Clinical

The incidence of pelvic fractures with traumatic lower limb amputation in modern warfare due to improvised explosive devices

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Abstract

Aims

A frequently-seen injury pattern in current military experience is traumatic lower limb amputation as a result of improvised explosive devices (IEDs). This injury can coexist with fractures involving the pelvic ring. This study aims to assess the frequency of concomitant pelvic fracture in IED-related lower limb amputation.

Methods

A retrospective analysis of the trauma charts, medical notes, and digital imaging was undertaken for all patients arriving at the Emergency Department at the UK military field hospital in Camp Bastion, Afghanistan, with a traumatic lower limb amputation in the six months between September 2009 and April 2010, in order to determine the incidence of associated pelvic ring fractures.

Results

Of 77 consecutive patients with traumatic lower limb amputations, 17 (22%) had an associated pelvic fracture (eleven with displaced pelvic ring fractures, five undisplaced fractures and one acetabular fracture). Unilateral amputees (n=31) had a 10% incidence of associated pelvic fracture, whilst 30% of bilateral amputees (n=46) had a concurrent pelvic fracture. However, in bilateral, trans-femoral amputations (n=28) the incidence of pelvic fracture was 39%.

Conclusions

The study demonstrates a high incidence of pelvic fractures in patients with traumatic lower limb amputations, supporting the routine pre-hospital application of pelvic binders in this patient group.

Introduction

Many military surgeons regard the traumatic lower limb amputation following blast injury from improvised explosive devices (IEDs) as the signature injury pattern in recent military surgical experience. These weapons are typically triggered and buried, then initiated by the victim via a pressure-plate as shown in figure 1. Recent United States (US) estimates hold IEDs responsible for 63% of US deaths on combat operations (1). The US Joint Theatre Trauma Registry records 423 combat casualties with major limb amputations between October 2001 and June 2006. 88% of these were caused by explosive devices (2). More recent data from a US facility in Afghanistan revealed 915 multinational patients with IED blast related injury (three times more than any other single mechanism) in the fifteen months from Oct 2009 (3).
Lower limb amputation from IED blasts can coexist with pelvic ring fractures. In civilian practice, the prevalence of pelvic fracture in studies of patients with blunt trauma is between 5% and 16% (4-6), but no such data exists on the prevalence amongst military casualties. This study aims to assess the incidence of concomitant pelvic fracture in traumatic lower limb amputation due to blast.

**Methods**

A retrospective analysis of the notes of consecutive patients with lower limb amputations was carried out at the UK Military field hospital at Camp Bastion in Afghanistan between 15 September 2009 and 30 April 2010. This hospital was the primary receiving centre for all International Stabilisation and Assistance Forces (ISAF) operating in Helmand Province and also accepted patients from the local population who met the ISAF eligibility criteria for treatment.

All patients arriving at the Emergency Department with a traumatic lower limb amputation proximal to the ankle from an explosive mechanism were included, and there were no exclusions based on military/civilian status or nationality. Clinical notes and radiographs of all identified cases were reviewed. The level of amputation was classified on presentation and not after surgical debridement.

**Statistical Analysis**

The incidence of pelvic fracture in different amputation cohorts was compared using Fischer’s exact test.

**Results**

Seventy-seven consecutive patients with lower limb amputation due to blast injury were identified. All casualties were adult males injured by IEDs whilst ‘dismounted’ i.e. on the ground on foot and not in vehicles. The most common amputation pattern was bilateral above knee amputation, with 28/77 patients sustaining an injury of this type as seen in Figure 2.

Seventeen patients in this series of 77 casualties had a concurrent pelvic fracture (22%). Three of the 31 unilateral amputees had an associated pelvic fracture (10%), whereas there were concurrent pelvic fractures in fourteen of the 46 bilateral amputees (30%) and this difference in incidence was significant (p=0.0295, Fisher’s exact test). Among the 28 casualties with bilateral above knee amputations, eleven had a pelvic fracture (39%), of which eight (29%) were displaced (Table 1).

<table>
<thead>
<tr>
<th>Amputation pattern</th>
<th>Incidence of pelvic fracture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any lower limb amputation</td>
<td>22</td>
</tr>
<tr>
<td>Unilateral lower limb amputation</td>
<td>10</td>
</tr>
<tr>
<td>Bilateral lower limb amputations</td>
<td>30</td>
</tr>
<tr>
<td>Bilateral above knee amputations</td>
<td>39</td>
</tr>
</tbody>
</table>

Table 1: Summary of incidence in pelvic fracture in traumatic lower limb amputation in blast injury. It should be emphasised that 29% of the pelvic fractures seen in bilateral above knee amputation were displaced.

The association between bilateral above knee amputation and pelvic fracture when compared with other bilateral amputee patterns was, however, not statistically significant (p=0.5112, Fisher’s exact test).

Thirteen of the patients died of their wounds within 24 hours of hospital admission. These included six of the seventeen patients with known pelvic fractures, four of whom had recognised displacement of the pelvic ring. In two of the thirteen fatalities, no imaging was available to assess the pelvic injury as the casualties presented peri-arrest and did not survive initial resuscitation attempts due to the severity of their injuries.

**Discussion**

IEDs are now recognised as the primary threat to military personnel in Afghanistan (1). The assessment of occult pelvic injury has been problematic, especially in the unconscious patient, and index of suspicion due to injury mechanism is relied upon (7). Although clinical examination has been validated in alert patients (7), there is significant distracting injury in our patients that is certain to make assessment less reliable. The high incidence of pelvic fractures in traumatic amputees (22%), with a rate of 39% in bilateral above knee amputations, necessitates a high index of suspicion in future casualties with this injury pattern. Bony pelvic injury should, therefore, be assumed to be present until reliably excluded. This data differs from previous international data from the Red Cross on lower limb amputation due to antipersonnel mines, where pelvic injury was not discussed but “genital and central injuries” were not common (8). It is reasonable to speculate that patients exposed to larger force of blast are now surviving to hospital due to improved pre-hospital care and faster...
evacuation times and more extensive injuries of this nature in survivors are therefore likely.

Major pelvic ring disruption injuries are commonly subdivided by mechanism: antero-posterior compression (APC); lateral compression (LC); vertical shear (VS); and combined mechanical injury (CMI) (Young Burgess Classification) (9). In the civilian population (where the majority of these fractures result from road traffic collisions), higher grades of APC fracture were most associated with shock. However, this was substantially attributed to massive torsional forces causing concomitant visceral injury (10). Organ injury patterns and mortality are difficult to extrapolate into the military setting due to the different mechanisms of injury (6, 12).

Amputation, occurring as a consequence of blast, results from the direct coupling of the blast wave into the tissues, causing axial stresses to the bone and thus fracture. The limb then flails due to gas flow over the limb and amputation is completed (11). These patients experience the additional trauma of being thrown by the blast and subsequent injury on landing. Depending on the level of amputation it would seem reasonable to conclude that the risk of pelvic injury is high in these patients due to a combined mechanism of the blast wave, axial stresses of the flailing lower limbs, and impact from being thrown. The predominant fracture pattern in our population of patients seemed to be of a combined mechanism, typically being a combination of antero-posterior compression and vertical shear, making classification difficult. An inferior-superior open-book fracture pattern has been proposed for blast injuries resulting from the hemi-pelvis being distracted from the sacrum by the upward force of the blast, and is believed to be more consistent with military injuries (Figure 3) (12). However, although commonly victim-initiated IED strikes are buried in the ground, it is possible to place these weapons in walls so that the direction of the explosive charge may not necessarily be directed upwards at the victim but could be tangential in some cases, striking the victim from the front, behind or the side and not just from below.

Pelvic displacement can be an independent cause of occult, catastrophic blood loss in all traumatic amputees, distinct from the amputation site and, therefore, further compromises the cardiovascular status of those with traumatic amputations. Although most studies of civilian patients with pelvic fracture conclude that mortality is determined by associated injuries rather than the pelvic fracture, Balogh et al. refute this in their 2007 prospective population-based study; they found a fatality rate of 33% in pelvic ring fractures, all of which were related to pelvic haemorrhage (13). Pelvic immobilisation with circumferential compression is recommended for routine use if there is any suspicion of pelvic fracture based on the mechanism of injury (14-16). Treatment of a potential pelvic fracture from blast injury, with the associated potential life threatening haemorrhage, should therefore begin as far forward as possible in the military setting.

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The pelvic radiograph is a fundamental part of the primary survey. However, in those patients imaged with binder in situ, an apparently normal pelvic radiograph may be falsely reassuring. In patients in this series excellent reduction was produced with the binder correctly applied, potentially masking a fracture if a second radiograph was not taken after binder removal. In future medical support to military operations, which may well be conducted without a CT scanner available for peri-resuscitation imaging, serial pelvic X-rays before and after binder removal should be the standard practice. Limitations of this study include its retrospective design,
the circumstance of the trauma being in a military setting, potentially limiting extrapolation to civilian practice, and the outcomes beyond 24 hours being unavailable. We were unable to analyse CT radiography to classify fracture type exactly, but relied on the written reports. This study supports the association between IED injury, amputation and pelvic injury. We were not able to collect data on those who died pre-hospital and it was outside the scope of this study to determine whether massive haemorrhage from pelvic bony injury contributed to death in our patients.

**Recommendations and conclusions**

The defining pattern of injury in current warfare is traumatic lower limb amputation from IED blast. This study shows a high association with pelvic fracture in this population, to the extent that a pelvic binder should be applied routinely as part of the initial resuscitation in all significant lower limb traumatic amputations due to blast injury. Pelvic binder protocols and training emphasising binder positioning should be employed. The importance of repeat imaging after binder removal is essential, even if initial imaging with binder in situ shows a closed pelvis.

**References**


![Figure 4. Pre-hospital pelvic binder application algorithm.](image-url)
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Acknowledgements
The professionalism, hard-work and dedication of the members of the Royal Navy Medical Service and wider Defence Medical Services who treated the casualties described in this work is gratefully acknowledged.