

Mortality in Terrorist Attacks: A Unique Modal of Temporal Death Distribution

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Abstract

Background: Terror-related multiple casualty incidents (MCI) in Israel since September 2000 have resulted in a new pattern of injury as a result of the mechanisms of trauma. The objective of this study was to assess the temporal death distribution among the civilian casualties in the Jerusalem vicinity during a 3-year period.

Methods: All terrorist attacks in the Jerusalem district from September 2000 to September 2003 were included in this study. The data of all deaths were processed including the time of the attack, the evacuation time to the hospitals, and the time of death.

Results: During the study period 28 terror-related MCI occurred. A total of 2328 victims were injured and 273 died, for an overall fatality rate of 11.7%. A unique temporal death distribution was identified; 82.8% of the deaths occurred immediately, at the scene of the attack (scene death); of the remaining 17.2% of patients who died in the hospital, half died within 4 hours of arrival (immediate death), one quarter within 5–24 hours (early death), and one quarter later than that (late death). The temporal death distribution was significantly different when classifying the mechanism of trauma to suicide bombings versus shooting. The scene mortality was higher in the suicide bombings than in shooting attacks (86.7% versus 77%, $P = 0.039$). In contrast, the mortality within 1–24 hours was higher in the shooting attacks (17% versus 6.3%, $P = 0.05$).

Conclusions: Terror-related MCI occurring in civilian settings have a unique temporal death distribution. A very high scene mortality is seen compared to the classical description of Donald Trunkey¹ in 1983. The late deaths, which composed 30% of the mortality in civilian settings, comprise only 4.4% of the total mortality in MCIs. A rough estimate of the in-hospital mortality could be achieved after the first 4 hours, allowing the assessment and distribution of hospital resources. Futile care should be identified early and availability of ICU beds can be calculated according to the immediate mortality.

Mortality related to injury time in civilian trauma is traditionally divided into three peaks. Donald Trunkey¹ in 1983 described a trimodal death distribution in civilian trauma after multiple casualty incidents (MCI). The first peak of death is seen immediately following the

insult and consists of 50% of the overall mortality. These casualties die very soon after the injury, mainly from central nervous system or major blood vessels injuries. The second peak of death is seen within the first few hours post-injury (early deaths). These casualties constitute 30% of the mortality and are associated mainly

with major internal hemorrhages. The third peak of death, late deaths, occur within days to weeks post-injury. Sepsis and multi-organ failure are the main causes of death in these remaining 20%.

Mortality in war was traditionally divided into “killed in action” and “died of wounds.”² As the time to definitive surgical care decreased, the mortality of injured soldiers reaching medical care decreased from 8.5% in World War I to 1.7% in the Vietnam War. In the Lebanon War in 1982, 90% of the moderately and severely wounded soldiers reached the hospital within 120 minutes,³ making it possible to evaluate a temporal pattern of death in modern wars. There is a prominent difference in the magnitude of the different peaks and causes of death compared to civilian trauma. More than 93% of the 351 soldiers who were killed died within the first hour. A similar conclusion was reached when analyzing the mortality in “low-intensity warfare” during 1996–1998 in Israel.⁴ Eighty-eight percent of the 106 soldiers killed during that time died within 30 minutes of injury.

Since September 2000 a unique pattern of injury has emerged.^{5,6} Terrorist attacks on civilian targets combined some of the mechanisms of injury associated with war with the quick evacuation and short interval to definitive surgical care similar to other forms of civilian trauma. The magnitude of civilian attacks ranges from mega terrorist attacks as on September 11, through suicide bombings in crowded restaurants, malls, and buses—as frequently occurred in Israel—to focused shooting attacks and hand grenade assaults.

For every preventive intervention and policy affecting hospital resources brought to bear on such incidents, a complete database is essential, and careful analysis to determine the implications of such data is mandatory. From our experience MCI can follow one after another, sometimes as often as 3 times in a week. For long-term optimization of expensive resources, understanding the natural history of the critically wounded victims is invaluable. The temporal death distribution and mortality of these casualties should therefore be studied.

METHODS

All death related to terror attacks between 29 September 2000 (day of the start of the last terror wave) to 28 September 2003 in the Jerusalem district were evaluated. Data sources were Magen David Adom (Israel’s Emergency Medical Service—EMS) operational registry, the trauma registry of Hadassah-Hebrew University Medical Center

(level I trauma center), and patient admission data and charts of all four general hospitals in Jerusalem.

Accurate assault time (time of detonation or shooting as recorded by the Israeli authorities) and time of death was recorded in every case. Evacuation time was defined as the time from the assault to the time of arrival to the emergency department (ED). Time of death was defined as the time elapsed between time of injury and time of death declaration. Bombing mechanism is defined as an injury related to detonation, asymmetrical missiles (shrapnel), and or blast. Shooting injuries are associated with symmetrical missile bullets. Multiple casualty incidents were defined numerically for convenience as, for example, a single incident involving more than 10 victims at the scene. Injury was defined as any physical injury excluding sole stress reactions.

The treatment policy of the Israeli EMS during the MCIs was basically “scoop and run.” The goal was to deliver the casualties to a definitive care facility as soon as possible with minimal delay, and to rejoin the available EMS teams at the scene. The only procedures that were performed by the EMS personnel, if necessary, were definitive airways, intercostal needle applications, and external hemorrhage control. Intravenous access was achieved en route to the hospital if possible. The triage at the hospital entrance and treatment protocols practiced during the MCIs were based on the ATLS guidelines according to the American College of Surgeons Committee on Trauma^{7,8} and specific modifications based on our previous experience.⁶

The cause of death was determined by reviewing all charts available from the non-trauma center hospitals, operative findings, various imaging modalities, our trauma registry database, and documented mortality conferences. The causes of death were classified into six major categories: severe brain injury, major thoracic bleeding, major abdominal bleeding, multiple injuries with significant blood loss, significant blood loss associated with advanced age, and sepsis. Severe brain injury was determined to be the cause of death in situations that according to computed tomographic (CT) findings and neurosurgical evaluation the patient was not salvageable, or when there was no other significant injury. Major thoracic and abdominal bleeding were determined as the cause of death usually during surgery for uncontrollable bleeding from major vascular injuries. Significant blood loss in advanced aged casualties was defined as the cause of death in 3 patients in whom bleeding was under control but the magnitude of trauma together with the patient’s advanced age (66 years, 70 years, 79 years) overcame the ability to recover from the insult. Sepsis

was determined to be the cause of death in patients who survived the first few days but whose hospital course was complicated by recurrent infections that did not respond to medical or surgical interventions, leading to multiple organ failure. Analysis of the cause of death was not performed on 17% of the patients whose medical records were irretrievable. One patient who died from asphyxia due to esophageal intubation at the scene was omitted from the statistical analysis.

Data analysis was performed using SPSSWIN software. Relations between categorical variables were assessed by the χ^2 test.

RESULTS

In the period of 3 years from September 29, 2000, to September 28, 2003, 273 victims died from terrorist attacks in the Jerusalem vicinity. During this period 28 terror-related MCI occurred, with number of victims per event ranging from 10 to 136. The total number of terror assault victims was 2328, creating an overall fatality rate of 11.7%. The death toll from suicide bombings was 173 victims and that from shooting attacks was 100 victims. Some 82.8% (226) of the deaths occurred immediately, at the scene of the attack (scene death); 8.4% (23) occurred within 4 hours (immediate death); and 4.4% (12) occurred between 5 and 24 hours post-injury (early death). Late deaths, occurring more than a day post-injury represented 4.4% (12) of all fatalities (Fig. 1). Among the casualties who reached the hospital, 49% (23) died within the first 4 hours and an additional 25.5% (12) within 5–24 hours. Late deaths within days to weeks accounted for 25.5% (12) of the overall mortality (Fig. 2).

When classifying the mechanism of trauma to bombings versus shooting, it is evident that the distribution of time of death is different. Suicide bombing attacks resulted in 86.7% scene mortality as opposed to a lower 77% mortality in shooting attacks ($P = 0.039$). The mortality within 1–24 hours, however, is 6.3% in the suicide bombing attacks and a much higher 17% in the shooting attacks ($P = 0.05$). The mortality in the late stage, within days to weeks, is similar for both mechanisms and reached 4% and 4.6%, respectively.

The evacuation time from the attack site was determined by the location of the assault, the density of the traffic, and the time of day. The first casualties arrived at the hospital as soon as 11 minutes following the injury, and 78% arrived within 59 minutes. The median time to arrival was 36 minutes, with the last casualty arriving

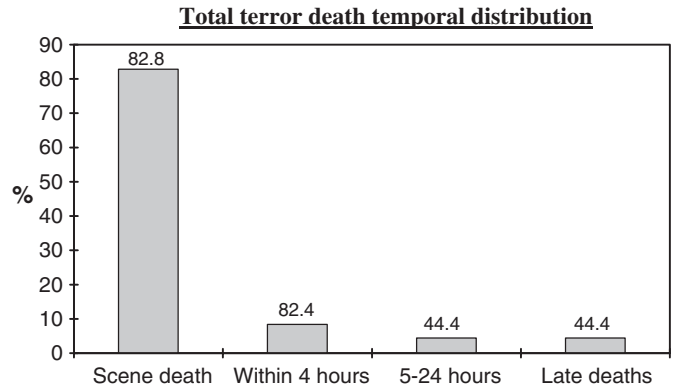


Figure 1. Total terror death temporal distribution.

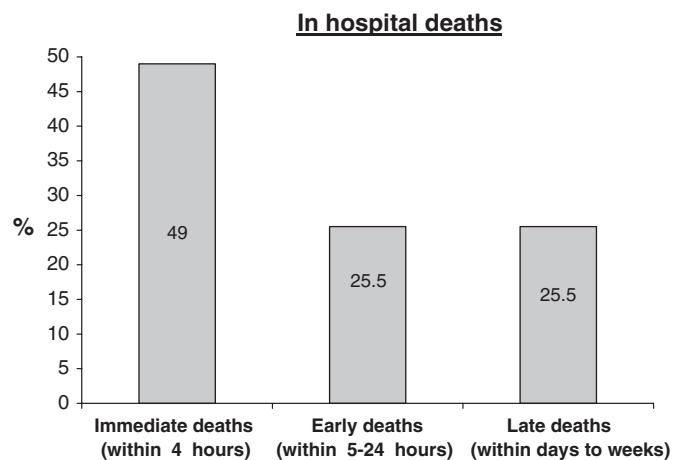


Figure 2. In hospital deaths.

3 hours post-injury. There was no relation between the evacuation time period and time of death.

The median injury severity score (ISS) was 34, ranging from 16 to 75. No correlation between the ISS and the time of death was noted. The median calculated probability of survival (PS) was .052, ranging from .0008 to .96. No correlation between the PS and the time of death was noted as well.

When classifying evacuation times according to the mechanism of attack, it is apparent that the casualties from suicide bombing attacks arrived at the hospital earlier than the casualties related to shooting attacks (Fig. 3). By the first 30 minutes after the attack 61% of the bombing victims had already arrived at the hospital in contrast to 22% of the shooting attack victims. By 1 hour approximately 87% and 78% arrived, respectively.

The 48 patients who died in the hospital setting suffered from significant injuries (AIS 3–6) to one or more body areas (Table 1). Clinical information was available for 39 (83%) patients: 20 casualties (51%) suffered from

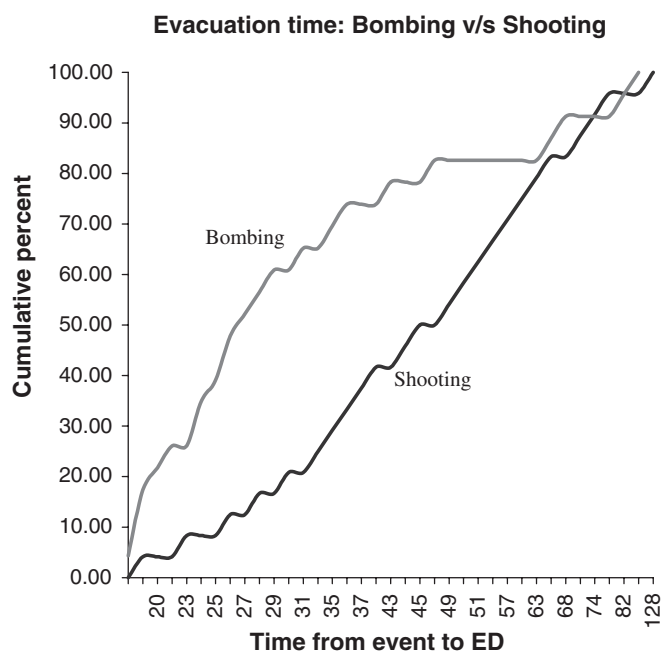


Figure 3. Evacuation time bombing versus shooting.

head injuries, 19 from thoracic injuries (49%), and 21 from abdominal injuries (54%). Immediate death occurred in 58% (11) of casualties suffering from thoracic injuries and 48% (10) suffering from abdominal injuries; 47% of these casualties were injured in more than one body region.

Six of 8 patients who suffered from major thoracic bleeding died immediately and represent 31.6% of the immediate deaths (Table 2). Severe brain injury was responsible for 26.3% of the immediate death toll and 50% of the late deaths. Major abdominal bleeding was the cause of death in 42.1% of the immediate deaths and 41.4% of the early deaths. No late deaths were attributed to major abdominal and thoracic bleeding. Sepsis was the cause of death in only 4 cases (10.2%) of the total mortality.

DISCUSSION

The trimodal death distribution identified by Trunkey¹ was reported in 1983 and related to all types of civilian trauma. Since that time much has been done on all levels of prevention that has affected the immediate mortality (avoiding driving under the influence of alcohol, seat belt use, the addition of air bags, etc.), and in the area of rapid evacuation and quality of treatment, which has affected the early mortality. Other significant interventions consisted of establishment of national trauma systems, early treatment by proven protocols of Pre-Hospital Trauma Life Support (PHTLS)⁹ and Advanced Trauma Life

Support (ATLS).^{7,10,11} The concept of “skipping” trauma centers and evacuating casualties to the nearest hospital in MCI, as has recently been suggested,¹² should be carefully judged. The authors of this article strongly disagree with the concept of evacuating casualties to the nearest hospital. We believe that EMS teams should adhere to established guidelines and even be more permissive than usual when evaluating the victims for evacuation to a trauma center. The construction of trauma systems has definitely decreased the mortality associated with trauma casualties, and the further goal should be to decrease the morbidity associated with these injuries.¹⁰ This challenge should involve the level I trauma centers, and not the nearest hospitals to the incident. The late deaths ratio has decreased tremendously since 1983. Twenty percent of the mortality in 1983 was attributed to sepsis and multi-organ failure in the late deaths, and in the Lebanon War the late deaths ratio was only 4.3%. In the present study the late deaths figure is similar at 4.4%. This trend can be attributed to early accessibility of definitive care facilities, advances in surgical technique, the practice of “damage control”¹³ surgery, and the availability of advanced medical technologies and care provision in intensive care units.

The temporal death distribution among terrorist attack victims in the Jerusalem vicinity is unique regarding the mechanism of injury, the evacuation times, and the quality of treatment. As opposed to all civilian trauma, which consists mainly of blunt trauma (82%),¹⁴ terrorist attacks cause mainly penetrating trauma (73%) from gunshot wounds and complicated shrapnel injuries, combined at times with blast injuries and burns. These mechanisms of injury are similar to those occurring during full-scale war, but they occur in a civilian setting, where evacuation of the wounded is invariably much quicker, first because the injured and the emergency workers are not under fire and also because of the shorter distances to definitive care facilities. This combination of combat injuries and a civilian setting may have led to a tremendous increase in the scene death toll beyond that described by Trunkey.¹

During the data collection we realized that 17% of the medical records were irretrievable. This loss of information may be attributable to the chaotic nature of the MCIs; therefore statistical analysis was also performed taking the data to the extreme in each situation. Although the percentages could be different in these situations they did not alter the final conclusions.

The mortality among terror casualties arriving at the hospital alive can be divided into three categories in relation to time. Half of all deaths occurred within the first

Table 1.

	Head	neck	Thorax	Abdomen	Extremities	1 injured areas	2+ injured areas
<4 hours (n = 19)	7 (35)	1 (14)	11 (58)	10 (48)	3 (23)	10 (67)	9 (38)
5–24 hours (n = 10)	4 (20)	4 (57)	3 (16)	7 (33)	7 (54)	2 (13)	8 (33)
>24 hours (n = 10)	9 (45)	2 (29)	5 (26)	4 (19)	3 (23)	3 (20)	7 (29)
Total 39 patients	20	7	19	21	13	15	24

Data are shown as number of patients (and percentage)

Table 2.

	Severe brain injury	Major thoracic bleeding	Major abdominal bleeding	Blood loss and advanced age	Sepsis	Total
<4 hours	5 (45.5)	6 (75)	8 (67)	0	0	19
5–24 hours	1 (9.0)	2 (25)	4 (33)	3 (75)	0	10
>24 hours	5 (45.5)	0	0	1 (25)	4 (100)	10
Total	11	8	12	4	4	39

4 hours, a quarter of deaths occurred within the rest of the 24-hour period, and a quarter occurred within the following days to weeks.

The temporal distribution of death is different between the victims of bombings and the victims of shootings. The scene mortality is much higher after bombings (86.7% versus 77%). However, the early mortality within 1–24 hours after the incident was three times higher in the shooting group (17% versus 6.3%). In a bombing attack the victims who are in close proximity to the detonation focus are exposed to very high blast winds, shearing forces, and multiple asymmetrical pieces of shrapnel, which are associated with multiple injuries immediately incompatible with life.^{15–17} An additional explanation for the differences in mortality after bombings and after shootings may be related to different evacuation times. Shooting attacks were usually on the periphery of Jerusalem, whereas the bombing attacks were mostly in the center of town; hence the evacuation time of the shooting attacks took longer. Other than the different injury mechanism, it could be that this relative delay of arrival to the hospital is responsible for the greater mortality during the first hours after the shooting attacks.

The late mortality in both mechanisms of trauma was due to sepsis and multi-organ failure as a consequence of severe injuries,¹⁸ and hence the similar numbers.

Trunkey stated in 1983 that in civilian trauma “immediate deaths” (the mortality within the time of injury up to 2 hours) comprised 50% of the total mortality. Here we describe that in an MCI the scene death alone reaches 82.8%. The early deaths described by Trunkey (mortality

within 4 hours) constituted 30% of the total mortality. After MCI the mortality within 4 hours reached only 8.4%. We also identified one more peak of death, those that occurred which is within 24 hours (4.4%). The late deaths which represented 20% of the mortality in 1983 are now responsible only for 4.4%.

The injuries were categorized into five body regions, and according to this definition 61.5% of the casualties suffered from two or more injured body regions. Head injuries were present in 51.3% of the casualties and abdominal injuries in 53.8%. The time of death was not determined by the body region injured, but it seems that thoracic and abdominal injuries are associated with immediate and early death more than other injuries.

According to Trunkey, immediate deaths are caused typically by lacerations of the brain, spinal cord, and major blood vessels. This time frame corresponds to our definition of scene deaths. This article describes only the casualties that arrived at the hospital, and therefore no comparison is available. The deaths within 4 hours are due to major internal hemorrhage, and this is consistent with our finding as well. Here in we present another peak of mortality. This peak was identified in the time frame of 5–24 hours after injury. These patients died from internal hemorrhages (90%) and represent the aggressive treatment and advanced surgical and medical support applied in these situations. The improved quality of care, establishment of national trauma systems, and the practice of “damage control” surgery reduced the overall mortality of trauma patients but also represent this additional peak of mortality. These casualties belong to a larger group of

patients that survived the first 4 hours after injury because they received state-of-the-art treatment but ultimately died in this time frame.

Late deaths according to Trunkey result from infection and sepsis. Our data demonstrate that only 40% of the late deaths are attributable to sepsis; in fact, most are due to severe brain injuries. The liberal use of intensive care units, broad-spectrum antibiotics, invasive radiology measures, and improved quality of nursing has led to a significant decrease in mortality due to uncontrolled sepsis. The survival of casualties suffering from severe brain injuries is prolonged as a result of the same factors, but some patients eventually die.

In times of a large-scale MCI or when two or more MCIs follow in quick succession, there is need for long-term optimization of expensive resources. The most critical resources are physicians, nurses, and ICU beds. Early identification of futile care may aid in achieving this goal of optimizing resources. In a suicide bombing attack, patients who arrive at the hospital with no signs of life and one or more amputated limbs are not resuscitated. From our previous experience¹⁹ these patients, which in other circumstances would have been resuscitated, in the setting of suicide bombing attack are 50 times more likely to die from their wounds. Similarly, casualties with no signs of life and with more than 30% body surface area burns or open fractures are also very likely to die, so careful judgment should be applied before resuscitation. Overflow of the capacity of ICU beds is a daily challenge, but according to the temporal death distribution we can anticipate the mortality within the first 4 hours. Extra ICU beds are usually manned in the post anesthesia care unit (PACU) as an extension of the intensive care unit. We can roughly anticipate by the first 4 hours how many of these beds will be evacuated due to further mortality in the first 24 hours and hence be prepared with the necessary personnel.

CONCLUSIONS

The trimodal death distribution applies to civilian trauma as in Trunkey's study and in war trauma as in the Lebanon War. In the former, non-war injuries in a civilian setting and in the latter, war injuries with air transport evacuation contributed to this death distribution. Terror attacks occurring in civilian settings, however, have a different death distribution. The war-like injuries, coupled with quick transport to level I (80% of the casualties) and level II trauma centers contribute to a different pattern of death: 82.8% of the mortality was at the scene of terror. The remaining 17.2% of casualties reaching the hospital

could be stratified into 3 more peaks of death: immediate death—within 4 hours of the incident (a half of the in-hospital mortality); early death—within 24 hours (a quarter of the in-hospital mortality); and late death—within days to weeks (a quarter of the in-hospital mortality).

Not only does the temporal death distribution differ in MCIs. Since 1983 the causes of death have changed as well. A significant improvement in the quality of care has enabled the reduction of the overall mortality, and death attributable to sepsis is no longer the leading cause in the late phase.

In conclusion, the death rate among critically wounded patients using the ICU beds can be anticipated for optimization of expensive resources. In addition, futile care can be and should be identified early according to the type of injuries suffered by patients who show no signs of life. The decision not to resuscitate when the probability of death is high preserves valuable resources for patients who are likely to survive.

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