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OP TELIC

Ballistic Fractures During The 2003 Gulf Conflict – Early Prognosis And High Complication Rate

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ABSTRACT

Background
Ballistic fractures are devastating injuries often necessitating extensive reconstructive surgery or amputation, particularly if associated with high-energy transfer wounds. Infective complications are common, particularly in the austere environment encountered in war. We present the management and early outcome of these injuries with reference to the mechanism of injury and bony injury.

Method
Data on ballistic fractures was collected prospectively during the 'war-fighting' phase of the 2003 Gulf Conflict, between 19th March and 20th May. Fractures were scored using the Red Cross Fracture classification and early outcome analysed.

Results
Thirty-nine patients, with 50 ballistic fractures, were treated by British military surgeons. Patients were predominantly Iraqi (90%) and 50 per cent of ballistic fractures were caused by bullets. Seventeen upper limb fractures and 33 lower limb fractures were sustained. There were seven traumatic amputations, and a further 2 limbs were amputated primarily. Methods of primary stabilisation for the remaining 41 fractures were: external fixation (22%), POP (14.5%), K-wires (14.5%) traction (10%), and no stabilisation (39%).

Seven individuals were evacuated early after primary surgery, hence 43 ballistic fractures were available for follow-up. 13/43 (30%) of wounds became infected, 5/43 (11.5%) were deep infections necessitating surgical drainage. There were 4 late amputations (9.5%), 3 of which had initially been managed by external fixation. Infection occurred significantly more often in gunshot fractures (10/21, 48%), wounds closed primarily – against the principles of war surgery (4/5, 80%) and intra-articular fractures (3/3, 100%) (p=0.022, 0.024 and 0.023 respectively). Differing methods of stabilisation had no bearing on the rate of postoperative infection.

Conclusion
Ballistic fractures remain a challenge for trauma surgeons in times of war and still have a poor prognosis. Further work is required to determine the optimal treatment of these injuries during conflicts. In addition, there still seems to be a continued need to re-learn the principles of war surgery in order to minimise complications and optimise functional recovery.

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Background

Infection, non-union, amputation and death are possible sequelae following high energy ballistic fractures. The personality of the fracture, level of contamination, delay to definitive treatment(1) and the surgical management can all influence the eventual outcome.

The surgical options in the management of war wounds are limited by numerous factors. Field hospitals are often tented and operating theatres do not have a sterile environment hence internal fixation is contraindicated in all but a minority of situations. The mobility of military units requires that equipment is kept to a minimum and hence the options for external fixation are limited. Military medical units are obliged to treat enemy prisoners of war (POW) and injured non-combatants; the mid- to long-term reconstructive options in these patient groups may not be the same as the servicemen that they are trained to treat and consequently the management plan must be tailored accordingly.

The aim of this study was to investigate the extent of the bony injury following ballistic fracture, and to analyse the method of stabilisation based on early outcome.

Method

202 Field Hospital (Fd Hosp), a tented and containerised hospital, was deployed to Northern Kuwait on 16 March 2003, to provide medical support to the south-eastern region of Iraq. Three days later, coalition forces began military operations in Iraq. The hospital had six operating theatres. Four of these were tented, without sterile air filtration, and were used for all limb surgery. The remaining two theatres were in iso-containers

and reserved for head and neck surgery. Details of the hospital set-up have been described previously(2).

Casualties received initial treatment and resuscitation at forward medical units prior to evacuation to 202 Fd Hosp. The majority of casualties were evacuated by helicopter, the remainder arriving in wheeled vehicles. Some cases had their initial surgery conducted by forward surgical team or in Iraqi surgical facilities(2).

Data was gathered prospectively to document demographic details, wounding agent, and anatomical location of injury for all battle casualties. Wounding agents were bullet, fragment (e.g. shell casing), anti-personnel mine and blast. In all cases of blast injury there were associated fragment wounds. Fractures were classified, using the Red Cross Fracture Classification(3) (Table 1), and anatomical location of the fracture with respect to proximity or involvement of joints was documented. This information was recorded in the operation notes and in a separate trauma database. All wounds were explored according to established principles of war surgery(4). Benzylpenicillin had been administered to all casualties before arrival in hospital. Flucloxacillin was added to this regimen and continued for a minimum of five days.

Infection was graded as either superficial (cellulitis), requiring antibiotics alone or deep, requiring surgical drainage (deep infection or osteomyelitis)(5).

The results were analysed independently using Fishers exact test.

Table 1. Red Cross Fracture Classification (3).

Type	Definition
A	Incomplete fracture.
B	Complete fracture but relatively simple.
C	Multi-fragmentary fractures with greater than 3cm extent.
D	Fractures are associated with an extensive defect, loss of periosteum and require reconstruction or amputation.

Table 2.Red Cross Fracture Classification compared with mode of injury.

	A	B	C	D	Traumatic Amputations	Hands/Feet	Totals
Mine					3		3
Blast		1	2	2	4	2	11
Bullet	3	9	9	3		1	25
Fragment	3	1	3			4	11
Totals	6	11	14	5	7	7	50

Results

During the conflict, we treated 39 casualties with 50 ballistic fractures. Of the 39 casualties, 36 were male and three female; five were children. The median age of the study group was 25.5 years (range 3-63). Twenty of the casualties were enemy prisoners of war, 15 were civilians and four were coalition service personnel.

Twenty-five (50%) of the fractures were caused by bullets, 11 (22%) by secondary blast effects, 11 (22%) from fragments and 3 (6%) were due to anti-personnel mines. Of the 50 ballistic fractures sustained by the study group, 17 were upper limb fractures and 33 lower limb fractures. Red Cross fracture scores related to the mode of injury are shown in Table 2.

Specific Injuries And Methods Of Stabilisation

Amputations

Thirteen limbs were amputated; 7 of these were traumatic in origin (defined as loss of a limb proximal to wrist or ankle as a direct result of the traumatic insult)(6). They were all below knee with three secondary to anti-personnel mines (100% of all mine injuries) and the remaining four due to secondary blast (36% of all secondary blast injuries). One below knee amputation developed a superficial infection following delayed primary closure.

Figure 1. Type D fracture of Tibia and Fibula.

Primary Amputation

Two primary amputations were performed immediately as the limbs were considered unsalvageable following gunshot wounds; a type D fractures of the tibia and fibula (Figure 1) undergoing a below knee amputation and a type D fracture of the proximal humeral metaphysis underwent a shoulder disarticulation. Both amputation stumps were closed primarily, and both developed superficial infections but eventually healed.

Intra-articular fractures were uncommon (n=3). All became infected and analysis revealed the deep infection rate to be significantly higher than occurring in the extra-articular fracture group (p=0.031). There was no significant difference between groups in terms of superficial infection.

External fixation

Nine fractures were primarily stabilised by external fixators. Three frames were applied to the upper limb and six to the lower limb.

Figure 2. Type C gunshot fracture of the femur. Note fragmentation of the bullet.

In total, three lower limbs were secondarily amputated. Two type C fractures of the femur were revised to above knee amputations (Figure 2). One patient became septic, secondary to a deep infection, and the second patient had a failed vascular repair, resulting in ischaemia, leading to amputation. One type C fracture of the tibia and fibula developed a deep infection and was revised to a below knee amputation following failure to eradicate the infection despite serial debridement. In addition, two superficial wound infections occurred.

In total, four of the eight wounds, with adequate follow-up, became infected. The outcome of those wounds managed with external fixation has, in part, been discussed previously(7).

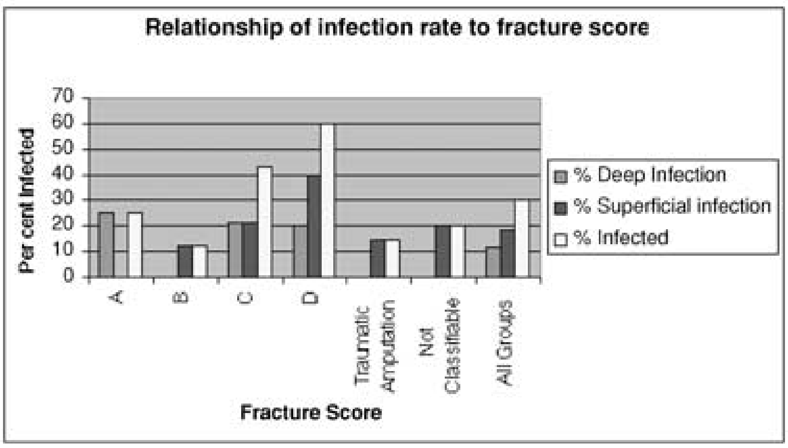

Figure 3. Infection related to ICRC Fracture Score

Traction

Traction was employed, primarily, on four occasions for femoral fractures (1 type D, 2 type C and 1 type B fracture). Follow up was only available for two patients, and a superficial wound infection developed in one of the type C fractures, which, resolved with antibiotics alone.

Plaster of Paris (POP) Stabilisation

Six fractures were primarily stabilised with POP, all were available for follow-up. Two type B fractures of the tibia with small wounds healed uneventfully. A superficial infection developed in a type C fracture of an isolated fibula. A type C fracture of the tibia and fibula healed, in a three year old child. The remaining two injuries in this group were grade C fractures of the radius with an intact ulna.

Kirschner-wiring

Six fractures were stabilised using Kirschner-wires, two in a child and four in adults. A six year-old child sustained bilateral tibial fractures (type C and type D fractures respectively), these were stabilised with K-wires and then augmented with a POP splint. Three hand and one foot fracture were stabilised with percutaneous wires, two were available for follow-up. There were no infective complications in this group.

Debridement only

Sixteen fractures did not require stabilisation at initial debridement and 14 were available for follow-up. Of the eight upper limb long bone fractures, one was an isolated ulnar diaphysis fracture, one was a single stable phalangeal fracture, the others were in the metaphyseal region with four in the proximal humerus and one distal humerus/radial head fracture in the same patient. The latter two fractures, type C and A respectively, developed a deep infection following primary suture. A superficial infection developed in a type C proximal humerus fracture.

Of the lower limb fractures, all were either metaphyseal (2 type A proximal tibial and 2 type A distal femoral fractures) or isolated fibula fractures (2 type B, 1 type C and 1 type D). The type D fracture of the isolated fibula was closed primarily and later required a below knee amputation.

Infection

Follow-up was available for 43 wounds (Figure 3).

Primary suture was performed on 5/43 (12%) of wounds with the remaining 38/43 (88%) undergoing delayed primary closure. Three deep and one superficial infections occurred in the primary closure group (4/5, 80%) compared to two deep and seven superficial in the delayed primary suture group 9/38, 24%. This difference was statistically significant, p=0.024.

Forty-eight per cent (10/21) of gunshot wounds became infected compared to 14%(3/22) from other mechanisms. This represented a significantly higher total infection rate and deep infection rate than non-gunshot wounds (p=0.022 and p=0.021 respectively). There was no significant difference between superficial infection occurring in gunshot fractures when compared to superficial infection in non-gunshot fractures.

Discussion

The very nature of war, with difficulties in follow-up and data collection(8,9), means that there is a paucity of data on the infection rate in ballistic fractures. Jacob *et al*(10). reported the US experience of managing military gunshot fractures, in Panama, with infection rates of at least 22 per cent whilst Tikka *et al*(11). reported infection rates as high as 41 per cent when they retrospectively studied 36 civilian (Gustillo - Anderson grade III(12,13)) gunshot fractures. Our overall infection rate of 30 per cent is comparable.

Infection rates, in open fractures managed in the UK and US, are 10 to 16 per cent(14,15). However, it is inappropriate to compare our study, of high energy ballistic fractures, with studies that cover a broader cross section of the population and, in particular, different modes of injury. Furthermore, we operated in an austere environment with limited resources and treatment options. Early administration of Benzylpenicillin has been shown to reduce the risk of infection in war wounds(16); this is standard procedure for coalition casualties who have this administered by medical personnel prior to arrival at surgical facilities. This was not necessarily the case in Iraqi war wounded. As the majority of the casualties were Iraqi it is not possible to comment on the effectiveness of this antibiotic regime.

In our series, 50 per cent of fractures were caused by bullets, which have a greater lethality and a propensity to cause complex fractures with significant soft tissue injury compared to other injurious agents(2). We demonstrated a significantly higher infection rate in gunshot fractures (48%), when compared to other injurious agents (16%). In addition, all the deep infections and late amputations occurred in this group.

In our study, there were only three intra-articular fractures, but they had a 100% infection rate compared to 25% in extra-articular fractures. Two of the three wounds were closed primarily and they subsequently developed deep wound infections.

The basic principles of war wound management have not changed in recent years(4). These consist of complete excision of non-viable tissue and removal of foreign material, leaving the wound open and delayed primary closure(17). Five wounds were closed primarily with an infection rate of 80 per cent compared to 24 per cent when delayed primary suture or secondary healing was employed. This is a recurring theme, where the principles of war surgery have to be re-learned(11). It may also reflect a failure to recognise the difference between military and civilian wounds; significant contamination and high energy transfer being much more common in military wounds. In addition, wounds which were closed primarily often had an intra-articular communication, or were following early amputation. They may have been closed due to concerns about leaving these types of wound open rather than ignorance of the basic principles.

The relatively low incidence of infection in those limbs that sustained a traumatic amputation (14%) compared to those limbs that were salvaged (33%) highlights the potential poor outcome of limb salvage. Those limbs that were traumatically amputated were due to blast or anti-personnel mines and it is possible that the poor outcome in the limb salvage group was related to the high number of GSW's. It also demonstrates the difficulty in deciding whether to amputate or to salvage a limb. Precise indications for amputations are difficult to define and a number of different scoring systems have been developed. However, none are reliable, sensitive and specific enough to determine which limbs should be salvaged(18). The final treatment decision still rests with the empiric clinical impression of the treating surgeon(19).

Some authors have advocated external fixation as the preferred treatment option in the management of ballistic fractures(20,21). They conducted the surgery in standard civilian hospitals and have included Gustilo-Anderson grade I and II fractures as those requiring external fixation. However, external fixation, when performed in battlefield conditions, has a high incidence of infective complications and frequently requires revision or removal(22,23). Our study demonstrates a 50 per cent infection rate in fractures stabilised with external fixation, however, this method was reserved for the most severe injuries, associated with significant soft tissue injury and an unstable fracture. The infected cases were gunshot fractures, which have a similar infection rate (48%), in our series, irrespective of the method of stabilisation. This suggests that it may be the nature of the injury, rather than the method of stabilisation, that determines outcome. It may also represent a failure to appreciate the degree of tissue damage at the time of initial surgery and possible inadequate debridement. Further work is necessary on the debridement and outcome of ballistic fractures following gunshot wounds.

The indications for immobilisation of open fractures in POP casts are considered limited(17), but in the military environment are indicated due to resource limitations. We restricted this method to either simple fractures with simple wounds (e.g. type A or B fractures) or isolated ulna/radius or fibula fracture. However POP has been used extensively in the past for all types of open ballistic fractures, Trueta described 225 ballistic tibial fractures treated with debridement and total encasement with POP, reporting 88 per cent good result(24).

Nikolic *et al* reported the results following external fixation or POP stabilisation of sub-trochanteric missile fractures, treated in a University hospital, during the civil war in Croatia(25). The complication rate was high, in both groups, with 52 per cent in the external fixation group and 86 per cent in the POP group suggesting that, in a war environment, where internal fixation is contra-indicated, there is no simple solution to the stabilisation of femoral fractures.

In our study, we employed traction, in the management of femoral fractures. Follow-up data was very limited but we and other authors have used this method successfully previously(7,22).

The success of Red Cross classifications are due to their ease of use (little experience of ballistic trauma is required); thus it tends to be willingly adopted by surgeons in the field(2,3,26). In our series, the ICRC fracture score does not specifically correlate with infection; type A fractures having a higher rate of infection than type B, but this may be due to the small numbers involved. At the severe end of the spectrum (type C and D fractures do, however, demonstrate the highest rates of infection.

The limitations of existing open fracture classifications has been described previously (27). In particular, the Gustilo-Anderson classification,(12,13) which scores all high energy ballistic fractures as grade III; in the absence of a vascular injury, there are only two grades. Consequently, the ability of this classification to discriminate between differing severity of injuries is reduced. The ICRC fracture classification has the advantage of being, largely, a radiographic classification, allowing retrospective analyses of all bar the type D fractures. It has been criticised on that basis, however, as it does not specify the severity of the soft tissue injury in types A, B and C. Our experience suggests that type A fractures can be managed with no stabilisation or POP stabilisation. Some type B fractures have complex wounds and so the classification is less helpful in guiding which method of stabilisation is recommended. It is uncommon that a complex fracture (type C and D) is associated with a simple wound (in our series there were only three) and therefore it can be presumed that these fractures correlate with Gustilo-Anderson type III injuries. This suggests that, in ballistic fractures, the radiographic appearance of the fracture may be useful in predicting of the severity of the soft tissue injury and hence outcome. On this basis, and in the interest of further audit of war wounded, we advocate continued use of the ICRC fracture classification.

This study provides further evidence that the management of high-energy ballistic fractures is demanding, requiring skill and experience from the operating surgeon and adds to current literature. In the theatre of war existing civilian practice has to be modified if complications are to be minimised and long-term function maximised. This can only be achieved with continued training and education.

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