

Assessment of Injuries Following Terrorist Attacks: A Narrative Review

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Received September 10, 2019; Accepted December 14, 2019; Online Published January 01, 2020

Abstract

Background: In the few past decades, the world has experienced numerous terrorist attacks.

Objectives: We sought to review the mechanisms and patterns of injuries in terrorist attacks; the main goal being better management of victims of these attacks.

Methods: In current narrative review; electronic databases (PubMed, Wiley, EMBASE, ISI Web of Knowledge, and Scopus) were searched seeking relevant publications between 2000-2018. The keywords used when searching for articles included: violence, terrorism, disasters, trauma, trauma centers, war, mass casualties, wounds, and injuries. Searching, screening, and assessment of records were done separately by two authors; disagreements were resolved by discussion with a third reviewer.

Results: Nine studies were found to be eligible for inclusion in this study. The most common device-related terrorist attacks were explosives and bombs. More than half of the victims suffered minor injured and could be treated promptly. The most common causes of mortality were head injuries, airway burns, and internal bleeding. The secondary and tertiary results of terrorist attacks were head and neck injuries. Pulmonary injuries were also common injuries in terrorist-attack victims. The most significant cause for emergency treatment was airway burns. The head, neck, pelvis, and hand were the most commonly exposed body areas. Limb amputation is a major result of complications and mortality. The mortality rate of victims that referred to a hospital was low; most deaths occurred at the scene of the attack. Aging victims, children, and women were most influenced by terrorist attacks. Immediate examination, long-term follow-up, and advanced therapeutics and psychological therapy are necessary.

Conclusion: Differences in the severity and type of injuries among victims of terrorist attacks depend upon the various causes of blast injuries, the power of the explosion, the open or enclosed location setting, the destruction of structures, and the interval between cases and the explosion. The current results showed that head and lung injuries are major causes of mortality in victims of terrorism. Appropriate emergency medical services and early management could increase patient survival rates and reduce complications.

Keywords: Injuries, Crisis, Terrorist Attacks.

Introduction

In the past few decades, the world has experienced more terrorism than before and a new type of injury as a result of terrorist attacks. Every country where attacks have already taken place or are likely to happen soon has stressed the need for a pre-emptive plan to minimize the rate of injuries referring to hospitals (1-4). The increasing trend of these events in the world indicates the obligation of health administrators to be equipped for such an incident (2,5). The threat of terrorist attacks has become a global dilemma (5-8). Bomb explosion is the common method of terrorist attacks, which cause particular physical and psychiatric trauma (9-12). In t such situations, the multiple trauma cases presented by a blast will have correlated head, lung, and limb injuries due to crushing from falling structures (13). Burn teams

could have a crucial function in the treatment of traumatic injury patients from a bombing attack (7,13). However, bombing attacks can cause extensive mortality and more severe injuries. They could also produce large numbers of patients who are not severely injured and need only outpatient therapy (13,17). Models of injuries due to open-air explosions are very different from injuries caused by explosions in restricted locations (18-22). Evidence shows that chaotic medical management could result in greater morbidity and mortality. Explosion and bombing injuries are usually the field of military doctors and surgeons, but in terrorist situations, civilian hospitals and physicians are anticipated to be faced with more of this variety of injuries (13). To administer suitable treatment, it is essential for doctors in civilian hospitals to be educated on the

mechanisms, effects, and treatments of such injuries. Injuries caused by bombing attacks have been represented as quaternary damages. Knowledge about the management of these injuries is very essential for surgeons, healthcare workers, and psychiatrists who must be prepared with particular requirements.

A review on terrorist attacks studies could illuminate how healthcare organizations after a terrorist attack should approach and prepare for such trauma patients, and resuscitation and treatment procedures should progress in a methodical manner.

Objectives

The present research focused on the types of injuries inflicted on victims in terrorist attacks to identify a pattern of injuries to aid hospitals in better management during critical situations. Studies regarding mechanisms and the pattern of injuries in terrorist attack events were reviewed. This study could be useful for healthcare workers to become familiar with terrorist attack injuries, to counter them quickly, and to identify and manage such injuries in what are chaotic circumstances.

Materials and Methods

This narrative review study included previously published studies that evaluated injuries incurred in terrorist attacks.

Search strategy

The electronic databases PubMed, Wiley, EMBASE, ISI Web of Knowledge, and Scopus were searched for potentially relevant studies published between 2000 and June 2018. The terminology and keywords used to identify articles included violence, terrorism, disasters, trauma, trauma centers, war, mass casualties, wounds, and injuries. Suitable combinations of the keywords mentioned above were also used employing "OR" and "AND" operators for searching.

Inclusion criteria

Articles meeting the inclusion criteria were original articles only, English language studies only, and studies that assessed civilians injured in terrorist attacks. A broad range of studies have been carried out on the pattern of injuries to victims at terrorist bombings. Some studies examined only one single attack, while others collectively analyzed a set of events. In the current study, the researcher used resources with high volumes of data and reporting a greater number of incidents.

Data screening

Two authors separately searched databases and screened titles and abstracts. Then, after duplicate records were eliminated by EndNote software, version seven, all full-text articles were included for final assessment. Any disagreements were resolved by discussion and consultation with a third reviewer. Also, data synthesis was done by two reviewer authors independently, and disagreements were managed by discussion and a third reviewer/author.

Data collected included authors' names, publication year, locations and years of events, mechanisms, mortality rates, and patterns of injuries. Furthermore, attempts were made to include the studies' recommendations regarding the triage of these patients.

Results

A total of 21,582 records published between 2000 and June 2018 were retrieved. Then, 5,409 records were omitted due to duplication between databases, 21,500 records were excluded after their titles and abstracts were screened, 52 records were excluded after full-text assessments, and 22 records were excluded for not meeting the inclusion criteria. Finally, 9 records were included for full-text review. Table 1 shows the 9 included records. These records provided information on terrorist attacks.

Causes and mechanisms of injuries in terrorist attacks

The most common method used in terrorist attacks was bomb explosion (6, 9, 13-18). More recently, improvised explosive devices have been more frequently utilized as the major mechanisms for applying terrorist attacks and causing casualties in the world (17). These bombs are usually homemade by terrorism groups and use different explosive substances, such as C4 plastic explosive, TNT, mortar rounds, and rocket warheads (19).

Such attacks are administrated in various methods, e.g., manually, by cell phone, or in suicide bombing attacks (1-4, 17).

These devices are frequently used in most terrorist attacks because they are easy to manufacture and the materials are readily available. Moreover, because of the casualties caused by explosive devices based on the type and amount of explosive materials aimed at causing multiple traumatic injuries in crowded populations, the use of these devices is prevalent among terrorist groups (17).

Table-1. Medical report papers identified for estimation of statistical research data

Authors (year)	Number of Patients	Time and location of events	Mortality	Weapons	Details
Paydar et al. (2012) (13)	202	April 2008 in Shiraz, Iran	12	bombing attack	The most common cause of mortality was head trauma (41.6%), burn including airway burn in 4 (33%), and internal bleeding in 3 (25%). The average age of the subjects was 26.2 (min 2 to max 51) years that 66.8% of them were males. 12.8% were children. The burn was the most common reason for admission. 13.5% patients required chest tube insert and 21% required skin grafts due to burn.
Chim et al. (2007) (14)	15 cases in 2002 Bali attack, 14 cases in 2003 Jakarta attack and n cases in 2005 Bali attack	2003 and 2004 in Jakarta and 2005 in Bali; Indonesia	1	suicide bombing attacks	Burn surface area in all cases was about 29% and the average of abbreviated burn severity index was six. Eight of 15 cases were referred to the ICU. In the Jakarta attack, the average burn surface area was 10%, and the abbreviated burn severity index was four. Also. A majority of victims had other damages.
Milagros et al. (2006) (15)	36	March 11, 2004 in Madrid	1	bombing attacks in traveler trains	Severe injuries in 47.2% of cases and mild injuries in 52.7% of cases. The major damages were thoracic trauma and blast lung injury, acoustic trauma, and orbital and paranasal sinus fractures. Splenic lacerations and hepatic, and limb fractures and vertebral were other injuries.
Goodwin, et al. (2017) (16)	1981 and 1878	January 2015 Charlie Hebdo attack and the November 2015 Bataclan concert hall/restaurant attacks	-	Gunshot and Grenade or rocket launcher	Charlie Hebdo, 2015; Bataclan concert hall/restaurant, 2015; The rate of severe mental disorder was 7.0% following the first attack, 10.2% the second attack as were probable posttraumatic stress symptoms.
Hirsch et al., (2015) (7)	498	Nov 13, 2015, Stade de France	130	explosions	They pointed out the situation and how Paris hospitals respond to the November 13th attack. In that terror attack, 130 people were killed and 368 were injured, of which 100 were severely injured.
Gates et al., (2017) (6)	284	Boston Marathon terrorist attack on April 15, 2013.	3	bomb blast	They examined the In that study, 22 physicians described how the terror situation was managed. They reported that 66% of the injured people suffered from bone and jaw fractures, while 31% had bleeding trauma. Based on these data, the authors proposed several strategies to prevent and manage the crisis in other similar situations
Hoencamp et al. (2014) (9)	199	Southern Afghanistan, 2009-2010, Dutch battle casualties	19	explosions in 83.9 % of cases	The percentage of the mortality rate was about 9.5 %: 16.5 % of cases died in the scene, and 1.1 % of cases were died due to wounds. The injuries pattern included head and neck 32.2%, thorax 7.8%, abdomen 12.7%, upper extremity 17.6%, and lower extremity 29.7%. The mean Abbreviated Injury Scale and Injury Severity scores were three in wounded cases and 11 in action cases. They concluded that 85 % of the casualties were created by explosions and it much higher than previous wars. Therefore, the management of explosive injuries can be help to treating terrorist casualties. In the other hand, the standardized trauma registry system for data collection that presents all aspects of the medical support organization should be carry out.
Gataa and Muassa (2011) (17)	551	June 2005 to June 2006, Iraq, patterns of maxillofacial injuries	11	Improvised explosive device in 70.59%, gunshot 18.51% and Mortars and rockets 10.88%	551 injured in two Iraqi hospitals; aged 15-29 years were most common affected age group. They reported 2% mortality rate reported in pure maxillofacial injuries; and they recommended unique maxillofacial injuries due to terrorist attacks should be considered a new part in the trauma.

Tresson et al. (2017) (18)	351 injured, 20 cases with nonthoracic vascular trauma	November 13, 2015, Paris and Saint-Denis; nonthoracic vascular trauma	0	gunshots in 85% of cases, handmade bomb in 15% of cases	The percentage of cases that underwent CPR throughout prehospital care was 60%. Nonthoracic vascular trauma influenced the limbs in 70% cases and the abdomen or the small pelvis in 30% of cases. 11 venous injuries were managed by direct repair/ligation. Associated injuries needing a specific medication were present in 95% of cases and were primarily osseous, nervous, and abdominopelvic. The percentage of severe postoperative complications was in 45% of cases. 70% of cases needed a blood transfusion. They recommended that vascular surgery should be organized to receive many injured victims of terrorist attacks in all the departments.
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Patterns of injuries

Terrorist attacks by explosive device have generated a different group of victims, which creates a new medical challenge for physicians and health administrators. Explosions usually create four patterns of damage: primary damage created by the blast; secondary blast damage created by projectiles; tertiary blast damage created by the intensity of the explosion and disruptive wind damage; and quaternary blast damage resulting from the fire and heat caused by the explosion (13-18).

Classifying soft tissue injuries according to wound type in terrorist attack victims is a main clinical challenge because of the variation in injury types. Most victims have a mixture of soft tissue injuries, affecting the whole body (17, 18).

Most victims of terrorist attacks have been young people in the 15-30-year age group (13-18). Fatalities and severe injuries are remarkably higher among children than grown-up victims (13).

The secondary and tertiary results of explosions cause most head and neck injuries in terrorist attacks, and head and lung injuries are the most common injuries in these victims (6, 9, 13-18). The most significant symptom requiring emergency treatment is airway burn, the delay of which could increase the mortality rate. Most victims referring to the ICU have either airway burns or need intubation because of critical burns (13). These injuries can cause critical hypotension following bradycardia and a reduction in compensatory vasoconstriction, and it could increase the number of fatalities. Traumatic brain injuries, internal bleeding, and severe burning are the major causes of increased rates of mortality and morbidity among terrorist attack victims; thus, these patients are prioritized into suitable levels in triage at the incident location and even in the hospital (6-8). Usually, more than 50% of patients suffer from isolated soft tissue damage occurring from secondary blast causes (6-8, 13,17). One of the most frequent injuries in bombing attacks is

auditory damages (6-8). The majority of patients with nonthoracic vascular trauma are injured on the limbs, small pelvis, or the abdomen. The majority of patients require a blood transfusion (18).

Musculoskeletal damage and fractures are common in bombing attacks in restricted scene events due to crushing under falling structures. Projectile hard fragments cause musculoskeletal damage to be very common in these events. The head, neck, pelvis, and hand areas are the most commonly exposed areas and would be expected for better management. Limb amputation is one of the most common causes of tragic complications and mortality (13,17).

Lower mortality rates in terrorist attacks may be attributed to open air locations and lower grade explosive materials which cause fewer cases with high severity injuries. Generally, the mortality rate among victims of terrorist attacks who refer to a hospital is low; most deaths usually occur at the scene (13). Differences in the severity and type of injuries depend on the cause of the blast injuries, the power of the explosion, the open or enclosed location setting, the destruction of structures, and the interval between cases and the explosion (17).

Gender, age, region closeness, media application, and religiosity were correlated with distress (16). Aging victims, children, and women were more influenced by terrorist attacks. Immediate examination, long-term follow-up, and advanced therapeutics and psychological therapy are necessary for these victims (13).

Triage

Appropriate emergency medical services and early management could increase patient survival rates and reduce complications (13). The reviewed studies reported that more than half of the victims of terrorist attacks were not severely injured and could be treated promptly. In terrorist attacks, the number of outpatients is higher than severely injured patients, so it is recommended that non-urgent victims be

transferred to a hospital not far from the incident locale, but not the nearest either, which should be reserved to provide for the management of severe patients. Overcrowding at the scene of the incident generates many difficulties for the initial resuscitation of victims, even in hospitals (13-18).

Discussion

Following a terrorist attack on civilians in crowded situations, numerous patients with traumatic injuries will be transported to emergency departments, and each is suffering from multiple injuries caused by explosive weapons or bullets. Urgent victims should be transferred to the hospital closest to the location of the terrorist attack, and the closest emergency department should be ready to manage completely urgent cases (13). Overall, doctors and healthcare administrators must be aware of the clinical characteristics and management of terrorist-attack victims. Early and suitable treatment could save their lives and reduce complications.

In the current review study, an attempt was made to assess the patterns of terrorist attack injuries (13,18). However, the diversity of outcomes in different terrorist attacks was vast, indicating that these events usually follow a targeted plan for harm. In terrorism attacks situations identification of the type of surgery required and its difference from normal conditions is essential and it can enhance hospital management during crisis situations (19,20).

In their review study, Arnold et al. (20) examined mass casualty attacks in urban open spaces and compared them to natural disasters. They assessed 29 terrorist incidents involving 8,364 deaths, 903 potential deaths, and 7,461 emergency cases. Furthermore, chest and abdominal surgeries were required more often in terrorist attacks than in similar natural disasters. Their results were in agreement with the results of the current study.

Barillo et al. (21) reviewed relevant experiences in fire disasters or civilian burns happening in the United States between the years 1900 and 2000. Approximately 73 major U.S. fire disasters happened in the 20th century. By strengthening surveillance systems and establishing tight rules for dealing with fires, the losses caused by these disasters were reduced. A careful evaluation of these disasters indicates that there are many casualties, and most victims are injured or die at the scene or within 24 hours. High performance of emergency medical services (EMS) is very

important for saving victims. The current results emphasize the necessity for appropriate emergency medical services and early management that could save victims' lives.

Previous studies extensively explained the different patterns seen in terrorist attacks versus normal incidents (4, 5,17-23). Though all kinds of trauma were considered in this research, PTSD has been covered more broadly by other researchers. For instance, Bugge et al. stated that the severity of injury in psychological trauma can be even more permanent than physical trauma. They also showed that the recovery of victims should be followed up after they had left the hospital, so as to ensure that the violence would not jeopardize the victims' lives and futures (23). The results of the present study showed that aging victims, children, and women are more influenced by terrorist attacks, and long-term follow-up with psychological therapy is necessary. Goodwin et al. examined the psychological disaster of 1981 victims in a terrorist attack in France. They argued that the fear of terror syndrome and psychological injuries among victims increased between 7% and 11% depending on the severity of injuries (16). Therefore, government health management should aim to study the psychology conditions of victims of a terrorist attack and manage the crisis in the hospital through well-calculated plans.

The current results showed that major percentage of victims of terrorist attacks are young. Moreover, fatality and severe injuries were remarkably higher among children than adults. Furthermore, injuries caused by terrorist attacks often affect several zones in the body, requiring several surgical procedures for one injured person (4). Therefore, the most important factor in crisis management is the bottleneck of triage among casualties. A very different outcome can be achieved by planning to accelerate the triage of injured people and prioritizing the victims' needs for medical services (4). In all of the hospitals in this review, the emergency medicine administrators co-operated with the most superior trauma surgeons in the triage of trauma patients. Based on the distribution of various types of trauma, Edwards et al. proposed that optimal decisions can be made during critical situations. They believe that in such circumstances, the most important factor contributing to the minimization of casualties and injuries is how prepared hospitals are for these conditions (24). Edwards et al. also reported that decision-making is the most important factor in advancing hospital management in critical situations.

They believe that the most important factors contributing to crisis management in the hospital are the initial information obtained about the number and types of injuries at the hospital as well as police information to identify the number of injuries and mortality rates caused by the attacks (24). Rapid logistics response, quick access to the surgery room, and multidisciplinary surgical care units are the key factors proposed by Gregory et al. for hospital management in crisis situations. By implementing these three factors, they achieved a zero-mortality rate after admission to the hospital (25).

Conclusions

Differences in the severity and type of injuries among victims depended on the various causes of blast injuries, the power of the explosion, the open or enclosed location setting, the destruction of structures, and the interval between the cases and the explosion. The results showed head and lung injuries are the major causes of mortality in victims of terrorism. Appropriate emergency medical services and early management could increase the patient survival rate and reduce complications.

Acknowledgments

We thank the staff of the trauma research center, Baqiyatallah University of Medical Sciences, Tehran, Iran for kindly cooperation in this study.

Authors' Contribution

All authors pass the four criteria for authorship contribution based on the International Committee of Medical Journal Editors (ICMJE) recommendations.

Conflict of Interests

The authors declared no potential conflict of interests with respect to the research, authorship, and/or publication of this article.

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