Penetrating missile injuries during the Iraqi insurgency

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ABSTRACT

INTRODUCTION Since the invasion of Iraq in 2003, the conflict has evolved from asymmetric warfare to a counter-insurgency operation. This study investigates the pattern of wounding and types of injuries seen in casualties of hostile action presenting to a British military field hospital during the present conflict.

PATIENTS AND METHODS Data were prospectively collected on 100 consecutive patients either injured or killed from hostile action from January 2006 who presented to the sole coalition field hospital in southern Iraq.

RESULTS Eighty-two casualties presented with penetrating missile injuries from hostile action. Three subsequently died of wounds (3.7%). Forty-six (56.1%) casualties had their initial surgery performed by British military surgeons. Twenty casualties (24.4%) sustained gunshot wounds, 62 (75.6%) suffered injuries from fragmentation weapons. These 82 casualties were injured in 55 incidents (mean, 1.49 casualties; range 1–6 casualties) and sustained a total 236 wounds (mean, 2.88 wounds) affecting a mean 2.4 body regions per patient. Improvised explosive devices were responsible for a mean 2.31 casualties (range, 1–4 casualties) per incident.

CONCLUSIONS The current insurgency in Iraq illustrates the likely evolution of modern, low-intensity, urban conflict. Improvised explosive devices employed against both military and civilian targets have become a major cause of injury. With the current global threat from terrorist bombings, both military and civilian surgeons should be aware of the spectrum and emergent management of the injuries caused by these weapons.

KEYWORDS

War injuries – Iraq – Improvised explosive devices – Field hospital

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Since the end of the war-fighting phase of operations against the Iraqi regime in April 2003, British and coalition troops deployed in South-Eastern Iraq as part of a UN-mandated force to maintain security have been involved in a counter insurgency operation that has followed the usual pattern of this type of warfare. There is no front-line in Iraq; the insurgents merge with the general population and strike irregularly at widely scattered locations that cannot be readily anticipated. Ambush of patrols and convoys with small-arms fire and rocket-propelled grenades (RPGs), and indirect mortar fire of fixed positions are characteristic of previous insurgency operations;¹ however this conflict has been defined by the use of the roadside bomb or improvised explosive device (IED).

Previous studies have described the injuries sustained in conventional war fighting and asymmetric warfare in the Gulf.^{2–4} In this article, we report on the initial management of 82 casualties of the current insurgency and discuss the specific aspects of their surgical management.

Patients and Methods

The field hospital is a 50-bedded tented unit deployed in the British area of operations in South-Eastern Iraq with a surgical team consisting of one general surgeon working in tandem with one orthopaedic surgeon.

Data were prospectively collected on 100 consecutive patients from January 2006, either killed or injured as result of hostile action. Demographic data, wounding agent, anatomical location of injury, operative management and discharge information were recorded. The Red Cross Wound Classification (RCWC)⁵ was used to score certain features of the two most severe wounds sustained by each casualty including the size of entry and exit wound, and whether or not there was a significant wound cavity, fracture or injury to major vessels or visceral injury. The wounds were graded according to the amount of tissue damage: grade 1, low-energy transfer (LET); grade 2, high energy transfer (HET); and grade 3, massive energy transfer (MET). They were also typed according to the structures

Table 1 Red Cross Wound Classification

Feature	Score
E = Entry	Estimate maximum diameter of entry wound (in cm)
X = eXit	Estimate maximum diameter of exit wound (in cm) (X = 0 if no exit)
C = Cavity	Assess whether wound cavity will admit 2 fingers before surgery: C = 0, no C = 1, yes
F = Fracture	F = 0, no fracture F = 1, fracture no clinically significant comminution F = 2, fracture with clinically significant comminution
V = Vital structure	Assess for visceral, central nervous injury or major vessel injury (proximal to including brachial and popliteal vessels)
M = Metallic body	Count of bullets or metallic fragments on radiographs M = 0, none M = 1, one M = 2, more than one
Grade 1	$E + X < 10$, while C = 0 and F = 0 or F = 1 (low-energy transfer)
Grade 2	$E + X < 10$, while C = 1 and/or F = 2 (high-energy transfer)
Grade 3	$E + X > 10$, while C = 1 and/or F = 2 (massive wounds)
Type ST	Wounds with F = 0 and V = 0
Type F	Wounds with F = 1 or F = 2 and V = 0
Type V	Wounds with F = 0 and V = 1
Type VF	Wounds with F = 1 or F = 2 and V = 1

involved, soft tissue, vital structure or fracture. The nominal category of the wound was derived from a combination of grade and type to give an indication of the complexity and severity (Table 1) and recorded in a trauma database.

Results

Between 1 January to 1 October 2006, 1742 patients were assessed at the hospital, with 100 casualties either injured or killed from hostile action. Eighteen died at the scene of the incident (killed in action; KIA). The remaining 82 patients sustained penetrating missile injury and form the basis of this study. Eighty (97%) of the casualties were male. There were 57 coalition soldiers, 13 non-Iraqi civilians and 12 Iraqi civilians in the study group with a median age of 23 years (range, 18–65 years).

Fragmentation weapons accounted for 75.6% of injuries and the remaining 24.4% were caused by gunshot wounds. These casualties were injured in 55 separate incidents (mean, 1.49 casualties per incident; range, 1–6 casualties) with the 20 gunshot wound casualties presenting from 20 incidents (mean, 1.0 incident). Fragmentation weapon

attacks caused a mean 1.73 casualties per incident with IEDs producing a mean 2.31 casualties (range, 1–4 casualties) per incident.

The anatomical distribution of injuries is shown in Table 2. Two-thirds of all injuries were to the extremities. Injuries from gunshot wounds resulted in a greater proportion of injuries to the torso (39%) compared to fragmentation weapons (4.2%; Fisher's two-tail test, $P < 0.0001$).

Three patients (3.7%) died during treatment at the field hospital. Two deaths were from fragmentation weapons and one from gunshot wounds. Two deaths resulted from penetrating traumatic brain injuries and the third from chest and head injuries.

Red Cross Wound Classification

A total of 131 wounds were scored using the RCWC (Table 3). Thirty casualties (36.6%) had solitary wounds and 52 (63.4%) had multiple wounds (range, 1–23 wounds). Of all wounds scored, 82 (62.6%) were ST grade 1 injuries; 31.2% of all wounds had an associated fracture (F or VF); and 13.7% had damage to a vital structure (V or VF). Only 36.5% of ST grade 1 wounds were assessed as having sustained

Table 2 Penetrating missile wounds: site of injury

	Gunshot wounds (20 patients)		Fragment (62 patients)		Total wounds (82 patients)	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Lower limb	6	12.2	88	44.3	94	37.8
Upper limb	14	29.3	54	30	68	29.8
Face	2	4.9	25	11.3	27	10
Neck	3	7.3	10	5	13	5.5
Head	3	7.3	8	5	11	5.5
Abdomen	8	19.5	1	0.6	9	4.8
Pelvis	1	2.4	0	0	1	0.5
Chest/back	7	17.1	6	3.8	13	6.5
Total	44	100	192	100	236	100

significant underlying soft tissue damage to require formal wound debridement (Fisher's two-tail test, $P < 0.0001$). ST grade 1 wounds treated non-operatively were scrubbed clean and dressed, and the patients given a 7-day course of Penicillin V 500 mg qds and Flucloxacillin 500 mg qds. There were no complications arising from non-operative management of these wounds at 1 year. For those ballistic wounds that underwent surgery, the principles were fol-

lowed of excision of a narrow margin of skin, generous release of fascia, exploration of all layers with removal of gross contamination, and excision of non-viable muscle.

CASE 1

A coalition soldier was admitted to the hospital after his vehicle was hit by an IED (Figs 1 and 2). He sustained multiple ST1 fragment wounds to his right forearm for which

Table 3 Wound analysis

Wound type	Grade	Bullet wounds	Fragment injuries	Total wounds	Wounds requiring surgery (<i>n</i>)	Wounds requiring surgery (%)	<i>P</i> -value (Fisher's test)
ST	1	7	75	82	30	36.5	0.0001
	2	0	4	4	4	100	NS
	3	0	0	0	0	N/A	N/A
F	1	8	5	13	9	69	NS
	2	7	4	11	11	100	NS
	3	2	1	3	3	100	NS
V	1	0	1	1	1	100	NS
	2	1	1	2	2	100	NS
	3	1	0	1	1	100	NS
VF	1	0	1	1	0*	0	NS
	2	0	3	3	2	66.7	NS
	3	5	5	10	8	80.0	NS
Total		32	99	131	71	54.2	

*Patient died.

NS, not significant; N/A, not applicable

Figure 1 Radiograph of right forearm showing multiple small fragments following an IED attack.

his initial treatment was non-operative; however, within an hour of his admission, the forearm flexor compartment became swollen in association with pain on passive extension of the digits. He was taken to theatre and a forearm fasciotomy for compartment syndrome was performed. He subsequently made a full recovery.

Statistically, casualties from gunshot wounds (17 of 20; 85%) were more likely to require surgery compared to

Figure 3 Abdominal radiograph of a civilian following a gunshot wound to the abdomen. The bullet fragmented on the transverse process of L1 and the fragments can be seen in the right upper quadrant.

Figure 2 The soldier subsequently developed compartment syndrome. The swollen flexor compartment is visible prior to formal fasciotomy.

casualties injured by fragmentation weapons (29 of 62; 46.7%; Fisher's two-tail test, $P = 0.0038$). Gunshot victims required a median 2.0 surgical procedures (range, 1–5 procedures), lasting a median 85 min (range, 30–270 min). Fragmentation injuries required a median 1.0 surgical procedure (range, 1–4 procedures) lasting a median 90 min (range, 25–240 min).

Thoracic injuries

Seven patients sustained thoracic wounds, three due to gunshot wounds. Only the gunshot wounds penetrated the pleural cavity. Two of these patients were treated conservatively with chest drains and wound excision. Both of these patients were Iraqi civilians and were not wearing body armour. The third patient was a coalition soldier who was wearing body armour and suffered head and chest injuries from gunshot wounds. He had an asystolic cardiac arrest on transfer to the operating theatre and subsequently died.

Abdominal injuries

Penetration of the peritoneum (V or VF) occurred in six patients; five of whom (83.3%) had suffered gunshot wounds. Only one casualty was wearing body armour at the time of injury.

CASE 2

A civilian presented to the hospital following a gunshot wound to the back. The entry wound was at the level of L1. The bullet had fragmented on the transverse process of L1 (Fig. 3) and then exited through the right upper quadrant of the abdomen. At presentation, the patient was hypotensive and tachycardic with significant bleeding from his exit wound and he had a flaccid paralysis of his lower limbs. Following resuscitation, the patient was immediately transferred to the operating theatre.

Figure 4 This UK soldier presented with a gunshot wound in the back of the neck with the bullet exiting his mandible. Fortunately the CT angiogram revealed no damage to the carotid sheath.

At laparotomy, he was found to have a grade V (American Association for Surgery of Trauma) injury of his right kidney, a perforated hepatic flexure, a ruptured cystic duct and a grade I (American Association for Surgery of Trauma) liver laceration. He underwent a right nephrectomy, a right hemicolectomy with a primary stapled anastomosis, a defunctioning loop ileostomy, a cholecystectomy and packing of the liver laceration. The entry and exit wounds were debrided and the abdomen was packed. The abdomen was subsequently closed 72 h later. Despite making a full recovery from his abdominal injuries, the patient remains paraplegic from his spinal cord injury.

CASE 3

A 20-year-old Iraqi civilian was treated at the facility after sustaining multiple gunshot wounds to the elbow and buttocks during an ambush. The bullet to his elbow shattered and the fragments penetrated his abdomen. On presentation, he was profoundly hypotensive and tachycardic despite the administration of 7 litres of crystalloid in the pre-hospital environment. At laparotomy, he was found to have multiple small bowel perforations, a perforated sigmoid colon and a retroperitoneal injury with a ruptured left ureter. He underwent a small bowel resection with a primary stapled anastomosis; the perforated sigmoid colon was exteriorised as a stoma. The elbow wound was debrided and an external fixator applied (Hoffman II, Stryker, USA). The complexity of the ureteric injury required transfer to a specialist urological unit in another coalition facility, where he subsequently underwent a left nephrectomy and the stoma was reversed 8 weeks later.

Two further casualties underwent laparotomy. In the first case, a small serosal perforation of the transverse colon from a small mortar fragment was primarily repaired and covered with an omental patch. In the second, laparotomy

Figure 5 Three-dimensional CT reconstruction revealing the extent of the mandibular fracture. The patient had the wound debrided in Iraq and then transferred back to the UK, where he underwent reconstructive surgery using a fibular free flap.

for gunshot wound revealed no visceral injury. Two other patients underwent laparotomy at local Iraqi facilities for small bowel perforation prior to transfer to this facility.

Head and neck injuries

Thirty-one patients (37.8%) suffered injuries to the head and neck. The spectrum of injury ranged from superficial fragmentation wounds to open facial fractures and penetrating traumatic brain injury. All three in-hospital deaths were

Figure 6 This UK soldier walked into the emergency department following a gunshot wound to the neck. The bullet had been deflected by his helmet and bullet fragments came to rest by the lamina of C2.

Figure 7 Three-dimensional CT reconstruction indicating the path of the bullet fragments. A large fragment is seen adjacent to the lamina of C2. The patient had the wound debrided and later returned to full active duty.

related to penetrating traumatic brain injury and all presented to the emergency department with a GCS 3. Two of those patients were treated expectantly and the third died on transfer to the operating theatre. Operative management was required for 17 (55%) of head and neck casualties.

CASE 4

A UK soldier presented to the hospital following a gunshot wound to the back of his neck with an exit wound through his jaw (Fig. 4). He was bleeding profusely from the wound that was compromising his airway. At surgery there was a comminuted fracture of the mandible with an associated perforation of the oral mucosa (Fig. 5). He underwent wound debridement with closure of the oral mucosa and a tracheostomy. A computed tomography (CT) angiogram confirmed no injury to the carotid sheath. The patient was subsequently transferred back to UK for reconstructive surgery and has since returned to duty.

CASE 5

A UK serviceman walked into the emergency department having sustained a gunshot wound to his neck after the bullet had been deflected by the rim of his helmet (Fig. 6). He had no neurological symptoms and a CT scan showed that the bullet had lodged on the lamina of C2 (Fig. 7). He underwent debridement of the wounds and removal of any easily accessible bullet fragments. He was transferred to a neurosurgical unit in the UK where the deeper bullet fragments were removed. He made a full recovery and subsequently returned to duty.

Figure 8 The new Combat Action Tourniquet.

Figure 9 This UK civilian suffered a traumatic amputation of his left lower leg following an IED explosion. The wound was debrided in theatre and the patient was repatriated to UK for stump reconstruction and prosthesis fitting.

Amputations

Three lower limbs and one upper limb were amputated. Of the lower limb amputations, two were below knee and the other was above knee. Two patients had the new combat action tourniquet (C-A-T®, Phil Durango, LLC) applied. This tourniquet can be applied single-handedly and consists of a built-in windlass mechanism for tightening (Fig. 8). In all cases, the limbs had been traumatically amputated. The upper limb amputation was above elbow and was classified 3 VF (massive wound with fracture and major vessel injury) using the RCWC.

CASE 6

A UK civilian was injured when his vehicle was hit by an IED. He suffered a traumatic amputation to his left lower leg (Fig. 9) and a ST grade 2 injury to his right calf (Fig. 10). The Combat Action Tourniquet was applied to both limbs prior to his arrival in hospital. Both wounds were thoroughly

Figure 10 The patient also suffered an ST2 wound on his right calf. Following wound debridement in Iraq, he underwent split-thickness skin grafting to cover the skin defect. Despite extensive injuries to both lower limbs, he made a good recovery and is mobilising well with his fitted prosthesis.

debrided and the patient was repatriated to the UK for stump reconstruction and artificial limb-fitting.

Outcome

The outcome following admission is represented in Figure 11. Only 36% of casualties presenting to the field hospital were deemed fit to return to their unit in theatre. A further 60% of casualties required further medical intervention either in the UK or in another medical facility.

Discussion

From March 2003 till March 2007, 3494 coalition troops have been killed in Iraq with a further 24,187 wounded in action.⁶ Iraqi civilian deaths have been a subject of intense controversy and figures range from 65,573⁷ to 654,965.⁸

In conflicts since World War I, penetrating injuries from fragmentation weapons have caused 60–80% of all casualties.⁹ Our figure of 75.6% of injuries from fragmentation weapons is in keeping with these findings. However, where previous conflicts have shown these injuries to be caused by conventional artillery and mortars, our study has shown the emergence of improvised explosive devices as the predominant cause of injury. An IED comes in various forms from buried artillery rounds to above-ground explosive or shaped charges to car bombs all of which are designed to destroy or incapacitate personnel or vehicles. Injuries from IEDs differ from those of gun-shot wounds. The contamination and soft tissue injury often requires aggressive surgery that is time consuming. In one incident, an IED can cause multiple casualties and devastating injuries that place a significant burden on field hospital surgical facilities.

The anatomical pattern of wounding from explosive ordnance provides a unique challenge to the military surgeon

Figure 11 Initial discharge location.

deployed on operations. Of our casualties, 63% presented with multiple wounds that often required orthopaedic and general surgical teams to work in tandem. Our experience mirrors that of previous studies, which have shown that terrorist bombings inflict a distinctly different pattern of injury, with increased severity and increased number of body regions involved compared with non-terror-related trauma.¹⁰

Penetrating head and neck injuries were present in 31.7% of casualties and the management of these injuries is not often seen in routine civilian general surgical practice. Our data would suggest that specific training in the management of these injuries would be useful prior to deployment on operational tour. This has been recognised within the Defence Medical Services with the appointment of deployable neurosurgical assets. In addition, all deploying surgeons are required to attend workshops in emergency neurosurgery and maxillofacial surgery prior to operational deployment.

Central injuries accounted for only 10% of injuries presenting to the hospital. This is, in part, due to the effectiveness of the combat body armour, which consists of a Kevlar (DuPont, USA) and Nylon woven vest augmented with ceramic plates that provide extra protection to the mediastinum. Previous casualty analysis from Israel has shown that people wearing body armour had reduced severity of injuries to the chest and abdomen.¹¹ This is also illustrated in our experience where penetrating injuries into the thorax and abdomen were predominantly seen in casualties not wearing body armour (6 of 8; 75%).

Wounding to the unprotected extremities continued to produce the greatest number of penetrating injuries (67.6%) and provided a considerable workload for the surgical teams in the field. In addition, these patients often require further surgical debridement, fracture fixation and soft tissue coverage once they are repatriated to the UK. They can place significant burden on orthopaedic and plastic surgery resources

for several weeks after injury. This was highlighted in Israel where Einav *et al.*¹² found that, in multiple casualty events following terrorist bombings, initial demand in the first 24 h was for general surgical resources, but after 24 h it was orthopaedic and plastic surgical resources that predominated. In our current mode of evacuation, this operative workload is transferred to civilian hospitals in the UK, as casualties are rapidly transferred from the field hospital.

The Red Cross Wound Classification has been used extensively in conflict to stratify the severity of penetrating injuries.⁵ While the conventional military approach to the management of penetrating war wounds is by exploration, debridement, excision of dead tissue, and delayed primary closure,¹⁵ recent experimental evidence and clinical experience suggests that selected LET small fragment wounds may be safely managed non-operatively.^{14–16} We found that, following wound assessment, only 36.5% of ST grade 1 wounds ($P = 0.0163$) required any surgical intervention. For those wounds managed non-operatively there were no complications in any of the UK service personnel at 1-year follow-up.

Conclusions

Injuries in conflict produce a pattern of injury that is not seen in routine civilian general surgical practice. In an era of increasing surgical sub-specialisation, the deployed surgeon needs to acquire and maintain a wide range of skills from a variety of surgical specialties. Military surgery has, therefore, been appropriately recognised as a subspecialty within General Surgery by the Intercollegiate Surgical Curriculum Project (ISCP).¹⁷ Given the current global security situation, these injuries may be equally encountered in a civilian setting. We believe that knowledge and training in the management of these injuries is relevant to military and civilian surgeons.

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