A modern combat trauma

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Received 19 June 2013
Accepted 26 June 2013
Published Online First 18 July 2013

ABSTRACT

Introduction The world remains plagued by wars and terrorist attacks, and improvised explosive devices (IED) are the main weapons of our current enemies, causing almost two-thirds of all combat injuries. We wished to analyse the pattern of blast trauma on the modern battlefield and to compare it with combat gunshot injuries.

Materials and methods Analysis of a consecutive series of combat trauma patients presenting to two Bulgarian combat surgical teams in Afghanistan over 11 months. Demographics, injury patterns and Injury Severity Scores (ISS) were compared between blast and gunshot-injured casualties using Fisher's Exact Test.

Results The blast victims had significantly higher median ISS (20.54 vs 9.23) and higher proportion of ISS>16 (60% vs 33.92%, p=0.008) than gunshot cases. They also had more frequent involvement of three or more body regions (47.22% vs 3.58%, p<0.0001). A significantly higher frequency of head (27.27% vs 3.57%), facial (20% vs 0%) and extremities injuries (85.45% vs 42.86%) and burns (12.72% vs 0%) was noted among the victims of explosion (p<0.0001). Based on clinical examination and diagnostic imaging, primary blast injury was identified in 24/55 (43.6%), secondary blast injury in 37 blast cases (67.3%), tertiary in 15 (27.3%) and quaternary blast injury (all burns) in seven (12.72%).

Conclusions Our results corroborate the 'multidimensional' injury pattern of blast trauma. The complexity of the blast trauma demands a good knowledge and a special training of the military surgeons and hospital personnel before deployment.

INTRODUCTION

Currently, the world remains plagued by a large number of wars and terrorist attacks.[1] Improvised explosive devices (IED) are the main weapon of our current enemies which are responsible for almost two-thirds of all combat injuries. Analysis of combat blast injuries (BI) by several authors reveals a unique 'multidimensional' injury pattern, which is different from those in non-terror-related trauma and gunshot injuries (GSI), and require different management strategies.[2]

MATERIALS AND METHODS

Since 2002, Bulgaria has deployed surgical teams in Afghanistan as a part of the International Security Assistance Force (ISAF). Although elective surgery was performed, this study focused only on the cases with blast or gunshot trauma. We collected data on a consecutive series of Afghan patients treated by the Bulgarian surgical teams from September to December 2010 in the Role 2E surgical facility in Herat, and from January to July 2010 in Kandahar Regional Military Hospital (KRMH—Role 2) in Afghanistan. To analyse the pattern of blast trauma, the patients with blast and gunshot injuries were divided in two distinct groups and were compared by gender, mean age, mean Injury Severity Score (ISS), severity of the trauma (ISS>16), anatomic distribution of the injuries and number of affected body regions. We were unable to calculate exact mortality rates due to a lack of sufficient information, because most of the patients were transferred into the civilian hospitals soon after the initial stabilisation. Fisher's Exact Test was performed by SPSS V.13.0 software for Windows, and p value <0.05 was considered statistically significant.

RESULTS

In the two study periods, there were 111 blast or gunshot injuries. Most of the cases were treated in KRMH (n=42 in the blast group and n=49 in gunshot group). In both groups, the casualties were predominantly men, with mean age of 23 years (Table 1). The blast victims suffered from more severe trauma with significantly higher median ISS (20.54 vs 9.23) and higher proportion of ISS>16 (60% vs 33.92%, p=0.008) (Figure 1). There was more frequent involvement of three or more body regions, whereas, GSIs were predominantly isolated (Figure 2). A significantly higher frequency of head (27.27% vs 3.57%), facial (20% vs 0%) and extremities injuries (85.45% vs 42.86%) was noted among the victims of explosion (p<0.0001), (Figure 3 and Table 1).

Chest injuries were found in 38.18% (n=21, 4 penetrating) in the blast group compared with 28.57% (n=16, all penetrating) in the gunshot cases. A diagnosis of primary blast lung injury was made on clinical, X-ray and CT findings in 13/21 (61.9%), whereas 8/21 (38.1%) were injured by secondary projectiles (SP). Tube thoracostomy was sufficient treatment for 12/21 (57.4%) of the patients in the blast group compared with 12/16 (75%) in the gunshot group. Thoracotomy was required in 9.5% (n=2) and 25% (n=4) of the blast and GSI groups, respectively, due to active bleeding (more than 1500 mL blood since insertion) from the chest drain. In all cases, peripheral lung lacerations were found and haemostasis achieved by stapled non-anatomic lung resection. In one of the blast cases, the internal thoracic artery was an additional source of bleeding and was ligated; one GSI patient had an injury of the superior vena cava identified at thoracotomy which was converted to sternotomy, but he died intraoperatively.

Abdominal injuries were noted in 25.5% (n=14, 11 penetrating) in the blast group versus 35.7% (n=20, 8 penetrating) in the gunshot group. There was only one case of primary blast injury of the small bowel (7.1% or 1.8% of all blast injuries).

To cite: Popivanov G, Mutafchiyski VM, Belokonski EI, *et al*. *J R Army Med Corps* 2014;**160**:52–55.

Table 1 Demographic and injury characteristic of 111 consecutive trauma patients and comparison of blast and gunshot injury groups

	Blast injuries		Gunshot injuries		
	n	%	n	%	p Value
Mechanism	55		56		
Age (range)	23.6 (5–70)		23 (6–40)	–	–
Male gender	51	92.7	55	98.2	0.206
Median ISS	20.5	–	9.2	–	0.008
ISS>16	33	60	19	33.9	<0.008
Anatomical location of injury					
Head	15	27.27	2	3.57	<0.0001
Face	11	20	0	0	<0.0001
Neck	6	10.91	2	3.57	0.162
Chest	21	38.18	16	28.57	0.318
Penetrating	4	7.27	16	26.79	<0.0001
Non-penetrating	17	30.91		–	–
Abdomen	14	25.4	20	35.7	0.304
Penetrating	11	20	18	32.1	0.627
Non-penetrating	3	5.5	2	3.6	0.627
Extremities	47	85.45	24	42.86	<0.0001
Upper	18	32.73	8	14.29	0.797
Lower	29	52.73	16	28.57	0.797
Fractures	7	12.73	6	10.71	0.34
Burns	7	12.73	0	0	<0.0001
Thoraco-abdominal	2	3.63	5	8.92	0.438
Number of body regions involved					
1	16	29.09	46	82.14	<0.0001
2	14	25.45	8	14.29	0.16
3	23	41.82	1	1.79	<0.0001
>3	3	5.45	1	1.79	0.364

ISS, Injury Severity Score.

Laparotomy was performed in 85.7% (n=12) of the blast cases, and the distribution of the organ injuries and their management are shown in Table 2. The small bowel was the most commonly affected organ (n=7). Of note, one patient had several perforations of the distal ileum caused by secondary bone projectiles from a comminuted fracture of the right iliac crest. In four cases the small bowel injuries were sutured, while in another three partial resections were performed. The two cases with colonic injury were treated with suture and right hemicolectomy, respectively. All liver injuries (n=3) were managed with electrocoagulation only; two of these patients had concomitant diaphragmatic injury. In one, the laparotomy was performed 5 h after admission due to delayed recognition of the abdominal injury, and the patient died of irreversible haemorrhagic shock.

Seven patients (12.7%) from the blast group had burns versus 0% in the GSIs group (p<0.0001). Based on the clinical assessment, X-ray in all cases and CT examination in some of them, the blast injury mechanisms were primary in 43.63% (n=24), secondary in 67.27% (n=37), tertiary in 27.3% (n=15) and quaternary in 12.72% (n=7) (Figure 4).

DISCUSSION

Analysis of the wounded from World War II to date shows a changed wound pattern on the modern battlefield with increase of the head (10–35% vs 15%) and the extremities injuries (76–90% vs 65%) and almost the same rate of torso injuries (10–30% vs 20%), perhaps as a result of the use of modern body armours.[1 3] In our study, the blast group had similar rates with the extremities, head and face injured in 85.4%, 27.2% and 20% respectively, but significantly more frequent involvement of the chest and abdomen—38.2% and 25.4%, respectively. This probably reflects the fact that Afghan soldiers are often not protected with body armours.

Bomb explosions damage the body through four mechanisms.[2 4] The primary blast injuries (PBI) are induced by interaction of blast wave (overpressure) with the body causing damage in the air-containing organs. Bowel perforations occur in only 1.2% and the colon is most commonly affected.[5 6] In our series, only one patient had blast bowel injury which is 7.5% of abdominal and 1.8% of all cases. At laparotomy, based on the presence of free air on CT scan, a small bowel injury was found, which was treated by partial resection. These injuries may present in a delayed fashion, usually 1–2 days, but occasionally up to 2 weeks after the blast, and careful observation is necessary to ensure a good outcome.[5 6]

Based on the presence of lung contusion or adult respiratory distress syndrome, confirmed through X-ray as well as the lack of obvious penetration wounds and the intraoperative findings at laparotomy in one patient, PBI was the leading mechanism of

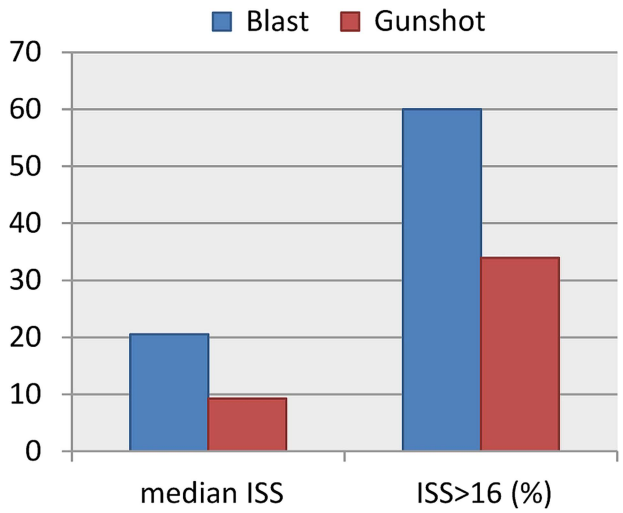

Figure 1 Median Injury Severity Scores (ISS) and % of the patients with ISS>16, p=0.008.

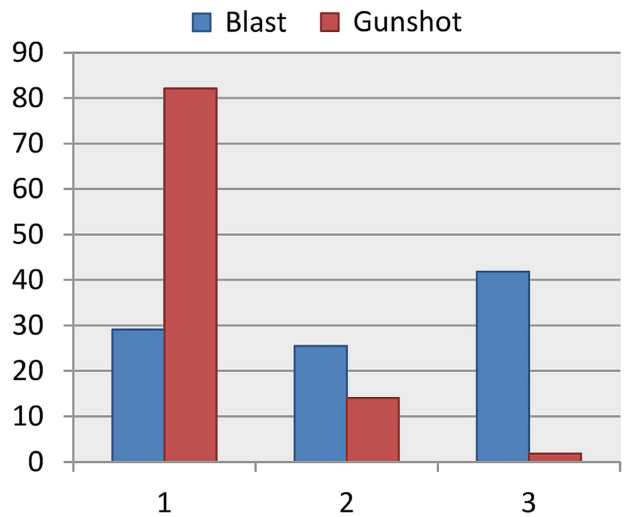

Figure 2 Proportion of body regions involved (%), p<0.0001.

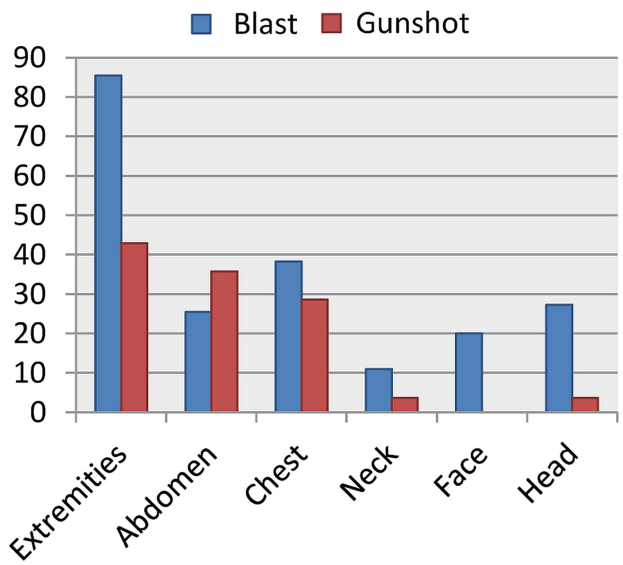

Figure 3 Anatomic distribution of the injuries (%), p<0.0001.

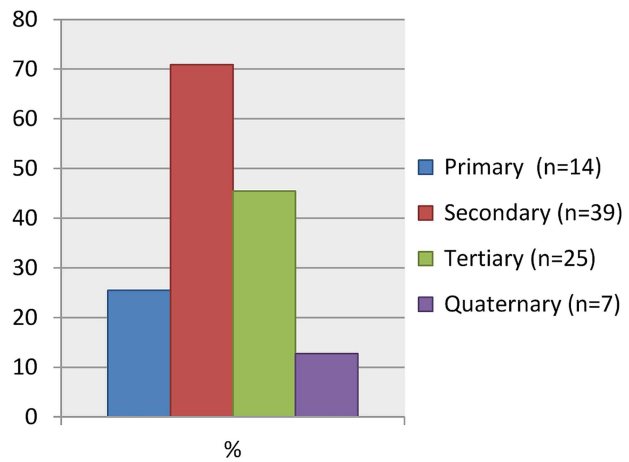

Figure 4 Distribution of the blast injuries by the leading mechanism.

injury in one quarter (14/55) of the blast patients 13 of the chest injuries.

Secondary injuries are those produced by the secondary projectiles (SP)—bomb fragmentation, pellets, nails, stones, glass and other energised debris, which are generally with low velocity and do not cause a specific wound pattern.[4] According to Brooks, SPs cause about 90% of the wartime penetrating wounds.[7] Bala and colleagues reported that 94.4% of the blast bowel injuries were caused by SPs.[8] In our series, 70.9% of the blast injuries (n=39) were caused by this mechanism, including 38.1% of the chest (n=8) and 92.85% (n=13) of the abdominal injuries. Five of the bowel injuries in our series were successfully treated by suture repair alone, due to the low-energy transfer and associated limited tissue trauma. However, these injuries are usually multiple and should be deliberately looked for.

The tertiary mechanism is related to the displacement of the body by the blast wind, leading to a blunt trauma and deceleration injuries including limb amputations. Overall, nearly half the blast casualties suffered head trauma, fractures of the legs, spine and pelvis, or traumatic amputations due to this mechanism. The quaternary mechanism includes burns, inhalation injuries, intoxications and septic complications from contamination of the wounds which occur in 10.5% of the cases.[4 9] The frequency of combat burns is 8–10%, and they are associated with a higher ISS, a higher rate of inhalation injuries, and more frequent involvement of the head and hands than civilian burns.[9] In 6/7 burns patients in our series, the face, chest and upper extremities were involved.

Table 2 Organ injuries and interventions performed in 12 cases with abdominal blast trauma

Organ injuries	n	Interventions	n
Small bowel	7	Suture of small bowel	4
Liver	3	Small bowel resection	3
Diaphragm	2	Liver haemostasis	3
Colon	2	Right hemicolectomy	1
		Suture of colon	1

The simultaneous combination of these various mechanisms leads to unique injury pattern demanding special attention, and our results are in unison with those reported by other authors. To illustrate the complexity of the blast trauma and to highlight the need for a different treatment strategy, Kluger *et al*[2] introduced the term 'multidimensional' trauma. In a comprehensive analysis of 906 victims of terrorist bombings and 55 033 cases with non-terror-related trauma, they found that blast trauma was associated with higher percent of ISS>16 (28.7% vs 10%), higher frequency of three and more body areas involved (28.3% vs 6.2%), and a greater length of stay as compared with all other kinds of trauma.[10] Moreover, the blast victims were more frequently a part of mass casualty incidents (MCI),[2 11] and used more hospital resources.[2 12 13] There were no MCIs in our series.

Comparison with GSIs revealed that the blast victims suffered from more severe trauma with significantly higher median ISS, higher proportion of ISS>16, more frequent involvement of three or more body regions, and significantly higher frequency of head, facial, extremity injuries and burns.

Our results are compatible with others[9 11 12] who found that the BIs were associated with higher ISS (34 vs 9–18), higher frequency of multiple body regions involvement (40.9–85.7% vs 9.6–47%), head (27–34% vs 16%) and facial injuries (49.5% vs 14.7%) compared with GSIs. Peleg *et al*, [11] reported that GSIs were isolated in 58.3% of cases with a lower incidence of ISS>25 (33.6% vs 46.4%) and higher frequency of open wounds (63% vs 53%), thoraco-abdominal injuries (18% vs 12%), and fractures (42% vs 31%).

These findings clearly demonstrate the complexity of blast trauma and the requirement for different management strategies. Blast trauma confronts the surgeon with various organ injuries caused by different mechanisms, multiple body regions involved, and the need for quick decision making. Additionally, in the military setting, it often occurs on a background of haemodynamic instability, hostile environment, mass casualty influx, limited hospital and manpower resources and relatively inexperienced personnel. In this sense, a detailed knowledge of blast trauma management is essential for improving outcomes.

CONCLUSIONS

Our results corroborate the specific 'multidimensional' injury pattern of blast trauma and the differences with those seen in gunshot injuries. The unique combination of blast-wave damages, blunt and penetrating injuries and burns occurring in

one patient leads to a complex and severe trauma demanding a special attention, a detailed knowledge and meticulous coordination of all resources.

In the light of the widespread threat of asymmetric war and terrorist incidents, we believe that this knowledge achieved by the work of the deployed military medical personnel will be adopted into the civilian trauma care system.

Educational points

- Blast trauma is characterised by higher Injury Severity Scores (ISS), higher frequency of multiple body regions involvement, head, facial, extremities injuries and burns as compared with gunshot injuries.
- The unique combination of blast wave damage, blunt and penetrating injuries and burns occurring in one patient leads to a specific 'multidimensional' pattern demanding special attention and different management strategy.
- The complexity of the blast trauma injuries demands a good knowledge and special training of the military surgeons and hospital personnel before their sending on missions.

Acknowledgements The author would like to thank to Cvetko Ventsislavov and Petko Kasarov for their encouragement.

Contributors GIP: performed the comparative analysys and wrote the manuscript; team leader in Kandahar. VMM: gave the idea and planned this study, performed the literature review, took part in the revision of the manuscript; guarantor. EIB: performed the analysis of gunshot group. ABP: performed the analysis of blast group; guarantor. GLK: team leader in Herat, took part in statistical analysis.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

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