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Blast injuries to the pelvis: essential lessons learned

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The most recent military conflicts have seen blast injury as the leading mechanism of wounding and death, with the Improvised Explosive Device (IED) as the signature weapon of choice.[1] Outside the military setting, terrorists have increasingly used the IED globally over the last 40 years.[2] One of the most challenging patterns of orthopaedic injury to emerge is that of blast injury to the pelvis.[3]

This involves pelvic instability, extensive tissue loss and heavily contaminated injuries.[4,5] It is frequently associated with vascular injury, traumatic amputation of at least one lower extremity (typically proximal transfemoral amputations), a severe injury to another extremity, and abdominal, perineal or urogenital wounding (Figure 1).[4–7] The associated mortality of all blast related pelvic fractures is 48%, rising to 73% when pelvic fractures are combined with open perineal injuries.[8,9]

This group of injuries is sustained by casualties who are wounded on foot patrol.[6] In vehicle, injuries consist primarily of rami, sacral and spinal fractures – consistent with an upwards deformation of the seat.[9] Causes of death in these circumstances are predominantly head or thoracic trauma, as the casualty is thrown upwards.[9,10] On foot, pelvic fractures sustained consist principally of disruption to the pubic symphysis and sacroiliac joints.[9] The fracture patterns are typically unstable injuries, classified as Tile type B or C.[4] They do not fit clearly into mechanistic civilian classification systems (such as the Young-Burgess classification).[11,12] The mechanism of injury is not clearly understood, but has been hypothesised to occur secondary to axial load via the femoral head, outward flail of the lower extremities (with a resultant superolateral displacing force acting upon the pelvis), blast wind with fragmentation causing direct tissue damage and displacement, or combinations of the above.[9,13]

As in civilian pelvic fractures, blast related pelvic fractures are associated with injuries to other body regions. One military cohort described 29 survivors (of a total cohort of 89 casualties) of open pelvic blast injuries as having median new injury severity scores (NISS)14 of 41 (range 8 to 75), with significant injuries (defined as abbreviated injury severity score (AIS)15 ≥ 2) in a mean of 3.9 additional body regions. In 90% of cases, the pelvic injury was the most severely injured body region (based on the AIS score), followed by lower extremity and abdominal injury. As such, patients with blast injury to the pelvis represent the extreme end of the trauma spectrum – significant resources and multidisciplinary surgical input are required in
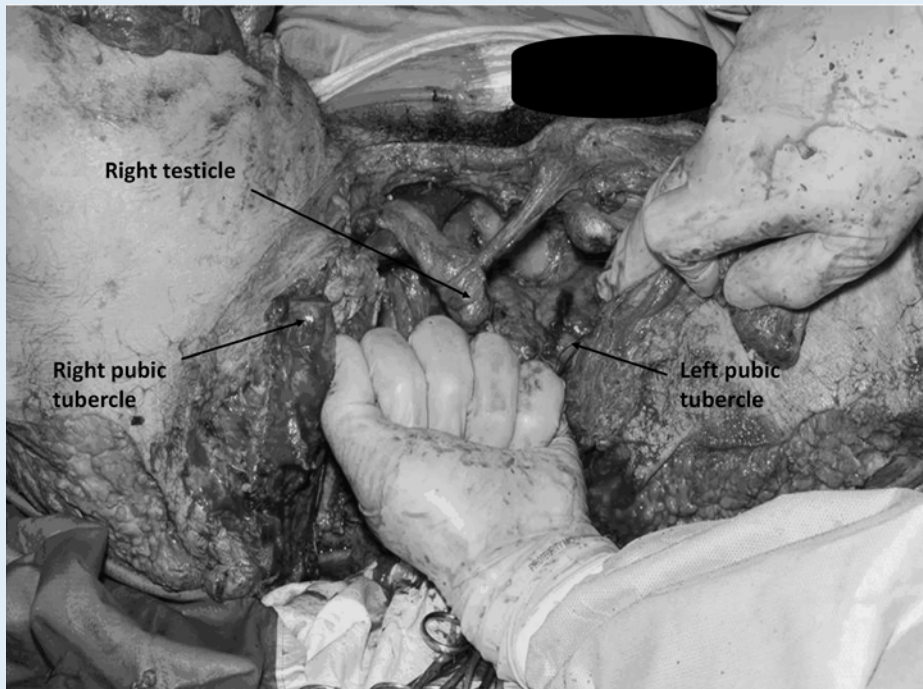
Figure 1: Intra-operative photograph showing a patient with blast injury to the pelvis (Tile C pelvic fractures) and open perineal injuries. The patient sustained bilateral proximal transfemoral amputations in addition to their pelvic blast injury. Image reproduced with permission.[5]

major transfusion protocol should be initiated early. Haemorrhage from a pelvic vascular injury frequently requires surgical control with pelvic packing and/or direct pelvic vessel ligation.[4] Vascular control should be achieved at the most distal level possible. Initial infra-renal control of the aorta through laparotomy, may then be moved distally to the internal and external iliac arteries.[21]

As blast injury to the pelvis results in fracture patterns of a mechanically unstable nature (Figure 2), emergent operative management should include fracture stabilisation. Damage control orthopaedics, with external fixation techniques, form the standard treatment in the acute setting. Management includes provisional fracture stabilisation, debridement of contaminated and devitalised tissue, and limb preservation surgery of associated traumatic amputation (where possible). Conservation of maximal skeletal length and intervening joint levels may require fracture stabilisation proximal to the point of amputation.[22] Provisional operative pelvic stabilisation is performed using iliac crest or supra-acetabular external fixation.[8] In severely unstable pelvic fractures, the addition of a compact external fixator at the pubic tubercles, may aid stability across the pubic symphysis.[23]

With risk of concurrent colorectal injury, the input of a general surgeon should be sought early. Inspection of the perineum, buttock and perianal tissues is required, including digital rectal examination to assess for sphincter function, luminal compromise, haematochezia, or foreign bodies. Blast injury to the anus, rectum or sigmoid colon are strong indications for a diverting colostomy; abdominal perineal resection may be required in cases of massive pelvi-perineal wounds with rectal destruction and pelvic necrosis.[24]

their management.[5] Owing to ever increasing use of the IED in terrorist related incidents, the civilian surgeon may be expected to treat a patient with blast injury to the pelvis – knowledge of the immediate and ongoing management is essential.

Management of the blast pelvis

The principle priority in the management of blast injury to the pelvis is haemorrhage control, beginning on-scene prior to hospital intervention. Both pelvic vascular injury and associated traumatic amputation present sources of major haemorrhage from which exsanguination can occur. Pre-hospital haemorrhage control can be achieved in traumatic amputation with the use of tourniquets.[16] For more proximal traumatic amputation where tourniquet application is not practical (such as the groin), advanced haemostatic products can help achieve haemostasis.[17] For non-compressible haemorrhage, resuscitative endovascular balloon occlusion of the aorta (REBOA) has been shown to have a positive effect on mortality and has been used as a pre-hospital resuscitation treatment

for patients with exsanguinating pelvic haemorrhage.[18,19] Additionally, application of a pelvic binder is mandatory in lower extremity blast injury with suspected pelvic fracture, to aid stable clot formation from low pressure bleeding sites.[20]

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Subsequent multidisciplinary operative management is required as soon as feasible to achieve vascular control and pelvic fracture stabilisation.[4,5,8,21] On arrival in the emergency department, hypotensive patients warrant immediate transfer to theatre for damage control surgery with concurrent resuscitation. These patients require massive blood transfusion (mean 28 units of packed red cells within the first 24 hours)[5] and the receiving facility's

Urological review is required as the risk of urogenital trauma is increased three-fold in casualties of blast injury where a pelvic ring fracture is present, and partial or complete loss of genitalia has been observed in up to 25% of these patients[8,25] Bladder or >>

Figure 2: Anteroposterior radiograph of a patient with blast injury to the pelvis, taken on presentation, showing diastasis of the pubic symphysis and disruption of the right sacroiliac joint. Image reproduced with permission.[5]

urethral injuries should be suspected with the presence of blood at the urethral meatus or scrotal bruising. A retrograde urethrogram is advised to detect urethral injury, which may be followed by a CT cystourethrogram to identify bladder injury.[26]

The principles of blast injury wound management emphasise extensive debridement, wound irrigation and negative pressure dressings. Repeated debridement over the initial days after injury are required, as blast effects on tissue viability are not always apparent at first. The zone of injury may be larger than initially apparent as tissues in close proximity to the primary blast region may die over time.[27] The number of debridements required for patients with blast injury to the pelvis has ranged from two to thirty-two (median six).[5] Subsequent soft tissue coverage and reconstruction is performed in a delayed fashion with split skin grafts or fasciocutaneous flaps.[28]

Bacterial and invasive fungal infections are common and may cause late mortality[29]. Intravenous prophylactic antibiotics should be administered as soon as possible, ideally within three hours of injury. At initial debridement, antibiotic-impregnated beads may be implanted in proximity to fracture sites. Prophylactic antibiotics should be continued for 24 – 72 hours. Antibiotic use beyond this is determined by the presence of an established infection or delayed wound closure.[30] Invasive fungal infections are challenging to treat and outcomes remain poor. Risk factors identified from previously injured military personnel include (on foot) blast injury and above knee traumatic amputations.[31] In cases of suspected fungal infection, intravenous antifungals should be administered in addition to repeated debridement of necrotic tissue – widespread debridement can be required.[32]

Definitive fixation of complex open pelvic fractures can include iliosacral screws, with anterior disruption managed with internal fixation, external fixation, or a combination of techniques. In contrast to civilian open fractures, as a result of the high degree of soft-tissue disruption and environmental contamination, deep infection rates in pelvic blast patients reach 80%.[5] The risk of infected indwelling metalwork is extremely high—one series reported a 57% removal of metalwork rate due to infection, subsequently requiring prolonged bed rest to achieve union.[5] Owing to severe contamination, subsequent wound reconstructive problems and risk of metalwork infection in these patients, external fixation should be considered as a definitive treatment in preference to internal fixation.

Blast injury is not limited to the battlefield and civilian orthopaedic surgeons may be required to manage these injuries following terrorist attack or similar mechanisms. These patients present with multiple life-threatening injuries and the most critical operative procedures should be prioritised — proximal haemorrhage control, pelvic stabilisation, contamination control, completion of amputations, bladder repair and colonic diversion.[33] Whilst blast injury to the pelvis represents the extreme end of the trauma spectrum, pelvic stability and return to walking on native or prosthetic limbs has been achieved in up to 80% of casualties.[5] Patients with blast injury to the pelvis require prior major incident planning, rapid surgical decision making, and prolonged multidisciplinary surgical and rehabilitation input in order to achieve optimal care and outcomes. ■

References

References can be found online at www.boa.ac.uk/publications/JTO.

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