ORIGINAL ARTICLE
Turk J Surg 2022; 38 (1): 67-73

Injury mechanisms and injury severity scores as determinants of urban terrorism-related thoracoabdominal injuries

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ABSTRACT

Objective: Improving the care of injuries resulting from terrorist attacks requires understanding injury mechanisms in armed conflicts. The aim of this study was to identify injury characteristics in military personnel with thoracoabdominal combat injuries resulting from terrorist attacks in urban settings.

Material and Methods: A retrospective study of military personnel with thoracoabdominal injuries who were referred to a tertiary center after treating and stabilizing at a primary healthcare organization due to terror-related injuries in various urban regions of Turkey between June 2015 and December 2016 was performed.

Results: A total of 70 patients were included in this study, of whom 87.1% were injured by explosives and 12.9% (n= 9) had gunshot wounds (GSWs). Mean injury severity score (ISS) was 21, blood transfusion amount was 3.7 units, and mortality rate was 8.5%. Patients injured by explosives had most commonly abdominal and extremity injuries (31.1%), whereas isolated abdominal injuries (55.6%) were observed among patients with GSWs. There were no significant differences between the mechanisms of injuries and the ISS, blood transfusion, and mortality (p= 0.635, p= 0.634, and p= 0.770, respectively). A significant correlation was observed between the ISS and transfusion amounts (r= 0.548, p< 0.001). Mortality was significantly higher in those with a high ISS and those undergoing massive blood transfusions (p= 0.004 and p< 0.001, respectively).

Conclusion: Explosive injuries, concomitant vascular injuries, high ISS, and the need for massive transfusions increased the mortality rate in urban combat injuries. To quickly identify high-risk patients and improve the care of injuries, it is essential to use predictive models or scoring systems.

Keywords: Combat injury, injury severity score, thoracoabdominal injury, terrorism, urban

INTRODUCTION

Urban warfare is combat that takes place in urban environments, such as towns and cities, and is mostly against terrorism threats. Urban combat is different from conventional warfare because of the presence of civilians and peculiar features related to the urbanized area, such as a three-dimensional environment, enhanced concealment for terrorists, limited fields of view, and spheres of engagement (surface, high-rise, and subsurface) (1). In many parts of the world, especially in the Middle East, combat injuries are ever-increasing due to ongoing regional wars, armed conflicts, and terrorist attacks. Thanks to technological advances, more complex and high-energy weapons have been developed that increase the severity of trauma, which ultimately results in a high number of fatal injuries (2).

Combat injuries, either due to gunshot or explosives, cause high rates of mortality and morbidity worldwide, as well as in Turkey. Recently, it has been shown that injuries caused by explosives are more common than gunshot wounds (GSWs) (3). In urban terrorism, an enemy or a sniper, usually concealed for an ambush, shoots a weapon or uses a booby-trapped improvised explosive device, which can increase the severity of injuries (4). Thus, combatants often have to fight at very close range, particularly in streets and buildings where they are confronted with machine guns and sniper fire. In the data reported by military trauma centers receiving survivors from Iraq and Afghanistan, the incidences of combat-related abdominal, thoracic, and extremity injuries have been reported to be about 11%, 6%, and 54%, respectively (5,6).

Cite this article as: Öztürk A, Şenocak R, Kaymak Ş, Hançerlioğulları O, Çelik SU, Zeybek N. Injury mechanisms and injury severity scores as determinants of urban terrorism-related thoracoabdominal injuries. Turk J Surg 2022; 38 (1): 67-73.

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Received: 04.09.2021
Accepted: 08.11.2021
Available Online Date: 28.03.2022

DOI: 10.47717/turkjsurg.2022.5506

Mortality in civilian and military trauma patients occurs mostly in the prehospital period; deaths can be reduced by increasing prehospital resuscitative care and taking protective and preventive measures. However, to a certain extent, the main cause of mortality in the-posthospital period has been suggested to be an insufficiency of hospital care services and trauma systems (7). Therefore, improving injury care resulting from terrorist attacks in urban areas requires an understanding of the mechanisms of the injury. The aims of this study were to describe injury characteristics of military personnel who had sustained thoracoabdominal injuries from terrorist attacks in urban settings.

MATERIAL and METHODS

Approval for this study was granted by the Ethics Committee of the University of Health Sciences with the registration number 17/22. The study was designed as an observational cross-sectional study and included 70 military personnel with abdominal or thoracoabdominal injuries. The patients were among the patients who were referred to Gulhane Training and Research Hospital, a tertiary healthcare organization (role 3 hospital), for further treatment. They were referred after they had been treated and stabilized at a primary healthcare organization due to terror-related injuries in various urban regions of Turkey between June 2015 and December 2016.

The patients' demographic details, mechanisms of injury, distribution of wounds by body region, total blood transfusions, and outcomes were obtained from the medical records. ISS is an anatomic scoring system that provides an overall score for patients with multiple injuries and is associated with trauma severity. It was calculated by identifying the patients' injured anatomical regions obtained by surgical records, physical examinations, and imaging findings. ISS is the sum of the squares of the highest abbreviated injury scale (AIS) code in each of the three most severely injured ISS body regions. The six body regions defined in the AIS are the head or neck; face; thorax; abdomen and pelvic contents; extremities, shoulder, and pelvic girdle; and external. ISS is categorized as minor to moderate (<16) and severe to very severe (≥16) (8).

The study group consisted of patients with major abdominopelvic organ injuries, or with accompanying thoracic and extremity injuries, which were followed up and treated in the general surgical intensive care unit. For this reason, since there were no patients with severe injuries from other anatomical regions (head/neck), these were not included in ISS calculation. The injury mechanism classifications were by penetrating injuries, such as those caused by GSW or explosives (improvised explosive devices, grenade, or shrapnel). No other blunt injury mechanisms were present except in the thoracic regions.

Data were analyzed using commercial computer software (SPSS ver. 14.0, SPSS Inc. Chicago, IL, USA). The resulting values are presented as mean ± standard deviation and percentages where suitable. Numerical data were analyzed using Student's t tests for normally distributed variables or Mann-Whitney U tests for non-normally distributed continuous variables. Categorical variables were compared with Chi-square tests and Fisher's exact tests, if necessary. Correlations between categorical data were investigated using Spearman correlation coefficients. A p value <0.05 was considered statistically significant.

RESULTS

Seventy patients were referred to our department with diagnoses of various thoracoabdominal injuries between June 2015 and December 2016. All patients were males and were mostly injured by explosives rather than GSWs. Mean ISS of the trauma patients was 21.0 ± 9.6. Two-thirds of the patients having multiple-organ injuries. More than half of the patients required blood transfusions with only a 15.7% requiring massive transfusions (>10 units). There were six deaths resulting from the injuries. Demographic, injury, and treatment data are presented in Table 1.

Patients injured by explosives had higher ISSs than those injured by gunshot; however, this was not statistically significant. Moreover, with regard to the mechanism of injury, there were no significant differences between the groups in terms of age, red blood cell transfusions, and mortality rates (Table 2). With regard to ISS, 44.3% of the patients suffered severe injuries. Table 3 details the distribution of ISS by blood transfusion amount, mechanism of injury, and outcome. Both mortality and blood transfusions of more than 10 units were significantly associated with an ISS≥ 16 ($p= 0.011$ and $p= 0.004$; respectively). In addition, a significant correlation was identified between the ISS and transfusion amounts ($r= 0.548$, $p< 0.001$). When patients were divided into groups based on blood transfusions, ISS for those who received blood was higher than for those who did not receive blood (31.0 ± 10.3 vs. 21.1 ± 7.6; $p= 0.006$). Mortality rate was significantly higher in patients in need of massive blood transfusions ($p< 0.001$) (Table 4).

Of the 11 patients who underwent massive blood transfusions, four (36.3%) were given blood transfusions in accordance with the massive transfusion protocol (MTP). No significant difference was found between MTP and mortality. Among all patients included in this study, three (4.2%) had abdominal vascular injuries and two of these resulted in death. Median ISS of the six deaths was 36 (25-41). Of the patients who died, five (83.3%) were injured by explosives and five (83.3%) had multiple organ injuries and underwent massive blood transfusions. Moreover, in 60% of those who underwent massive blood transfusions, the transfusions were carried out in accordance with MTP.

Table 1. Demographic and injury-specific data of the patients (n= 70)		
Variables		
Age, mean ± SD	31.9 ± 6.9	
Injury severity score, mean ± SD	21.0 ± 9.6	
Mechanism of injury, n (%)		
Explosive	61 (87.1)	
Gunshot	9 (12.9)	
Anatomical area of the injuries, n (%)	Explosive	Gunshot
Isolated abdomen	17 (27.9)	5 (55.6)
Abdominal and extremity	19 (31.1)	3 (33.3)
Thoracoabdominal	12 (19.7)	1 (11.1)
Thoracoabdominal and extremity	13 (21.3)	0 (0)
Injured organs, n (%)		
Single organ	23 (32.8)	
Multiple organ	47 (67.2)	
Abdominal organ injuries, n (%)	123	
Colon	36 (29.2)	
Small intestine	21 (17.1)	
Liver	18 (14.6)	
Spleen	12 (9.8)	
Kidney	7 (5.7)	
Gall bladder	6 (4.9)	
Vascular	3 (2.4)	
Others	20 (16.3)	
Thoracic injuries, n (%)	26	
Lung contusion/laceration requiring tube	13 (50.0)	
Diaphragm injury	6 (23.1)	
Multiple injuries	7 (26.9)	
Red blood cell transfusion (units), mean ± SD	3.7 ± 4.9	
Red blood cell transfusion, n (%)		
No transfusion	25 (35.7)	
1–10 units	34 (48.6)	
>10 units	11 (15.7)	
Mortality, n (%)	6 (8.5)	

Table 2. Comparison of the groups in terms of the mechanism of injury

	Explosive (n= 61)	**Gunshot (n= 9)**	**P**
Age, mean ± SD	32.3 ± 6.9	29.8 ± 9.3	0.083
Injury severity score, mean ± SD	23.0 ± 12.5	20.5 ± 9.2	0.635
Red blood cell transfusion, n (%)			0.634
No transfusion	23 (37.8)	2 (22.2)	
1–10 units	29 (47.5)	5 (55.6)	
>10 units	9 (14.7)	2 (22.2)	
Mortality, n (%)	5 (8.1)	1 (11.1)	0.770

Table 3. Comparison of the groups in terms of injury severity scores (ISSs)

	ISS< 16 (n= 39)	ISS≥ 16 (n= 31)	P
Age, mean ± SD	31.8 ± 7.3	32.6 ± 6.4	0.785
Red blood cell transfusion, n (%)			0.011
No transfusion	18 (46.2)	7 (22.6)	
1–10 units	19 (48.7)	15 (48.4)	
>10 units	2 (5.1)	9 (29.0)	
Mechanism of injury, n (%)			0.991
Explosive	34 (87.2)	27 (87.1)	
Gunshot	5 (12.8)	4 (12.9)	
Mortality, n (%)	0 (0)	6 (19.3)	0.004

Table 4. Comparison of the groups in terms of blood transfusions

	1–10 units (n= 34)	>10 units (n= 11)	P
Age, mean ± SD	31.1 ± 6.5	30.7 ± 10.3	0.785
Injury severity score, mean ± SD	21.1 ± 7.6	31.0 ± 10.3	0.006
Mechanism of injury, n (%)			0.782
Explosive	29 (85.3)	9 (81.8)	
Gunshot	5 (14.7)	2 (18.2)	
Injured organs, n (%)			0.958
Single organ	9 (26.5)	3 (27.3)	
Multiple organs	25 (73.5)	8 (72.7)	
Concomitant vascular injury, n (%)	1 (2.9)	2 (18.2)	0.078
Mortality, n (%)	1 (2.9)	5 (45.4)	<0.001

DISCUSSION

The incidence of combat injuries related to regional armed conflicts and acts of terrorism is increasing in many regions of the world. In 2010, 32 wars or serious conflicts were reported worldwide, and since 2003, 80.000 to 110.000 people have been killed every year due to combat-related injuries under war conditions (9). Between June 2015 and December 2016, 750 wounded military personnel were transferred to our hospital due to terrorist-related injuries in urban areas in Turkey. This suggests that, given the strategic position of our country and the geography of where it is located, injuries related to terrorist acts have a particular importance.

The effects of civilian and military weapons are very different, and the resulting injuries can vary. Although most of the current research concerns injuries related to civilian weapons and sharp objects, our study only covers gunshot and explosive injuries caused by terrorist acts occurring in urban areas. Considering the military injury-producing mechanisms in urban settings in recent years, injuries caused by explosives are now at the forefront, followed by gunshot injuries (5,6). This corresponds to our findings in which almost 90% of injuries were the result of explosive devices. Research on combat injuries in wars and rural areas shows that GSWs are more common than explosive injuries (10). The frequency of multiple organ injuries in both mechanisms of injury, whether explosives or GSWs, is almost identical; however, in explosive injuries, extremity injuries are more common (11,12). Abdominal or thoracoabdominal injuries were also accompanied by extremity injuries in the patients in our study. For this reason, orthopedic and vascular surgeons, as well as the main surgical branches, should be present in trauma centers or hospital emergency departments closest to conflict zones.

Total mortality rates vary between 1.8-6.9% in studies investigating military cases (11,13). Our results had a slightly higher mortality rate of 8.5%. In this study, there was no significant difference between the mechanisms of injury and mortality rates. In a study related to post-hospital admissions, mortality due to explosive injuries was 72.5% and mortality due to GSWs was 25%, but most of these patients had brain injuries with low probabilities of survival (13). Mortality in those likely to survive was mostly caused by acute bleeding from truncal and peripheral extremities. Mortality is expected to be higher in high-speed GSWs and those injuries caused by strong blast effects. However, more than one shrapnel tends to strike the body in shrapnel injuries due to explosives. This leads to an increased number of injured organs and extremity injuries throughout the body and explains why explosives increase mortality rates more than bullets.

Blood loss amounts and ISS come to the forefront in studies examining the factors affecting mortality in combat injuries (14). The terms trauma score and trauma severity have been used since 1971. The most widely used trauma scoring system for assessing patients with multiple traumas in recent years has been ISS (15). ISS was first developed by Baker et al. (8) from AIS. ISS is directly proportional to mortality, morbidity, length of hospitalization, and trauma severity, regardless of how the trauma occurred. In a post-hospital study, mainly on explosive injuries, ISSs in 27% of the patients were between 15 and 25, 51% of the patients were between 26 and 55, and 86% of the patients who died had an ISS greater than 16 (13). Similarly, median ISSs corresponding to explosive-related injuries have been reported to be greater than those corresponding to GSWs (16). In our study, the average ISS was 21.0 ± 9.6, and the mortality rate (19.3%) in explosive injuries, in which the ISSs were high (≥16), was significantly higher than in the patient group in which ISSs were smaller than 16. Median ISS of the six casualties resulting in death was considerably higher than the non-fatal casualties. The main disadvantage of the ISS is that it ignores areas other than those with the most severe injuries and other injuries in the same area. This may not offer a completely reliable outcome, especially for combat injuries that cause multiple injuries in a single body location (17,18). Nevertheless, ISS still plays an important role in combat injuries by offering the ability to make appropriate triage decisions, to distinguish high-risk patients, and to determine and shape treatment priorities. It has recently been suggested that the trauma and ISS (TRISS), the new ISS (NISS), and especially the military ISS (mISS) may predict mortality more effectively than the original ISS for complex combat injuries (18,19). Such data will help improve the quality of treatment and enhance clinical success.

One of the most significant causes of death after combat injuries is bleeding (20). Bleeding and coagulopathy are among the most common causes of death in patients admitted to hospital emergency departments due to trauma in the first 24 hours and are the cause of approximately 50% of deaths (10). Blood transfusions should be considered at an early stage in patients with hemorrhagic shock to prevent and correct the traumatic coagulopathy that occurs after combat injuries. Current military data show that about 25% of wounded personnel need blood transfusions, of which 4-8% undergo massive transfusions (21). However, in our study, blood transfusions were needed in almost two thirds of the patients, while massive transfusions were given to only 15.7% of patients. When compared to the rates cited in the literature, in urban combat injuries, the rate of blood transfusions was almost twice as high, while that of massive blood transfusions was nearly three times as high. Moreover, the mortality rates were significantly higher in patients who underwent massive blood transfusions, and ISSs were moderately correlated with the amount of blood given to the patients. In a study by Niles et al. (22), the authors reported that the incidences of early coagulopathy in transfused military personnel were 25-38%, which correlated with the ISS. In all type injuries, a high ISS and a high transfusion volume have been considered independent predictors of coagulopathy and increased mortality (18). In a study conducted to predict massive transfusion needs in combat casualties, the rate of massively transfused patients had significantly higher transfusion requirements, higher ISS, and greater in-hospital mortality rates than those not given massive transfusions (23). ISS cannot be used as a predictor of need for a massive blood transfusion during the prehospital period. Therefore, a useful model for massive transfusions in trauma settings must be based on information that is rapidly available, concrete, and simply applicable through physiologic and laboratory variable. Massive transfusion rates and aggressive resuscitations in American trauma Level I hospitals are higher than those in Level II hospitals where more seriously injured patients are treated. Although there is no difference between the blood and plasma products given at both levels, platelet use in Level II centers has been shown to be higher than that in Level I centers, and platelet administration has increased survival rates. It has also been shown that there is a difference in mortality rates between hospitals where massive transfusions occur and those that do not readily perform them (24).

The present study is subject to several limitations. First, most of the patients were hemodynamically stabilized to a certain extent by initially being treated in local hospitals in conflict zones, so there was no common transfusion strategy. Second, injury severities were evaluated anatomically with ISS; no other physiologic or anatomic scoring systems were used. However, the fact that the cases were monitored by a single surgical discipline is a strong aspect of our study.

In our study, the average amount of blood needed by patients due to urban combat injuries was almost four units, with over 60% of patients requiring a transfusion. Therefore, blood banks should be founded in trauma centers or those hospitals closest to the regions where conflicts occur, and blood banks should stock adequate amounts of blood and blood products. Previous research has shown that damage control or hemostatic resuscitation can reduce mortality rates from 38% to 20% in seriously injured patients who required due to massive transfusions (25). Thus, it is necessary to develop hemostatic techniques, such as freeze-dried plasma and novel topical/systemic agents, that can reduce the need for massive transfusions.

In conclusion, thoracoabdominal injuries due to urban combat are caused to a large extent by explosives. These injuries are often accompanied by extremity injuries. In urban combat injuries, the need for blood transfusions has increased, regardless of the mechanism of injury (explosives or gunshot), and patients with higher ISS may require more transfusions. Explosive injuries, concomitant vascular injuries, high ISSs, and massive transfusion requirements were found to increase mortality. To reduce mortality in urban combat injuries, greater importance should be given to the prehospital period. High-risk patients with penetrating trauma in need of massive blood transfusions should be identified rapidly using predictive models, and bleeding should be stopped by performing damage control surgery as soon as possible.

Ethics Committee Approval: The ethical approval for this study was obtained from the Non-invasive Clinical Researches Ethics Committee of the University of Health Sciences (Date: 16.01.2018, Decision No: 17/22).

Peer-review: Externally peer-reviewed.

Author Contributions: Author Contributions: Concept - O.H., N.Z.; Design - A.O., R.S., O.H., N.Z.; Supervision - R.S., O.H., N.Z.; Materials - A.O., R.S., S.K., O.H., N.Z.; Data Collection and/or Processing - A.O., R.S., S.K., O.H., S.U.C.; Analysis and/or Interpretation - A.O., R.S., S.K., S.U.C.; Literature Search - A.O., R.S., S.K., O.H., S.U.C.; Writing Manuscript - All of authors; Critical Reviews - All of authors.

Conflict of Interest: The authors declare that they have no conflict of interest

Financial Disclosure: The authors declared that this study has received no financial support.

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ORİJİNAL ÇALIŞMA-ÖZET
Turk J Surg 2022; 38 (1): 67-73

Kentsel terörizmde görülen torakoabdominal yaralanmaların belirleyicileri olarak yaralanma mekanizmaları ve yaralanma ciddiyeti skorları

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ÖZET

Giriş ve Amaç: Terörist saldırılardan kaynaklanan yaralanmaların bakımını iyileştirmek, silahlı çatışmalardaki yaralanma mekanizmalarının anlaşılmasını gerektirir. Bu çalışmanın amacı, kentsel ortamlarda terörist saldırı sonucu ortaya çıkan torakoabdominal savaş yaralanması olan askeri personeldeki yaralanma özelliklerini belirlemektir.

Gereç ve Yöntem: Haziran 2015-Aralık 2016 tarihleri arasında Türkiye'nin çeşitli kentsel bölgelerinde teröre bağlı yaralanmalar nedeniyle bir birinci basamak sağlık kuruluşunda tedavi ve stabilizasyonu sağlanarak üçüncü basamak bir merkeze sevk edilen torakoabdominal yaralanmalı askeri personelin retrospektif bir çalışması yapıldı.

Bulgular: Bu çalışmaya %87,1'i (n= 61) patlayıcılarla yaralanan ve %12,9'u (n= 9) ateşli silah yaralanması (ASY) olan toplam 70 hasta dahil edildi. Ortalama yaralanma ciddiyet skoru [injury severity score (ISS)] 21, kan transfüzyon miktarı 3,7 ünite ve ölüm oranı %8,5 idi. Patlayıcılarla yaralanan hastalarda en sık karın ve ekstremite yaralanmaları (%31,1) görülürken; ASY'li hastalarda izole karın yaralanmaları (%55,6) görüldü. Yaralanma mekanizmaları ile ISS, kan transfüzyonu ve mortalite arasında istatistiksel olarak anlamlı fark yoktu (sırasıyla p= 0,635, p= 0,634 ve p= 0,770). ISS ile transfüzyon miktarları arasında anlamlı bir korelasyon gözlendi (r= 0,548, p= 0,001). Ölüm oranı yüksek ISS olanlarda ve masif kan transfüzyonu yapılanlarda anlamlı olarak daha yüksekti (sırasıyla p= 0,004 ve p= 0,001).

Sonuç: Patlayıcı yaralanmalar, eşlik eden vasküler yaralanmalar, yüksek ISS ve yoğun transfüzyon ihtiyacı, şehir içi savaş yaralanmalarında ölüm oranını arttırmıştır. Yüksek riskli hastaları hızlı bir şekilde belirlemek ve yaralanmaların bakımını iyileştirmek için öngörücü modelleri veya puanlama sistemlerini kullanmak önemlidir.

Anahtar Kelimeler: Kentsel, savaş yaralanması, terörizm, torakoabdominal yaralanma, yaralanma ciddiyet skoru

DOİ: 10.47717/turkjsurg.2022.5506