Terror-Related Injuries: A Comparison of Gunshot Wounds Versus Secondary-Fragments—Induced Injuries from Explosives

Nadav Sheffy, MD, Yoav Mintz, MD, Avraham I Rivkind, MD, FACS, Shmuel C Shapira, MD, MPH

BACKGROUND: Terror-related injuries caused by secondary fragments (SF) from explosive devices show a distinctive pattern in severity, distribution, outcomes of assault, and health-system resource use as compared with terror-related penetrating injuries caused by gunshot wounds.

STUDY DESIGN: A case-comparison study conducted in a tertiary university hospital and the only Level I trauma center in the Jerusalem vicinity. During a period of 4 years, over 1,500 casualties of terror-related injuries were treated in one Level I trauma center. The study included 533 patients who were admitted for hospitalization. Excluded from the study were victims who were dead on arrival or who succumbed to their injuries within 30 minutes of arrival at the emergency department. Data were collected from trauma registry records.

RESULTS: Gunshot-wound victims were mostly men, aged 19 to 30, and SF victims were more evenly distributed between the genders and across the age spectrum. Injury Severity Score (ISS) was considerably higher in SF victims, although critical mortality rates were higher in gunshot-wound victims. More than 40% of SF victims were injured in three or more body regions, as opposed to $<$ 10% in gunshot-wound victims. Use of imaging modalities and ICUs was considerably higher for SF victims.

CONCLUSIONS: Terror victims suffering from SF wounds have more complex, widespread, and severe injuries than victims suffering from gunshot wounds. They tend to involve multiple body regions and use more in-hospital resources. Attenuation of bus seats and protective vests can lead to a reduction in severity of these injuries. (J Am Coll Surg 2006;203:297–303. © 2006 by the American College of Surgeons)

Terror is becoming an increasing concern for trauma care providers and health administrators, with the threat increasing tremendously over the last several years. Terror-related injuries, especially those seen with suicide-bomber attacks, are associated with a unique pattern of injury that must be dealt with explicitly to decrease the associated morbidity and mortality.[1-3] Most terror victims are injured either by explosive devices set in civilian or military scenarios, usually in the course of mass casualty incident or from gunshots, and in military or secluded settings.

Mechanisms of injury associated with explosions are traditionally divided into primary, secondary, and tertiary blast injuries. Primary blast injury occurs as a result of the blast wave-mediated atmospheric pressure change.[4-6] Secondary damage is caused by missiles and fragments, either embedded inside the explosive device (eg, bolts, ball bearings, nails) or its casing, or from the shattering effect of the blast on its surroundings (eg, glass). These secondary missiles are propelled by the blast energy, hitting the patient. Tertiary damage is caused by displacement of the patient's body by the blast wind powerful energy and consequent impact with the ground or surrounding structures. Additional damage, sometimes referred to as "quaternary blast injury," is caused by flash burns from the hot gases and extreme heat caused by the explosion itself. Burns typically affect exposed body parts, such as face, neck, and upper ex-

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From the Department of Anesthesiology, Rabin Medical Center—Beilinson Campus, Petah-Tikva, Israel (Sheffy), Department of General Surgery and Trauma Unit (Mintz, Rivkind), Administration and Department of Anesthesiology and Critical Care Medicine (Shapira), Hadassah-Hebrew University Medical Center, Jerusalem, Israel.
Correspondence address: Shmuel C Shapira, MD, MPH, Hadassah University Hospital, PO Box 12000, Jerusalem, Israel, 91120. email: sshapira@hadassah.org.il

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Abbreviations and Acronyms

AIS = Abbreviated Injury Scale
ISS = Injury Severity Score
SF = secondary fragments

tremities, and cause damage from ignition of flammable material, such as clothing.[5] Crush injuries[7] from collapsing structures can lead to traumatic rhabdomyolysis followed by acute renal failure, one of the most prominent and fearful complications of crush syndrome.[8] Other forms of quaternary damage are associated with inhalation of toxic agents. Secondary missiles—fragments injuries caused by metal debris embedded especially within suicide bomber's belts—are associated with unique injuries. Comparison of injuries associated with gunshot wounds with those caused by secondary fragments (SF) can be relevant to trauma care providers managing injuries of terror victims as well as to those involved with the designing of personal protection devices.[9] During the last 5 years of an extensive terror wave in Israel, 7,520 Israelis were injured by terrorist activity, with 1,074 killed.[10] Thirty-four percent of these casualties (n = 2,547) were treated at the Hadassah Ein-Kerem University Hospital in Jerusalem. Using this extensive experience of terror-related injuries, we try to define the unique patterns and characteristics of injury caused by secondary missiles from explosive devices as opposed to gunshots.

METHODS

Data of all patients admitted to the Hadassah Ein-Kerem University Hospital in Jerusalem for terror-related injuries between September 29, 2000 (first day of current wave of terror) and December 31, 2004 were reviewed. Included in the study were victims who suffered from injuries inflicted by an explosive device or gunshot wounds. (E codes 991 for bullets-induced injury and 993 for explosive-device victims). Excluded were victims who were dead on arrival or those who succumbed to their injuries within 30 minutes of arrival at the emergency department. Data were collected from the hospital's trauma registry and included vital signs on arrival at the emergency department, procedures conducted in the emergency department and in operating theaters, and interventions undertaken in the different wards. Different trauma scores were generated using the trauma registry software, including Abbreviated Injury Scale (AIS),[11] Injury Severity Score (ISS),[12] and Revised Trauma Score.[13]

Statistical analysis was performed using the SPSS 11.0 software (SPSS Inc). Mann-Whitney nonparametric test and *t*-test were used for quantitative variables; Pearson's chi-square test was used with categorical data. A p value < 0.05 was considered statistically significant.

RESULTS

From a total of 1,552 victims treated during the study period, 533 met the study criteria. Of these, 208 suffered SF injuries and 325 gunshot wounds. Almost 90% of gunshot victims were men and 60% were aged 19 to 30 years (Table 1). Age and gender were more equally distributed in the SF group. Mean age of gunshot victims was 27.4 (±12.9 SD) years, and that of SF victims was 28 (±14.6 SD) years. Soldiers represented 34.4% (n = 112) of those injured by gunshots, as compared with only 19.7% (n = 41) of those injured by SF.

Injury severity and distribution

Median ISS and rate of severe (ISS ≥ 16) or critical injuries (ISS ≥ 25) were greater for SF injuries than for gunshot wounds ($p < 0.001$ and $p = 0.013$, respectively, Fig. 1). Of SF victims, 45.2% suffered from severe and critical injury (ISS ≥ 16) in comparison with only 31.3% of gunshot victims ($p < 0.001$). Revised Trauma Score and Glasgow Coma Scale (GCS) were similar for gunshot wounds and SF victims (Table 2). Maximal AIS mean was similar in both groups, although the rate of victims sustaining more extensive injuries (maximal AIS ≥ 4) was greater for SF than for gunshot victims (Table 3). SF victims were more likely to be injured in multiple

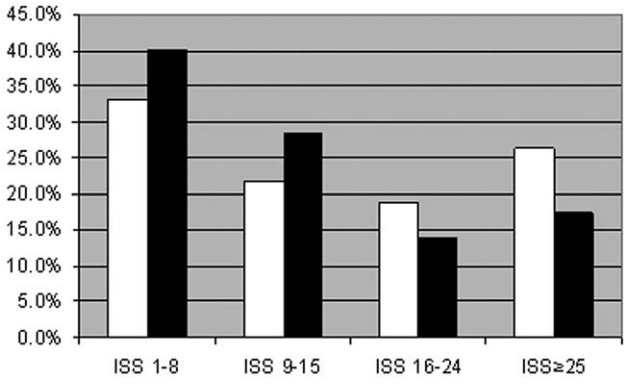

Figure 1. Injury Severity Score (ISS) distribution. Secondary fragments, white bar; gunshot wound, black bar.