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FULL PAPER

# Imaging features of blast injuries: experience from 2015 Ankara bombing in Turkey

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**Objective:** To present the radiological features of blast-related injuries in the victims of the 10 October 2015 Ankara bombing and emphasize the importance of imaging.

**Methods:** This retrospective descriptive study included a total of 28 patients who underwent CT scan or radiographic imaging within 6 h after the bombing on 10 October 2015. CT scans and plain radiographs were evaluated regarding mechanisms of injuries. Injuries were categorized as primary, secondary, tertiary and quaternary. The number of shrapnel and distribution of injuries were noted. Injury Severity Score (ISS) was used to rank the severity of the injury.

**Results:** Primary blast injuries consisted of only tympanic membrane rupture. A high rate of patients (21/28 patients) in the study group suffered from secondary blast injuries. Tertiary injuries were detected in only three patients. Of the severely injured patients, five had abdominal injuries, three had thoracic injuries and six had extremity injuries. ISS was significantly higher in patients with thoracic and abdominal injuries.

**Conclusion:** Our results after the suicide bomb attacks showed that the most common injury pattern was secondary blast injury. The torso was the most commonly injured body region, followed by the extremities. This specific injury pattern requires the use of immense radiological imaging. Hence, radiologists should be aware of the mechanisms and spectrums of blast-related injuries.

**Advances in knowledge:** Both the unique injury pattern and the following chaos make blast-related injuries a challenge in terms of triage, diagnosis and management. Radiologists should be familiar with the wide spectrum of these unique injuries.

## INTRODUCTION

### Mechanisms of injury

The patterns of blast-related injuries are categorized according to the basic effect of explosion (Table 1). This categorization provides a valuable theoretical framework for understanding blast injuries. However, various mechanisms occur together and victims usually have complicated injuries.[1,2] Primary injuries occur secondary to the direct effect of changes in the atmospheric pressure caused by the blast wave, which is an intense over-pressurization impulse created by the explosion. Gas-filled structures such as the middle ear, lung and the gastrointestinal tract are most susceptible. Secondary blast injuries result from flying debris and fragments. They can be seen in any part of the body and are considered to be the most common cause of explosion-related injuries. Fragments would be metallic (shrapnel) or non-metallic. Furthermore, bony fragments from other individuals can be encountered. Tertiary blast injuries occur when the victim body is thrown over by the blast wind producing blunt or penetrating trauma. Quaternary blast injuries are caused by burns, toxic inhalation and exposure to radiation.[1]

The Ankara bombing, which has been the largest terrorist attack recently in Turkey, took place at 10.04 am on 10 October 2015 in the capital city of Turkey, killing 101 people and injuring approximately >250 people. The two suicide bombers targeted a densely populated area where people had gathered for a meeting. In this article, we present the radiological features of blast-related injuries in the victims of 10 October 2015 Ankara bombing and emphasize the importance of imaging.

## METHODS AND MATERIALS

Our institutional review board has approved this retrospective study. After the attack, 32 patients were admitted within 6 h to the emergency department of Hacettepe University Hospital, which is located 3.6 km away from the bomb site. Only patients who underwent radiological investigations were included in the study. Patients who were critically injured and transferred directly to the operating room were excluded from the study.

Plain radiographs and CT scans were performed during the patients' initial assessments. No MRI examinations were

Table 1. Classification of blast injuries

| Categorization | Mechanism | Characteristic |
|---|---|---|
| Primary | Impact from overpressure created by explosion on the body surface | Air-containing structures such as the lung, gastrointestinal tract and ear |
| Secondary | Injuries from flying debris and shrapnel propelled by blast wave | Penetrating trauma; any body part might be affected |
| Tertiary | Injuries from the victim being thrown by the blast wind | Penetrating and blunt trauma; any body part might be affected |
| Quaternary | Other injuries from indirect blast-related trauma such as burns and smoke inhalation | |

performed during the acute presentation of the patients. CT images were obtained in compliance with the single-pass whole-body CT protocol.[3] All radiographs and CT scans were assessed retrospectively in terms of positive findings regarding penetrating and blunt trauma as well as more specific bomb blast injuries such as blast lung. Injuries were then categorized according to the injury mechanism, as described in Table 1. Injuries other than shrapnel and blast wave were considered to be tertiary injuries. The number, type and location of the shrapnel fragments were also noted for secondary injuries. In addition, shrapnel penetration, the presence of soft-tissue injuries and fractures were evaluated as well.

The degree of severity in critically ill patients was assessed using the Injury Severity Score (ISS).[4] The abbreviated injury severity scale is an anatomically based injury severity scale which scores each injury from 1 to 6 within six body regions. The ISS derived from the Abbreviated Injury Scale score with a range of 0–75 and is an overall measure of injury severity. ISS was categorized into three severity levels; mild $<9$, moderate 9–15 and severe $>15$.

In order to describe and analyze the distribution of secondary and tertiary injuries, the body was divided into five anatomical regions: head–neck; thorax; abdomen–pelvis; upper–lower extremities; and spinal cord and column.

Age was presented as median and interquartile range. The ISS, types and distribution of the injuries were described as frequency and percentage. Statistical analysis was performed with SPSS® v. 22 (IBM Corp., New York, NY; formerly SPSS Inc., Chicago, IL) for Windows®.

## RESULTS

32 patients were admitted to our accident emergency department. No patient was dead on arrival, but five patients died subsequently, four of them shortly after admission (only one of five patients had radiological imaging). Of the survivors, 28 patients (7 females and 21 males) who underwent radiological imaging were included in the study. The median patient age was 42 years (range 18–65 years, interquartile range: 32 years). The mean ISS was 9.6 (range 0–75).

23 patients underwent CT scans. Of these CT examinations, nine were a part of trauma whole-body CT scans. There were nine cranial CTs, three thorax CTs, two cervical spine CTs, four maxillofacial CTs, three abdominal CTs and two lower extremity CTs. 20 patients had plain radiographs. Overall, 26 patients had various types of blast injuries. The most common mechanism of trauma was secondary blast injury, for which 11 patients underwent a surgical procedure.

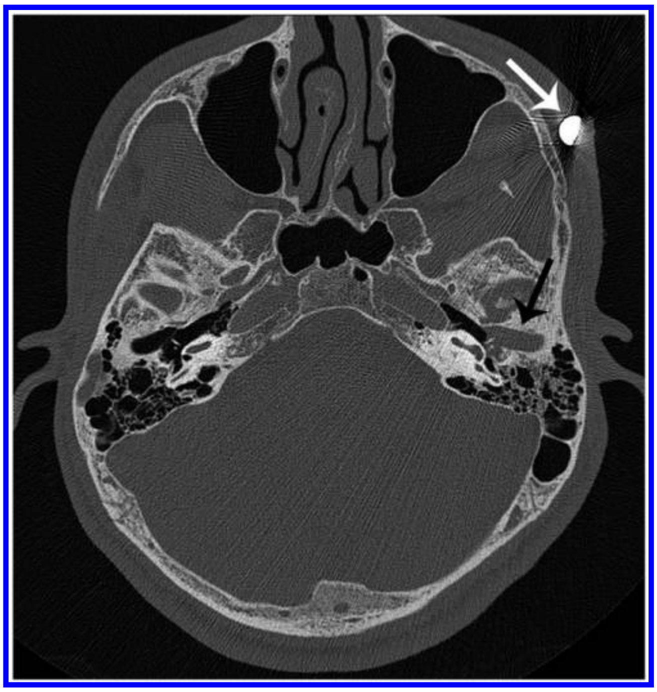
### Primary blast injuries

8/28 (29%) patients had tympanic membrane ruptures; 1 of them also had ossicle dislocation and haemotympanum (Figure 1). Five of them also had a secondary or tertiary injury. There was no blast lung or gastrointestinal perforation in the study group.

### Secondary blast injuries

21/28 (75%) patients sustained secondary blast injuries caused by penetrating shrapnel. A total of 23 metal fragments were

Figure 1. A 19-year-old male with primary blast injury. Axial high-resolution CT image demonstrating haemotympanium in the left middle ear (black arrow). A shrapnel fragment embedded in the soft tissue is also seen (white arrow).



identified on plain radiographs and CT scans (Figure 2). Most of the metallic fragments were ball bearings. Non-metallic fragments were not detected. Three of them were seen on only plain radiographs as CT examinations were not required because of the superficial penetration of the fragments (Figure 3). Overall, all body regions were injured by shrapnel fragments. There were shrapnel penetrating the peritoneal or pleural space with visceral injury in six patients. Mesenteric injuries and bowel perforations were detected in three of them (Figure 4). One of them had a thoracic injury consisting of the pneumothorax, haemothorax and parenchymal contusion in addition to abdominal injury (Figure 5). One patient had extraperitoneal bladder rupture (Figure 6). There were two patients who had thoracic injuries including pneumothorax, haemothorax, rib fractures, subcutaneous emphysema, contusion and laceration (Figure 7).

Figure 2. A 50-year-old male with extremity injury. Radiograph of the right leg demonstrating a ball bearing and fracture of the right fibula requiring surgical procedure.


Head and maxillofacial injuries were detected in six patients (Figure 8). Orbital injury was observed in only one of them (Figure 9). Extremity fractures were identified in six patients. 11 (52%) patients with penetrating injuries underwent a surgical procedure.

### Tertiary and quaternary blast injuries

Injuries in 3/28 (11%) patients were considered to be tertiary injuries, of which 1 patient had a zygomatic fracture, 1 had multiple thoracic vertebrae fractures and 1 had a renal laceration. There was no evidence of quaternary blast injuries revealed on imaging.

### Injury Severity Score

A total of 6 (21.4%) patients had severe injuries (ISS >15). 4 patients had moderate injuries (ISS 9–15) while 18 patients had mild injuries (ISS <9). The majority of the severely injured patients had thoracic and abdominal injuries (Figure 10).

## DISCUSSION

Injuries from explosive devices are due to multiple mechanisms that are evident in the wide variety of injuries affecting multiple body regions and organ systems.[5] Patterns of these injuries depend on several factors including the environment of the blast (close *vs* open space), the amount of shrapnel and nature of the explosive material.[6,7]

Figure 3. Soft-tissue shrapnel in the right lower extremity. Radiograph of the right leg showing a ball bearing in the soft tissue. There is no fracture in the tibia or fibula.

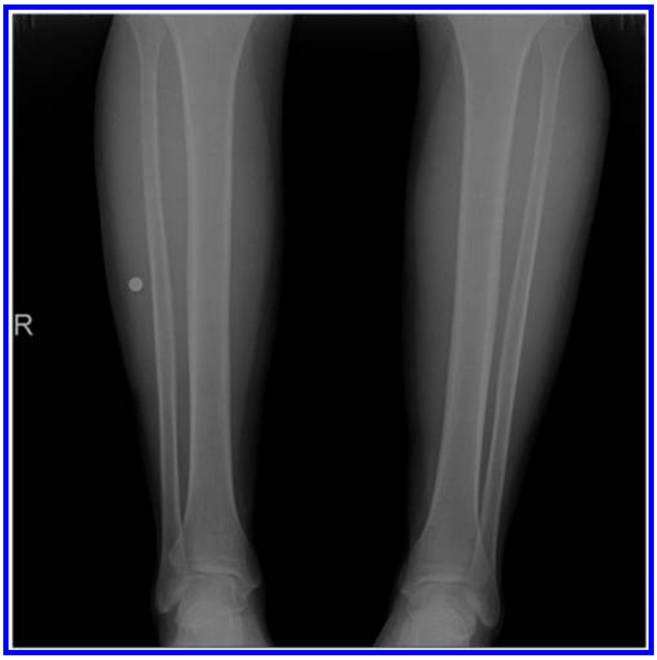
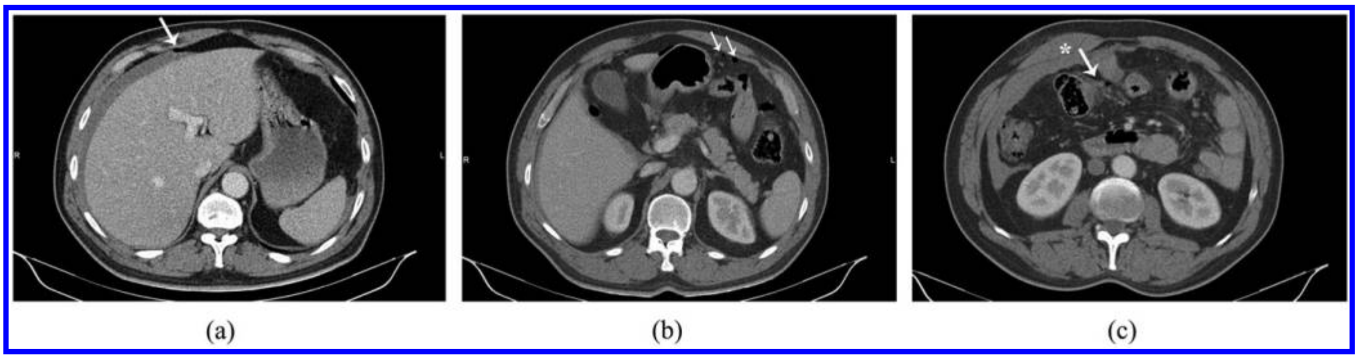


Figure 4. CT image in a 57-year-old male with multiple injuries. Axial CT images (a, b) showing haemoperitoneum and intraperitoneal free air (white arrows), suggesting perforation of the gastrointestinal organs. Lower slices revealing thickening of the transverse colon wall (white arrow) and rectus haematoma (asterisk) in keeping with the entry site of the shrapnel (c).



A study[6] of 297 victims of 4 bombing events compared the injuries of those who had been in open air and with those who had been in an enclosed space. Similar explosive devices had been used in all four explosions.[6] Results of this study showed that closed-space explosions cause higher mean ISSs, higher mortality and higher incidence of primary blast injuries than open air blasts. However, no difference was noted between open- and closed-space blasts in terms of prevalence of penetrating injury and traumatic amputations.[6,8,9] The higher mortality and morbidity rate in closed spaced explosions was explained by DePalma et al[10] with the amplified blast wave due to reflections of the blast wave from surrounding walls. Our results showed a high rate of severely injured patients (21.4%), which means involvement of multiple systems. This high rate is probably related to the suicide bombing, which contributed to the relatively severe injuries requiring more abdominal, vascular and neurosurgical procedures compared with the other forms of trauma.[11,12]

None of the imaged patients had evidence of blast lung. As a unique injury pattern of bomb explosion, blast lung injury is a major cause of immediate death and morbidity in patients who are critically ill.[13] Furthermore, primary blast lung prevalence has been reported to be significantly higher in patients injured in a confined-space explosion than in those injured in an open-space explosion. Radiological features of blast lung injury are characterized by ground-glass opacities or consolidation with typical butterfly distribution.[14] In addition, pneumothorax, haemothorax, pneumomediastinum and air embolism can be observed as well. In the 2004 Madrid bombings, blast lung injuries were reported in 16 patients (94%).[14] Similarly, after the attacks on the transport system in London (2005), blast lung injuries were common especially in severely injured patients.[12] On the contrary, in a study by Singh et al,[15] there were no blast lung injuries, which shows consistency with our results. We had no blast lung in our patients. This might be explained by the 2015 Ankara bombing being an open-space explosion or that majority of the victims suffering from blast lung were killed on site or immediately after.

Patients with no evidence of blast lung were not observed any further. Some authors believe that blast lung might develop within 48 h after the blast similar to adult respiratory distress syndrome.[16] While others claim that prolonged observation is not necessary.[17]

Figure 5. CT image in a 63-year-old male with injuries to the thorax and abdomen. Axial CT image (a) showing a ball bearing in the vertebra corpus (arrow). There were haemopneumothorax and parenchymal contusion in the right lung (b, c). The patient also had liver laceration and upper extremity injury.

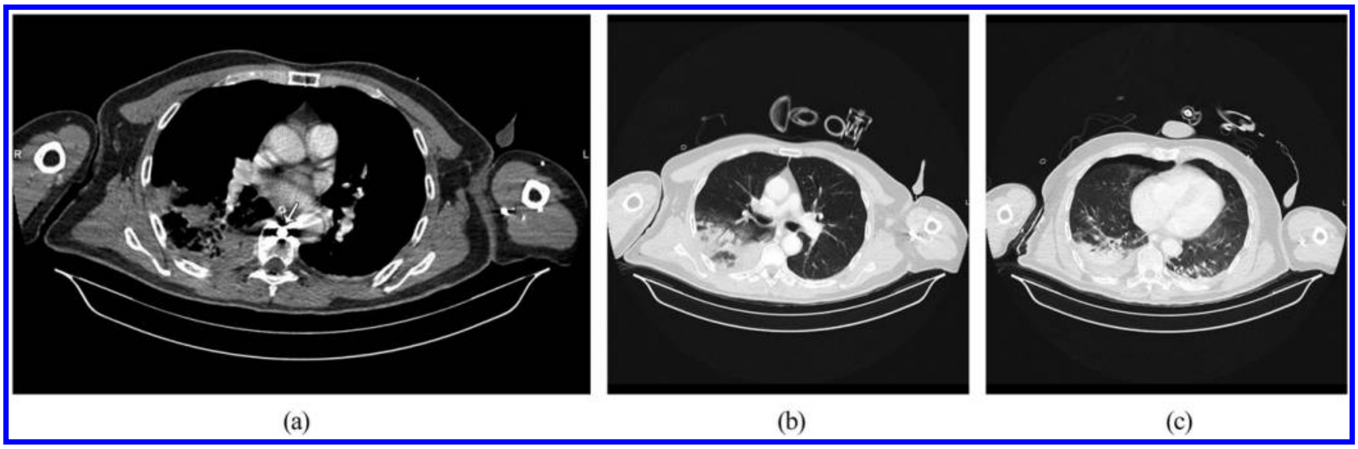
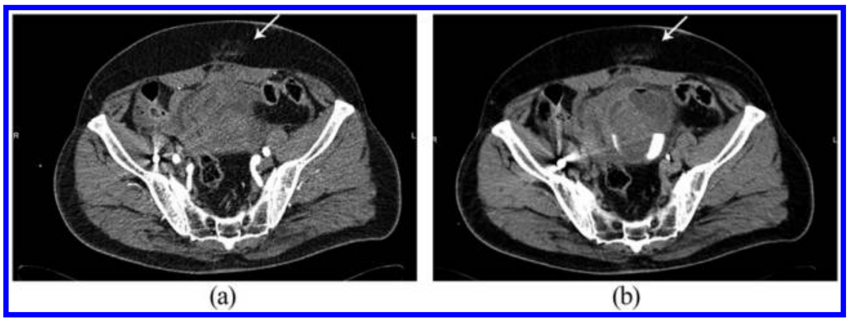


Figure 6. CT images in 64-year-old male with pelvic injury. On axial CT image (a), a ball bearing is seen in the right iliacus muscle and also at the entry site of the shrapnel in the anterior abdominal wall (arrow). CT cystogram (b) image illustrating extraperitoneal bladder rupture.



Tympanic membrane perforation is the most common primary blast injury, which is accepted to be an indication of blast pressure. There were 8/28 (28.5%) patients with tympanic membrane ruptures, of whom 1 patient also had ossicle dislocation and haemotypanum in the middle ear. In some series,[2,12] the prevalence of tympanic membrane rupture has been found to be up to 47%, which is consistent with our results. Some authors[10] accepting tympanic membrane rupture to be an indication of blast pressure have proposed investigating blast lung or hollow viscus perforation deliberately in patients with tympanic membrane ruptures.[18] In other words, in patients with no tympanic membrane rupture, the primary effects of the blast are unlikely. On the other hand, there is a controversy in the literature regarding the reliability of tympanic membrane rupture as an evidence of blast wave exposure.[6] Actually, it has been reported that four patients in the Madrid cohort had blast lung injury without tympanic membrane rupture.[14]

The majority of the injuries in our study group was secondary blast injuries, accounting for 75% (in 21/28 patients) of all injuries. This result is corroborated by the results of previous studies[19] of open-air terrorist bombings. In addition, the explosive devices used in the Ankara bombing were augmented by heavy-metal fragments, resulting in much severe penetrating injuries. Penetration of shrapnel fragments in the viscera was seen in six patients, of whom five underwent emergency surgery. Unlike in a previously published report by Bala et al,[20] we found that the distribution of severe injuries was predominant in the torso followed by in the lower extremity. Facial injuries were described as characteristic injuries in the series following the suicide bombing attacks of Jerusalem. Another study from Israel based on the comparison of gunshot and explosion injuries reported that the most commonly injured body regions were the head and the extremity.[21]

Abdominal injuries were reported in variable rates in the different series (Table 2). Abdominal and thoracic injuries were seen in 25% of our patients, of which all but one was caused by penetrating shrapnel, not by blast wave. Compared with other studies, there was a considerably higher rate of torso injuries in our cohort of patients, as in suicide bombings, shrapnel are propelled from an explosive device wrapped around the torso, which alters their distribution. On the other hand, the rate of severe extremity injuries was low in this study compared with that in the Boston Marathon bombings, where explosive devices were positioned on the ground.[15]

In this study, patients who were non-critical were evaluated with radiographs to detect metallic fragments and fractures as part of triage. Patients who were stable but critically ill were transferred to CT before the operating room. The whole-body scout view was obtained initially and followed by whole-body CT scans. In our institution, a single bolus examination protocol is performed for whole-body CT scan, which reduces the

Figure 7. CT images in a 45-year-old male with severe thorax injury. Axial CT images showing a metallic fragment and haemothorax, which induced a contralateral shift of the mediastinum (a). Free air in the pericardial space and pericardial thickening (arrow) suggesting pericardial injury (b). Parenchymal contusion is also seen in the left lung caused by the shrapnel (c).

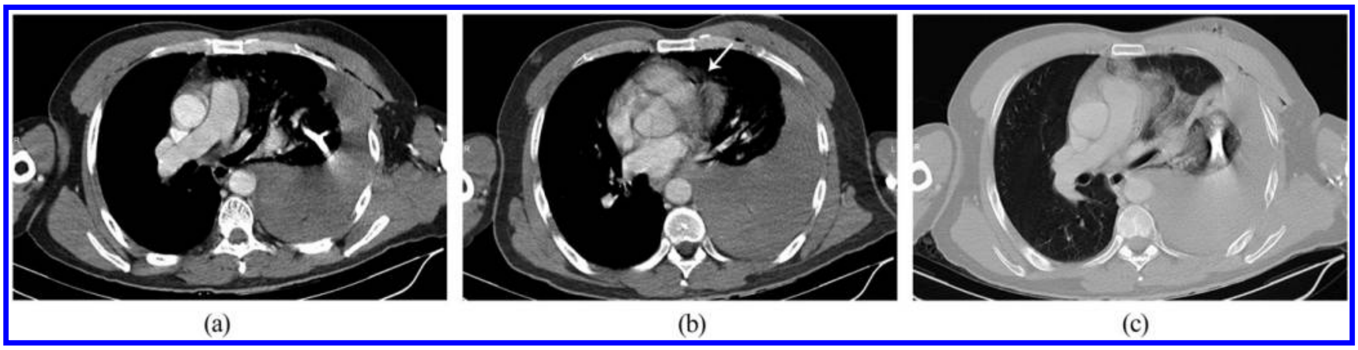
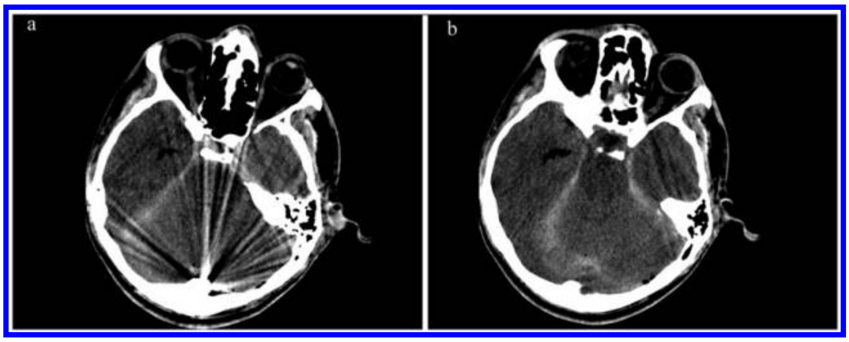


Figure 8. CT image in a 20-year-old male with penetrating head injury. Axial CT image showing an intraparenchymal ball bearing and subdural haemorrhage (a, b).




scanning time and allows more rapid evaluation of patients with polytrauma.[3]

In our cohort of patients, the majority of the injuries were secondary blast injuries requiring a multimodality imaging approach. Radiological evaluation of penetrating shrapnel injuries should involve the identification of shrapnel fragments and resulting injuries. Occasionally, a shrapnel fragment might be hidden or very difficult to identify with a small entry site. Thus, even victims who have apparently minimal injury can need radiological investigation.[21,25]

In a review published by Sosna et al,[26] which included a workflow chart for the imaging of terror victims, the authors have emphasized the importance of fast and accurate imaging in triage and evaluation of injuries. Radiographs are usually helpful in the triage of patients for further imaging with CT, particularly when metallic fragments are identified. The addition of the second orthogonal view as a part of initial evaluation can aid in more accurate localization of shrapnel. In addition, the whole-body scout view should be obtained initially for detecting additional unsuspected sites of shrapnel that are not identified on the radiographs.[26]

Figure 9. Axial CT image of the orbita showing a ball bearing in the left retro-orbital fat. Preseptal emphysema is also present. The patient was managed surgically by removing the metallic foreign body and repairing the choroid laceration.


CT continues to play an increasing role in the diagnostic algorithm for patients who are haemodynamically stable with penetrating injury and is used to triage patients for surgery. It is possible to demonstrate with CT the trajectories of fragments and the resulting injuries in patients with penetrating injury caused by an explosion. Even a single piece of shrapnel with a small entry site can lead to a catastrophic internal injury. Thus, CT should be performed in all patients with penetrating shrapnel injuries and particularly in patients with penetrating torso, head and neck injuries.[21,26,27]

Initial triage of the victims was carried out by the National Emergency Service, and the victims were subsequently transferred to the nearest hospitals, including our university hospital, five of which are Level 1 trauma centres. Severely injured patients were distributed in the Level 1 trauma centres according to their physical capacities. The primary limitation of this study is that our data consisted of a group of victims admitted to our emergency department. We were unable to investigate victims referred to other hospitals. Hence, our findings for the documented event might not represent the total of injuries. Secondly, our study included only immediately obtained images. In addition, patients with minor injuries were not included because they did not require any imaging.

Figure 10. Number of injuries distributed by the Injury Severity Score and body region.

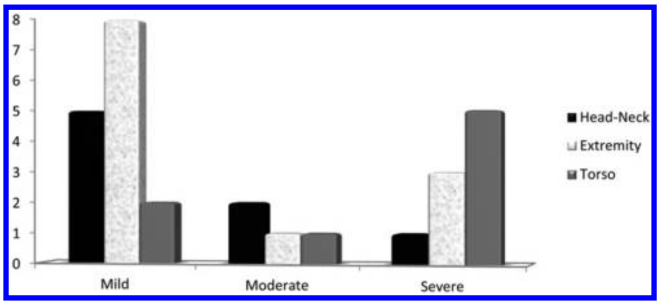


Table 2. Abdominal injuries from different series

| Location | Authors | Journals | Frequency of abdominal injury |
|---|---|---|---|
| Israel | Bala et al[22] 2008 | *Ann Surg* | Bowel (6%), parenchymal (2.9%) |
| Madrid, Spain | Turégano-Fuentes et al[23] 2008 | *World J Surg* | Abdominal visceral injury (5%) |
| Israel | Almogy et al[24] 2006 | *Ann Surg* | Intra-abdominal injury (8.4%) |
| Israel | Peleg et al[21] 2004 | *Ann Surg* | Abdominal injury (12%) |

## CONCLUSION

An analysis of the patterns of blast injuries from our experience showed a higher rate of penetrating injuries caused by shrapnel. In addition, the most commonly injured body region was the torso. These characteristics of injuries need an extensive use of radiology. Knowledge of the various patterns and the wide spectrum of these injuries can prevent further morbidity and mortality in casualty terrorist events.

## REFERENCES


1. Wolf SJ, Bebarta VS, Bonnett CJ, Pons PT, Cantrill SV. Blast injuries. *Lancet* 2009; **374**: 405–15. doi: http://dx.doi.org/10.1016/S0140-6736(09)60257-9
2. Ritenour AE, Baskin TW. Primary blast injury: update on diagnosis and treatment. *Crit Care Med* 2008; **36**(Suppl. 7): S311–17. doi: http://dx.doi.org/10.1097/CCM.0b013e31817e2a8c
3. Nguyen D, Platon A, Shanmuganathan K, Mirvis SE, Becker CD, Poletti PA. Evaluation of a single-pass continuous whole-body 16-MDCT protocol for patients with polytrauma. *AJR Am J Roentgenol* 2009; **192**: 3–10. doi: http://dx.doi.org/10.2214/AJR.07.3702
4. Baker SP, O'Neill B, Haddon W, Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974; **14**: 187–96. doi: http://dx.doi.org/10.1097/00005373-197403000-00001
5. Eskridge SL, Macera CA, Galarneau MR, Holbrook TL, Woodruff SI, MacGregor AJ, et al. Injuries from combat explosions in Iraq: injury type, location, and severity. *Injury* 2012; **43**: 1678–82. doi: http://dx.doi.org/10.1016/j.injury.2012.05.027
6. Leibovici D, Gofrit ON, Stein M, Shapira SC, Noga Y, Heruti RJ, et al. Blast injuries: bus versus open-air bombings—a comparative study of injuries in survivors of open-air versus confined-space explosions. *J Trauma* 1996; **41**: 1030–5. doi: http://dx.doi.org/10.1097/00005373-199612000-00015
7. Lavery GG, Lowry KG. Management of blast injuries and shock lung. *Curr Opin Anaesthesiol* 2004; **17**: 151–7. doi: http://dx.doi.org/10.1097/00001503-200404000-00011
8. Cooper GJ, Maynard RL, Cross NL, Hill JF. Casualties from terrorist bombings. *J Trauma* 1983; **23**: 955–67.
9. Mellor SG. The pathogenesis of blast injury and its management. *Br J Hosp Med* 1988; **39**: 536–9.
10. DePalma RG, Burris DG, Champion HR, Hodgson MJ. Blast injuries. *N Engl J Med* 2005; **352**: 1335–42. doi: http://dx.doi.org/10.1056/NEJMra042083
11. Aharonson-Daniel L, Klein Y, Peleg K; ITG. Suicide bombers form a new injury profile. *Ann Surg* 2006; **244**: 1018–23. doi: http://dx.doi.org/10.1097/01.sla.0000225355.06362.0f
12. Wightman JM, Gladish SL. Explosions and blast injuries. *Ann Emerg Med* 2001; **37**: 664–78. doi: http://dx.doi.org/10.1067/mem.2001.114906
13. Hare SS, Goddard I, Ward P, Naraghi A, Dick EA. The radiological management of bomb blast injury. *Clin Radiol* 2007; **62**: 1–9. doi: http://dx.doi.org/10.1016/j.crad.2006.09.013
14. Martí M, Parrón M, Baudraxler F, Royo A, Gómez León N, Alvarez-Sala R. Blast injuries from Madrid terrorist bombing attacks on March 11, 2004. *Emerg Radiol* 2006; **13**: 113–22.
15. Singh AK, Goralnick E, Velmahos G, Biddinger PD, Gates J, Sodickson A. Radiologic features of injuries from the Boston Marathon bombing at three hospitals. *AJR Am J Roentgenol* 2014; **203**: 235–9. doi: http://dx.doi.org/10.2214/AJR.14.12549
16. Chaloner E. Blast injury in enclosed spaces. *BMJ* 2005; **331**: 119–20. doi: http://dx.doi.org/10.1136/bmj.331.7509.119
17. Avidan V, Hersch M, Armon Y, Spira R, Aharoni D, Reissman P, et al. Blast lung injury: clinical manifestations, treatment, and outcome. *Am J Surg* 2005; **190**: 927–31. doi: http://dx.doi.org/10.1016/j.amjsurg.2005.08.022
18. Stein M. Urban bombing: a trauma surgeon's perspective. *Scand J Surg* 2005; **94**: 286–92.
19. Surani AA, Ali S, Surani A, Zahid S, Shoukat A, Varon J, et al. Pattern of external injuries sustained during bomb blast attacks in Karachi, Pakistan from 2000 to 2007. *J Pak Med Assoc* 2015; **65**: 715–20.
20. Bala M, Willner D, Keidar A, Rivkind AI, Bdolah-Abram T, Almogy G. Indicators of the need for ICU admission following suicide bombing attacks. *Scand J Trauma Resusc Emerg Med* 2012; **9**: 20. doi: http://dx.doi.org/10.1186/1757-7241-20-19
21. Peleg K, Aharonson-Daniel L, Stein M, Michaelson M, Kluger Y, Simon D, et al. Gunshot and explosion injuries: characteristics, outcomes, and implications for care of terror-related injuries in Israel. *Ann Surg* 2004; **239**: 311–18. doi: http://dx.doi.org/10.1097/01.sla.0000114012.84732.be
22. Bala M, Rivkind A, Zamir G, Hadar T, Gertsenshtein I, Mintz Y, et al. Abdominal trauma after terrorist bombing attacks exhibits a unique pattern of injury. *Ann Surg* 2008; **248**: 303–9.
23. Turegano-Fuentes F, Caba-Doussoux P, Jover-Navalon JM, Martin Perez E, Fernandez-Luengas D, Diez Valaderes L, et al. Injury patterns from major urban terrorist bombings in trains: the Madrid experience. *World J Surg* 2008; **32**: 1168–75.
24. Almogy G, Mintz Y, Zamir G, Bdolah-Abram T, Elazary Y, Dotan L, et al. Suicide bombing attacks:can external signs predict internal injuries? *Ann Surg* 2006; **243**: 541–6.
25. Guermazi A, Hayashi D, Smith SE, Palmer W, Katz JN. Imaging of blast injuries to the lower extremities sustained in the Boston marathon bombing. *Arthritis Care Res (Hoboken)* 2013; **65**: 1893–8. doi: http://dx.doi.org/10.1002/acr.22113
26. Sosna J, Sella T, Shaham D, Shapira SC, Rivkind A, Bloom AI, et al. Facing the new threats of terrorism: radiologists' perspectives based on experience in Israel. *Radiology* 2005; **237**: 28–36. doi: http://dx.doi.org/10.1148/radiol.2371040585
27. Dreizin D, Munera F. Multidetector CT for penetrating torso trauma: state of the art. *Radiology* 2015; **277**: 338–55. doi: http://dx.doi.org/10.1148/radiol.2015142282