Analysis of the Causes of Death of Casualties in Field Military Setting

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ABSTRACT  Objective: We assessed the causes of death of military casualties in order to determine the characteristics of injury and to determine how survivability can be improved. Methods: A retrospective review of the trauma registry of the Israel Defense Forces was conducted. The causes of death were determined. Casualties that were found alive but died later at any level of care were included. Results: Information about casualties that was recorded during the years 2002–2009 was reviewed. Eighty-one fatalities were included in the analysis. Fifty-one (63%) fatalities were caused by gunshot wounds. Analysis of the data regarding the cause of death revealed that 66 (81.5%) of the casualties died because of hemorrhage and 25 (30.9%) because of head trauma. Of the casualties that died of hemorrhage, 12 (18.2%) had neck or limbs potentially compressible hemorrhage. All fatalities from hemorrhage died before arriving at a medical facility. Conclusion: Torso noncompressible hemorrhage was found to be the main cause of death among the casualties investigated. Potentially compressible hemorrhage and head injury are significant too. Research and development of means to treat hemorrhage and emphasis on distribution of means to stop hemorrhage and on training may improve outcome of potentially compressible hemorrhage.

INTRODUCTION

Background

Research of the trauma in the military setting is important to pinpoint the causes of death and identify those which are potentially preventable. Data and conclusions regarding the circumstances of injury, type of injury, and causes of death of military casualties are important for evaluation of the quality of care and its limitations and strengths. Results of such investigations are important for the drawing of conclusions regarding medical equipment, personnel and training, development of new medical equipment and personal protective equipment, evacuation, doctrine, clinical guidelines, and research. Hemorrhage was demonstrated to be the most common cause of death in the setting of military trauma, and research in treating hemorrhage is in a high priority. The aim of this study was to investigate the causes of death in the Israeli Armed Forces setting and to conclude how chances of survival for these casualties may be improved.

MATERIALS AND METHODS

Study Design and Setting

This study is a retrospective review with a descriptive analysis of data from the Israel Defense Forces Medical Corps’ Trauma Registry (ITR). The ITR was initiated in 1997, and its aim is to collect data regarding trauma events in which medical teams from the Israel Defense Forces’ Medical Corps were involved. The data are collected by military personnel who are trained for this specific purpose. The collection process is supervised by a research officer who is also a medical officer. The data are collected within 75 different numerical or text fields and are related to the event and the scenario, the casualty, his personal protective gear, the injury, the caregivers and the treatment given in the field, the evacuation, the diagnosis, the treatment in hospital, and information from autopsies which are rarely performed because of cultural restrictions.

The medical personnel include qualified physicians and paramedics who undergo training in military medicine as well. They are assisted by medical orderlies who are trained to stop hemorrhage, administer intravenous fluids, and assist the physician and paramedics in life-saving procedures like cryocryothyrotomies and chest drains. All field medical units have basic life-saving equipment such as tourniquets, hemostatic bandages, fluids, cryocryothyrotomy, chest tube and other surgical sets, oxygen saturation and capnogram monitors, and resuscitation medications.

Data Collection and Processing

The data was extracted from the ITR and exported to excel sheets where it was analysed. In literature which addressed similar issues, the deceased casualties are defined as killed in action if they died before arriving at a deployed surgical facility. If they die after arriving at such a facility, they are defined as died of wounds. In the setting of the Israel Defense Forces, the first surgical echelon is usually a civilian hospital, and in most cases, the casualty will be evacuated within 1 to 2 hours. Therefore, a different categorization of fatalities was used. All patients that were found dead on the scene were excluded. The fatalities that were alive for several minutes or more after injury were included in this analysis. Inclusion criteria were any sign of life, such as consciousness, breathing or palpable pulse observed by anyone at the scene including a medical orderly or a comrade. Each record was analysed by the primary author and another physician.
Information regarding the type of injury and the cause of death was coded and analysed.

**Outcome Measures**
The cause of injury, the type of injury, the body regions which were injured, the sources of hemorrhage, and the estimated cause of death were determined based on the data.

**RESULTS**
All casualties that were recorded during the years 2002–2009 were reviewed. Casualties with minor injuries are not documented in our trauma registry; therefore, the overall fatality rate cannot be calculated in this research. The number of casualties that were recorded in that period of time was 4,629, of which 852 were fatalities. Of the 852 fatalities, 118 met the inclusion criteria. The remaining fatalities were dead on initial evaluation at the scene. Of the 118 casualties, 37 were excluded because of insufficient data regarding the injuries and causes of death, leaving us with 81 casualties that were included in the analysis. This group demonstrated signs of life for at least a few minutes after injury. Of the 81 trauma casualties, 54 (66.6%) suffered combat injuries and the rest noncombat injuries such as motor vehicle accidents and other causes. Thirty-four casualties had their exact evacuation time from injury to a surgical facility documented. On average, they were evacuated 80.5 minutes after the injury (median = 65.5 minutes).

Sixty-seven (82.7%) of casualties died eventually at the scene or dead on arrival at the hospital, and 14 (17.3%) died of wounds after arriving to the hospital. Fifty-one (63.0%) of the casualties were involved in events with up to three casualties, and 30 (37.0%) of the casualties were involved in events with more than 3 casualties. Figure 1 demonstrates that 51 (63.0%) of the casualties were caused by gunshot wounds. Figure 2 demonstrates that penetrating injury is the main cause of death in this group of casualties. Figure 3 demonstrates that 63 (52.1%) of the casualties (n = 121 injured body regions for 81 casualties) were torso injuries and 26 (21.5%) were head injuries. Cultural prohibition prohibits autopsy which is therefore rarely performed in the Israel Defense Forces. It is practically impossible to determine in thoracic military trauma if the cause of death was hemorrhage, or a ventilation compromise, or a combination of both. For the purpose of this study, we assumed in all these casualties that the cause of death was both. Analysis of the data regarding the cause of death revealed that 66 (81.5%) of the casualties died because of hemorrhage and 25 (30.9%) because of head trauma. Figure 4 demonstrates that 12 (18.2%) of the casualties who died of hemorrhage had potentially compressible hemorrhage in the neck or limbs.

**DISCUSSION**
Trauma registries are used as a tool for quality control and the dissemination of clinical best practices amongst field medical teams.1,2,3 The epidemiology of this subgroup of casualties offers a tool to determine how the outcome of military injury might be improved. A publication by Kelly et al from the U.S. Army Institute of Surgical Research demonstrated that hemorrhage is the main cause of death in the military setting.6 There are two important differences in the methodology. The first is that in all fatalities in the latter publication an autopsy was performed and the second that all fatalities were included and not only those which presented signs of life. Since the methodology differs between our research and the latter research, comparison should be made with caution. Nevertheless, it is evident that in comparing the two epidemiological reviews, hemorrhage is more frequent in the U.S. military
research and central nervous system injuries are more frequent in our review (Table I). This could be attributed to the improvised explosive devices which are encountered in Iraq and Afghanistan by the U.S. armed forces and the more conventional warfare with which the Israel Defense Force is confronted with. The majority of deaths in the battlefield are not preventable. Our data demonstrates that noncompressible truncal hemorrhage was the main cause of death in this subgroup of casualties. Other important aetiologies are possibly compressible hemorrhages either from the extremities or the neck and head injury. Similar research indicated that 83% to 87% of what is defined as potentially survivable death is caused by hemorrhage of which 50% are attributed to truncal penetrating injury with noncompressible hemorrhage. For the purpose of our research analysis, we assumed in thoracic injury that both exsanguinations and ventilator compromise to be the cause of death. The lack of an autopsy to further investigate this is a limitation in this study.

**CONCLUSION**

This research demonstrates that the most significant challenge for the military medical teams is hemorrhage. Up till now, there is no effective field treatment for severe noncompressible truncal hemorrhage. Innovative research and development of effective means to treat truncal noncompressible hemorrhage and perform damage control resuscitation might alter the grave prognosis of these casualties. Further improvement of means to treat compressible hemorrhage, such as tourniquets, and the commercially available hemostatic bandages remains an important tool. Training of medical military and nonmedical personnel in their use might also improve prognosis of compressible hemorrhage in the military setting. The development of blood products which can be available in the field and of the means for fast transfusion might prolong the survival of hemorrhaging patients and improve their chances of arriving at a medical facility where surgical definitive treatment can be performed. Improvement of means of evacuation such as fast armoured medical evacuation vehicles and unmanned evacuation aircrafts can contribute to the latter too.

**ACKNOWLEDGMENT**

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**REFERENCES**


**TABLE I.** A Comparison of This Research to a Similar Research From the U.S. Army Institute of Surgical Research About Preventable Deaths

<table>
<thead>
<tr>
<th></th>
<th>Kelly et al</th>
<th>Our Data</th>
</tr>
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<tbody>
<tr>
<td>Penetrating Injury Affiliated to Cause of Death</td>
<td>83%</td>
<td>71%</td>
</tr>
<tr>
<td>Hemorrhage as the Cause of Death</td>
<td>85%</td>
<td>68%</td>
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<tr>
<td>Traumatic Brain Injury</td>
<td>9%</td>
<td>30%</td>
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