%
Medical Providers Studied	P	P	P,I	P,FP	MM, MD, PA
Total Number of PC Patients	16	50	56	61	72
Medical or Trauma Indications	T	T	T	M,T	T
Surgical/Needle	S	S	S	S,N	S
Survival Rate	1 (6%)	19 (38%)	15 (27%)	8 (13%)	24 (33%)
Failed Attempts	2 (12%)	3 (6%)	6 (10%)	5 (8%)	19 (26%)
Minor Complications	3 (19%)	19 (38%)	2 (4%)	11 (18%)	15 (21%)

Note: P = Paramedic, I = Intermediate, FP = Flight Paramedic, MM = Military Medic

advanced airway maneuver of choice for medics on the battlefield. Yet one out of every three placed by medics in the combat setting was unsuccessful.

Conclusion

The majority of patients who underwent PC died (66%). The largest group of survivors had gunshot wounds to the face and/or neck (38%) followed by explosion related injury to the face, neck and head (33%). Military medics have a 33% failure rate when performing this procedure compared to 15% for physicians and physician assistants. Minor complications occurred in 21% of cases. The survival rate and complication rates are similar to previous civilian studies of medics performing PC. However, the failure rate for military medics is three to five times higher than comparable civilian studies. Further study is required to define the optimal equipment, technique, and training required to for combat medics to master this infrequently performed but lifesaving procedure.

Note

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