FATAL AIRWAY INJURIES DURING OPERATION ENDURING FREEDOM AND OPERATION IRAQI FREEDOM

Robert L. Mabry, MD, Jason W. Edens, MD, Lisa Pearse, MD, Joseph F. Kelly, MD, Howard Harke, MD

ABSTRACT

Introduction. Airway compromise is the third leading cause of potentially preventable death on the battlefield. An understanding of the injuries associated with fatal airway compromise is necessary to develop improvements in equipment, training, and prehospital management strategies in order to maximize survival. Objective. To determine injury patterns resulting in airway compromise in the combat setting. Methods. This was a subgroup analysis of cases previously examined by Kelly and colleagues, who reviewed autopsies of military personnel who died in combat in Iraq and Afghanistan between 2003 and 2006. Casualties with potentially survivable (PS) injuries and deaths related to airway compromise previously identified by Kelly et al. were reviewed in depth by a second panel of military physicians. Results. There were 982 cases that met the inclusion criteria. Of these, 232 cases had PS injuries. Eighteen (1.8%) cases were found to have airway compromise as the likely cause of primary death. All had penetrating injuries to the face or neck. Twelve deaths (6%) were caused by gunshot wounds, while six deaths (33%) were caused by explosions. Nine cases had concomitant injury to major vascular structures, and eight had significant airway hemorrhage. Cricothyroidotomy was attempted in five cases; all were unsuccessful. Conclusion. Airway compromise from battlefield trauma results in a small number of PS fatalities. Penetrating trauma to the face or neck may be accompanied by significant hemorrhage, severe and multiple facial fractures, and airway disruption, leading to death from airway compromise. Cricothyroidotomy may be required to salvage these patients, but the procedure failed in all instances in this series of cases. Further studies are warranted to determine the appropriate algorithm of airway management in combat casualties sustaining traumatic airway injuries. Key words: airway; tactical; cricothyroidotomy; Operation Iraqi Freedom; Operation Enduring Freedom; Iraq War; combat

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INTRODUCTION

Historically, airway compromise represents the third leading mechanism of potentially preventable death on the battlefield, behind compressible hemorrhage and tension pneumothorax.1 Significant advances have recently been made in the battlefield management of severe hemorrhage. Tourniquets are being used at higher rates for severe extremity injuries, and evidence supports their use for hemorrhage control in combat casualties.2–4 Hemostatic dressings are being employed in the field of battle for use in instances of hemorrhage not amenable to tourniquets, and recent studies demonstrate successful outcomes with the use of the agents.5,6 Additionally, further work is showing the efficacy of newer hemostatic dressings to control severe hemorrhage.7 Field medics are instructed on the diagnosis of tension pneumothorax in those casualties demonstrating respiratory distress with associated torso trauma. These medics are given 14-gauge, 3.25-inch needles and have the necessary training to perform needle thoracostasis in any casualty in whom a tension pneumothorax is suspected.8 To date, there are no studies examining combat-related airway injuries or prehospital airway management on the battlefield.

In order to formulate treatment strategies, design new equipment, and develop appropriate training...
protocols for battlefield medics and military physicians, it is important to understand the injuries associated with military trauma. Injury patterns in military conflicts differ from those seen in civilian trauma, as penetrating injuries predominate. The conflicts in the last several years show that the majority of injuries are due to high-velocity projectiles and explosions, which, for the most part, are extremely rare in civilian settings. These findings have directed combat casualty research and provided avenues and opportunities to improve combat casualty care.

Physicians are not typically present at the point of injury (POI) during combat operations. Battlefield care follows a "chain of survival" similar to civilian emergency medical services (EMS) models. Soldiers are taught to treat themselves initially, i.e., "self-aid," if they are not totally incapacitated. Bystander care or "buddy-aid" follows. Next is first-responder or "Combat Lifesaver" care, followed by care from the combat medic. The combat medic is trained to the National Registry of Emergency Medical Technicians-Basic (EMT-B) level with some advanced training in intravenous access and airway management, including proficiency with the King LT, the esophageal-tracheal Combitube (ETC), and surgical cricothyroidotomy. The combat medic is often the highest-level provider at the POI and may be required to attend to numerous casualties, many times alone, with a minimal amount of equipment that is often limited to that carried on his or her back. Evacuation times to surgical care may vary from a few minutes to several hours, and the combat medics are responsible for providing continued care to casualties until arrival to the forward surgical team or combat support hospital.

The purpose of this study was to examine the cases of fatal airway compromise on the modern battlefield. An understanding of these injuries is necessary to develop improvements in equipment, training, and prehospital management strategies that will maximize survival. Additionally, with increased concerns for mass violence, including terrorist attacks, bombings, heavily armed criminal gang activity, and mass shootings, this study may provide helpful information for civilian EMS providers who will be the first responders in these situations.

**METHODS**

This was a retrospective subgroup analysis of cases previously examined by Kelly and colleagues, who reviewed the autopsies of military personnel who died in combat in Iraq and Afghanistan from March 2003 to April 2004 and from June 2006 to December 2006. Institutional review board approval for the study was provided by the U.S. Army Institute of Surgical Research and the Armed Forces Institute of Pathology. All U.S. combatants from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) whose remains are recovered are transported to Dover, Delaware, where scientific identification and forensic examination are performed by the Office of the Armed Forces Medical Examiner (OAFME). Autopsy reports, photographs, available treatment records, and radiograph reports are kept on file with the Armed Forces Medical Examiner System in Rockville, Maryland. Autopsies were coded for Abbreviated Injury Scale (AIS) score and Injury Severity Score (ISS) using the 1998 versions by a single person certified in both AIS and ISS coding. Cases were examined for the mechanism of injury, age, branch of service (Army, Navy, Air Force, or Marines), combat theater (OIF or OEF), medical examiner reports, autopsy photographs, toxicology, and medical intervention received.

All cases studied consisted of combat fatalities and were categorized as killed in action (KIA), if they died before reaching medical care staffed with a physician, or died of wounds (DOW), if they died after arrival at a medical treatment facility. A panel of surgical residents, a military trauma surgeon, a civilian trauma surgeon, a trauma nurse, and a trauma epidemiologist were assembled for study of these cases. Forensic pathologists were available for consultation as needed. As in civilian studies for similar analysis of preventable deaths, the panel used a consensus rule format to determine whether an injury could be classified as potentially survivable (PS) or was non-survivable (NS). In the initial review, all members of the panel examined the mechanism of injury, ISS, age, medical examiner reports, and care received at the point of wounding to determine which cases merited further in-depth review. Cases that required deoxyribonucleic acid (DNA) identification because of the extensive nature of the injuries, or whose cause of death was labeled as "catastrophic" or "total body disruption," were recorded as NS and not reviewed further. In-depth review of the selected cases was conducted in a format similar to a morbidity and mortality conference, and, following critical analysis and discussion, the panel came to a consensus on the classification of the fatality.

The fatalities were classified as PS or NS as described in a similar study conducted on Special Operations fatalities. The panel's intent of this initial study was to identify the upper bound of PS injuries and to err on the side of inclusion, since defining too many injuries as NS might miss opportunities for improvements in Tactical Combat Casualty Care (TCCC). Therefore, generous criteria were used to determine whether a casualty's injuries were PS. Survivability was determined based on the injuries as identified at autopsy by the medical examiners. Treatment was noted when evident, but evidence of treatment was not used in the determination of survivability. If multiple wounds were
identified, each was evaluated individually for potential survivability. For example, if a casualty had three significant injuries of which each alone would be survivable, that case was considered PS. In this analysis, all patients were assumed to have immediate access to a fully equipped U.S. military surgical hospital. As mentioned previously, this assumption was made in order to open discussion for improvements in TCCC.

This study examined casualties with PS injuries whose deaths were related to airway compromise as previously identified by Kelly et al. These cases were reviewed in depth by a second panel consisting of a military surgical resident, a military emergency medicine physician, a trauma epidemiologist, and a forensic pathologist to evaluate and assess combat-related airway injuries and prehospital airway management on the battlefield.

RESULTS

Nine-hundred eighty-two cases were examined in the initial review by Kelly and colleagues. All casualties were U.S. servicemen who were killed in either OIF or OEF. Of these, 232 cases (24%) had PS injuries. Twenty-eight of the PS cases were initially identified as having airway compromise contributing to death.

Ten cases were eliminated after in-depth review determined that airway interventions at the POI would not have changed survival. These cases included three drownings, two with massive central nervous system (CNS) injury, two with >90% body surface area (BSA) burns and significant burns of the trachea, one with multiple severe injuries, one with transection of the bilateral carotid arteries, and one with traumatic asphyxia whereby the casualty’s chest was pinned under a collapsed stone wall.

Eighteen cases (1.8% of the total deaths) were found to have airway compromise as the likely mechanism of death (Table 1). All casualties had traumatic injury to the face or neck. Twelve (67%) were caused by gunshot wounds (GSWs), with seven casualties sustaining single GSWs and five casualties sustaining multiple GSWs. Six deaths (33%) were due to explosions. Nine cases (50%) demonstrated concomitant injury to major vascular structures, and eight of these nine had significant airway hemorrhage.

The majority of patients (83%) were severely injured, with ISSs > 15, and the average ISS among the casualties was 28 (range: 4–50). Injuries caused by explosions were typically the most severe, with an average ISS of 34 (range: 14–50). Injuries caused by a single GSW had an average ISS of 20 (range: 4–34), while those caused

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CS-5 = cervical vertebrae 5-6; DOW = died of wounds; ETT = endotracheal tube; GSW = gunshot wound; IED = improvised explosive device; ISS = Injury Severity Score; KIA = killed in action; T1 = thoracic vertebra 1.
by multiple GSWs had an average ISS of 31 (range: 29–36).

Eleven of the 18 casualties died on the battlefield, classified as KIA, and seven died of wounds in a medical facility, classified as DOW. All casualties classified as DOW showed autopsy evidence of attempted resuscitation. An endotracheal tube was present in five casualties (28%): four in the DOW group and one in the KIA group. The pathology report of the KIA casualty explained that the endotracheal tube was in the esophagus at autopsy. In five cases (three KIA, two DOW) (28%), a surgical incision over the anterior neck suggestive of a cricothyroidotomy was present. In each of the five instances, there was no evidence or mention on pathology report of an airway adjunct in the trachea. Ten of 18 casualties (56%) had no evidence of airway adjuncts present at autopsy; two casualties had endotracheal tubes in place with evidence of cricothyroidotomy. While it is possible that airway adjuncts could have been dislodged or removed during processing, in those cases where adjuncts were in place, their locations were noted in the pathologist report.

**DISCUSSION**

Historically, airway compromise has caused about 1% of all combat deaths, making it the third leading mechanism of PS battlefield death, behind compressible hemorrhage and tension pneumothorax.\(^1\)\(^-\)\(^1^1\) Bellamy reported the incidence of airway injury in the Vietnam War as 0.7%,\(^4\) yet Maughon, after conducting a detailed study of 2,600 autopsies from the Vietnam War, reported that lethal airway obstruction could not be objectively tabulated.\(^5\) He did, however, report a high incidence of fatal injuries to the anterior face and neck. In one case report documenting a single battle in Vietnam, one of 10 casualties (10%) died from a GSW to the face with upper airway injury and aspiration of blood.\(^6\) Another Vietnam War-era study documenting concomitant airway showed that carotid injury caused five out of 500 deaths (1%). More recently, Holcomb et al., in their study of deaths among Special Operations Forces during the ongoing Global War on Terrorism, documented that one of 12 (8%) PS casualties died from airway compromise.\(^1^1\) In our series, the incidence of fatal airway injury was 1.8% (18 of 982 cases), and this is concordant with the results other studies of battlefield airway deaths.

The majority of injuries (67%) seen in our study were caused by GSWs. This distribution is different from overall fatality statistics from the conflict, which show an overwhelmingly higher number of deaths due to explosions.\(^1^0\)\(^-\)\(^1^1\) Explosions, however, are much more likely to result in widespread, massive injuries than localized face and neck trauma. GSWs are by nature more localized in effect. Additionally, the anterior face and neck are relatively unprotected with armor and are therefore more exposed to injury. Maughon noted the high incidence of anterior neck and face wounds resulting from sniper fire in Vietnam and speculated on the utility of face and neck shields.\(^1^5\) This was echoed after the battle in Mogadishu in 1993.\(^1^8\)

All airway deaths on the battlefield in this study were the result of penetrating trauma to the face and neck. In many instances, there was significant hemorrhage from injury to nearby vascular structures as well as multiple and severe facial fractures leading to airway anatomy disruption. In comparison with common civilian prehospital airway algorithms where maneuvers for airway management are most often used in the setting of cardiac arrest or blunt neurotrauma related to motor vehicle crashes, airway management on the battlefield seems to be related to disrupted anatomy and hemorrhage from penetrating trauma. Insertion of an endotracheal tube (without paralysis and sedation) or placement of a supraglottic airway may not be optimal or feasible in the setting of disrupted airway anatomy and massive airway hemorrhage, except in moribund patients.\(^1^9\) Similarly, rapid-sequence intubation, with sedative and paralytic agents to facilitate intubation, may also not be feasible given the current level of training of frontline medics and tactical concerns at the POI.

While cricothyroidotomy is infrequently required in the civilian setting, the results of this study may suggest a potential benefit for its use in selected combat casualties. In civilian studies, the most common indications for cricothyroidotomy include maxillofacial injuries, facial fractures and deformities, and hemorrhage into the airway.\(^2^0\)\(^-\)\(^2^3\) Similar events occurred in our study, as many of the injuries leading to PS airway deaths were due to disrupted facial anatomy associated with hemorrhage into the airway and multiple facial fractures. With these types of injuries present on the battlefield, it may be beneficial to include the use of cricothyroidotomy in TCCC airway protocols and provide teaching to military medics who would perform this procedure. A similar approach has been adopted for paramedics and prehospital emergency service personnel in the civilian setting with successful performance of cricothyroidotomy.\(^2^1\)\(^-\)\(^2^3\) In our study, all five attempted cricothyroidotomies resulted in failure to secure the airway.

The tactical situation will often preclude optimal casualty management.\(^1^6\) It is important to note that just because a case is described as "potentially survivable," it does not mean that inadequate or improper care was provided. Several of the casualties were noted to have had PS injuries but no evidence of any first aid. Others had evidence of failed airway maneuvers. It is likely that in some instances casualties were injured and first responders were not able to reach them.
immediately because of enemy activity. No documentation concerning the tactical situation or delays in medical care was available from autopsy records. In those cases where cricothyroidotomy was unsuccessful, information regarding the level of provider (medic vs. physician) who attempted the procedure or the type of airway equipment used was likewise not available for review. Autopsy photographs did suggest the open surgical technique was used in all five instances in which cricothyroidotomy was attempted. The total number of successful versus unsuccessful cricothyroidotomies performed during this period is simply unknown. Therefore, generalizations regarding training and equipment cannot be made based on this study.

If prehospital combat casualty care is to be effective and appropriate, it should be based on actual battlefield casualty populations, not simply extrapolated from purely civilian trauma experience; however, collection of complete sets of data on the battlefield, especially from the POI, is notoriously difficult. This was a small series of cases pulled from a larger, retrospective analysis of autopsy files. Many details regarding the tactical situation, prehospital care, training level of the providers, type of equipment used, and many other key elements required for a comprehensive analysis were simply not available. This study was not able to define deaths resulting from airway compromise due to malpositioning of airway adjuncts or obstruction from the tongue in unconscious patients, nor were we able to quantify whether airway obstruction worsened outcomes or caused a later death in hospital (i.e., from anoxic brain injury). Similarly, since this study was from autopsy data, we did not examine instances of the performance of cricothyroidotomy that resulted in successful outcomes. Furthermore, as Maughon stated in 1970, deaths from airway injuries are difficult to objectively tabulate. This was illustrated in our study, as many of the casualties had other significant injuries, including several with severe injury to major vascular and neurologic structures in proximity to the airway that may have also contributed to death. These cases, while indeed having airway compromise as a factor, could reasonably have been coded differently.

This retrospective study is the only study to date that has examined prehospital airway fatalities in the current conflict, and in spite of its limitations, useful data can be gleaned from it. While fatal airway injuries occur infrequently, there remains a need for emergency medical responders to be familiar with these occurrences and to be adequately prepared to know how to handle these situations. Fatal airway injuries need to be a focus of future studies as the military reviews how it teaches prehospital airway management and seeks to leverage solutions to ensure that the right person, with the right equipment and the right training, is present at the right time if we are to improve the survival of patients with airway compromise on the battlefield. Military health care providers should continue to examine casualty information from the battlefield to determine whether cricothyroidotomy failure was related to the reticence of providers to perform it, the lack of proper equipment and training, or a tactical situation that precluded immediate lifesaving care.

**CONCLUSIONS**

Airway compromise from battlefield trauma results in a small number of PS fatalities. Penetrating trauma to the face or neck may be accompanied by significant hemorrhage, severe and multiple facial fractures, and airway disruption, leading to death from airway compromise. Cricothyroidotomy may be required to salvage these patients, but the procedure failed in all instances in this series of cases. Further studies are warranted to determine the appropriate algorithm of airway management in combat casualties sustaining traumatic airway injuries.

**References**


