Emergency management of pelvic fractures

Adrian C Day

Pelvic fractures are relatively uncommon, accounting for 1–3% of all fracture. Around 60% occur in men. This article discusses the multidisciplinary management of pelvic ring disruptions resulting from high energy transfer.

Pelvic fractures or, more precisely, disruptions of the pelvic ring are potentially life-threatening injuries and continue to be associated with significant morbidity, despite advances in their surgical management. Inappropriate selection of emergency treatment may prejudice the definitive management which is most appropriately carried out in a regional pelvic referral unit. The initial resuscitation and decision-making process, however, takes place in the emergency room. This process remains critical to the clinical outcome and although detailed analysis of the surgical management is beyond the scope of this review, an understanding of the principles which underpin that management is essential for correct decision making in the resuscitative phase. Furthermore, it avoids the need to be prescriptive when advising appropriate emergency treatment and offers both logical and flexible management protocols.

Those issues pertinent to emergency room management are outlined in order of priority.

HAEMORRHAGE

There are three distinct sources of haemorrhage in pelvic ring disruptions:

1. Venous plexus
2. Osseous
3. Arterial.

There is a very close correlation between the transfer of energy and the type of pelvic ring disruption, which in turn correlates with the risk of haemorrhage (McCoy et al, 1980; Wright et al, 1983; Cryer et al, 1988; Dalal et al, 1989). Life-threatening haemorrhage is predominantly of venous and osseous origin. Catastrophic disruption of the common, internal or external iliac vessels tends to be fatal at the scene. Haemorrhage of osseous origin may be self-limiting to some extent as it occurs in the subperiosteal and extra-muscular tissue planes which often remain at least partially intact.

The pelvic volume is approximated by the volume of a sphere ($V = 4/3\ \pi\ r^3$). Control of the pelvic radius is therefore critical as doubling the radius theoretically leads to an eight-fold increase in volume. There is no doubt that the reduction of pelvic volume is beneficial in controlling haemorrhage but the observed effect with retroperitoneal extension is probably much more modest than the above equation would suggest. Physical control of pelvic volume leads to an increase in pelvic rigidity and allows stable clots to form at the source of haemorrhage.

Venous haemorrhage tends to extend into the retroperitoneal space which can accommodate many times the circulating blood volume. It may be limited by the control of pelvic volume and abdominal muscle tone, both of which lead to a tamponade effect but the failure of these mechanisms despite adequate resuscitation may precipitate the requirement for pelvic packing. Loss of abdominal tone can disable the tamponade effect with a catastrophic drop in blood pressure.

Laparotomy should be considered carefully on its own merit. There may be intra-abdominal or other sources of bleeding in the presence of a pelvic fracture but a pelvic fracture is often the major source of blood loss. Laparotomy therefore should not be undertaken in the presence of an unstable pelvic ring disruption unless some degree of stability has first been re-established by the application of an external fixator device.

Reimer et al (1993) studied two groups of patients with pelvic ring disruptions and similar injury severity scores. The first group of 61 patients were managed before 1981 when external fixators were not part of the protocol. The second group of 476 patients post-dated 1983

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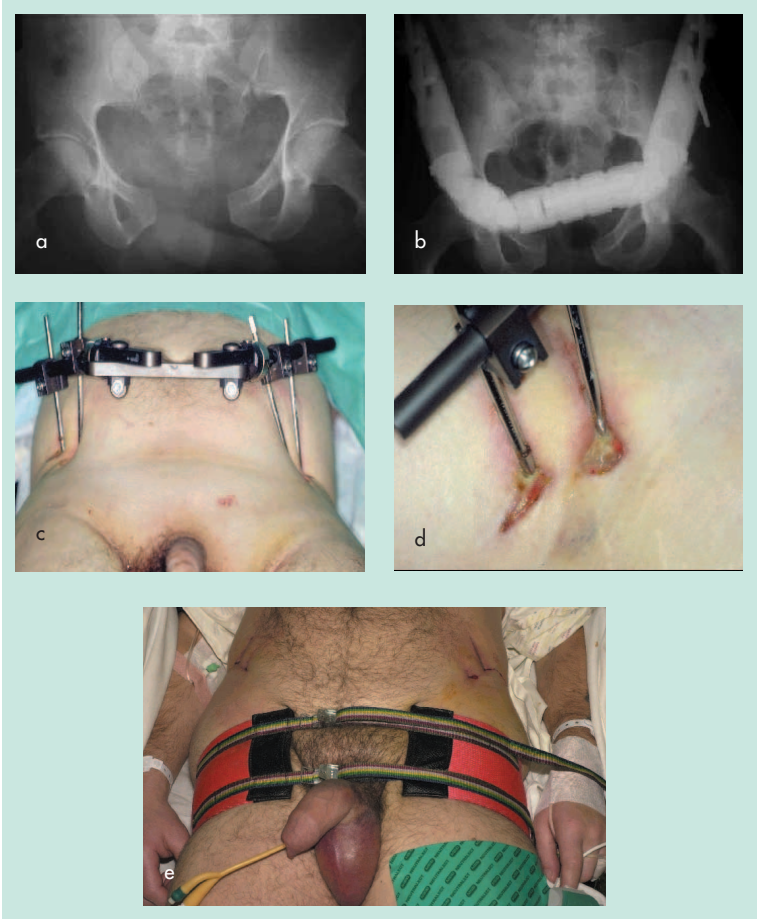
when external fixators were used in appropriate cases. The mortality rate fell from 26% to 6%, demonstrating the efficacy of pelvic external fixator devices. Stabilization of a symphyseal diastasis may be temporarily achieved with the use of two large fragment screws applied to the anterior aspect of the juxta-symphyseal bone and opposed with a screw reduction clamp through a minimal extra-peritoneal approach. This technique may precede laparotomy in specialist centres as it can be applied more rapidly than an external fixator device and allows definitive reconstruction plate or dynamic compression plate fixation at the end of the procedure. Rigid internal fixation offers considerably enhanced mechanical strength and reduces infection rates.

If pelvic retroperitoneal haemorrhage remains uncontrolled during the course of a laparotomy then formal pelvic packing should be undertaken. Rarely, the source of haemorrhage may be obvious, in which case the bleeding vessels should be addressed. There is no place for angiography and embolization as the primary method of diagnosis and treatment in this group of patients (*Figure 1*).

Figure 1. a. Tile type B 'open book' pelvic ring disruption. b. Injudicious application of an external fixator showing poor reduction. c. The Schanz pins thus directed cannot remain in the iliac wing. d. Pressure necrosis and infection prejudice definitive management. e. Application of a pelvic belt is quick, safe and establishes a satisfactory reduction, controlling pelvic volume.



The following measures are suggested for the management of haemorrhage in patients with pelvic fractures.

Advanced Trauma Life Support (ATLS) principles should be covered, including a full secondary survey. Other sites of bleeding should be identified, using diagnostic peritoneal lavage, computed tomography (CT), ultrasound and chest X-ray as required. An anteroposterior pelvic X-ray is required, along with a clinical examination of pelvic stability. Unnecessary movement should be avoided and the pelvis should be strapped. Circulatory resuscitation should match the rate of blood loss and follow ATLS guidelines. Monitor resuscitation, measuring the serum lactate, base excess and coagulation screen as necessary.

Skeletal traction should be applied by means of a proximal tibial traction pin where disruption of the sacro-iliac joint with vertical shear is apparent: Tile type C (Muller et al, 1990). The crescent fracture described by Borrelli et al (1996a, b) may be associated with limited vertical displacement and is often treated as a Tile type C injury. It is in fact a Tile type B2 injury and is almost invariably caused by a lateral compression mechanism. It is rarely associated with severe haemorrhage.

A posterior Ganz clamp may be considered for those patients requiring laparotomy who have significant lateral or posterior translocation and for vertical shear (Tile type C) disruption of the sacro-iliac complex. (This is advised only for those familiar with this device and its potential dangers.)

Responders should be converted to definitive treatment including open reduction and internal fixation. Non-responders require immediate surgical intervention: consider laparotomy which may be combined with internal or external fixation (*Figure 2*). Pelvic packing may be necessary and a second look, with a view to removing or replacing the packs, is advisable at 48 hours. Angiography has no place in this group.

The role of angiography

Arterial bleeding may occur from any branch of the internal or external iliac system. It may follow lateral compression, anteroposterior compression or vertical shear injuries but delayed presentation is typical in the majority of cases. This phenomenon may be caused by

arterial spasm associated with hypovolaemia which then relaxes following resuscitation, leading to the recurrence of high pressure/low volume haemorrhage. Angiography should be reserved for those patients who have responded to initial resuscitative measures and who then subsequently demonstrate haemodynamic decompensation. The value of a positive 'contrast extraversation sign' on contrast-enhanced CT (CECT) is highly predictive of the requirement for angiographic embolization (Stephen et al, 1999).

The positive predictive value (probability of requiring angiographic embolization given a positive contrast extraversation sign on CECT) of this test is 80%. The negative predictive value is 98%. The sensitivity is 80% and the specificity 98%. Angiography can then identify the precise source of haemorrhage and selective embolization may be achieved with a combinations of titanium coils, Gelfoam (Pharmacia Upjohn, Kalamazoo, USA) and polyvinyl alcohol. CECT and angiography should not precede the protocols outlined above. CECT should, however, be considered for those patients who have responded to initial resuscitation. Urgent provision should be made for angiography in those cases with a positive contrast extraversation sign following provisional pelvic stabilization and laparotomy if necessary. This may only be considered as a primary therapy in those patients with stable lateral compression injuries who have negative investigations for alternative sources of haemorrhage and have responded to the initial resuscitative efforts (*Figures 3* and *4*).

UROLOGICAL COMPLICATIONS

It is well recognized that disruption of the genitourinary tract may complicate pelvic ring injuries. Colapinto (1980) quotes an incidence of 13%. There is still a perception that this occurs relatively infrequently and that urethral

Figure 3. a. Contrast enhanced computed tomography contrast extraversation from a superior vesical artery bleed – arrowed. b. Pulse Doppler ultrasound scan demonstrating pseudoaneurysm of the superior gluteal artery. c. Angiography demonstrating the 'flare' sign (extraversation of arterial blood) from a ruptured superior vesical artery.

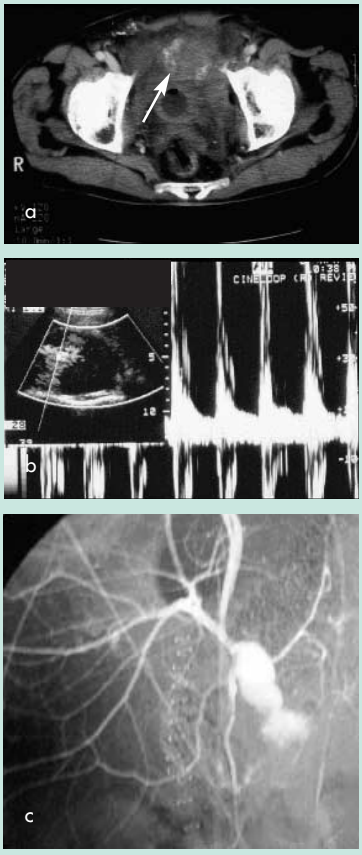
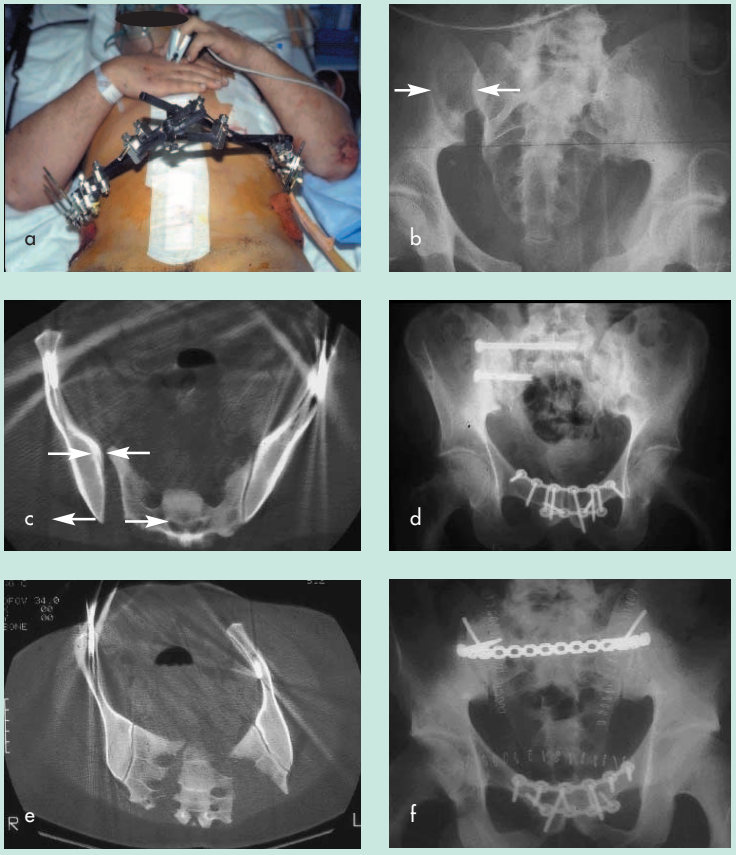


Figure 2. a. A correctly applied external fixator, using an 'A' frame construct with an AO device and independent pin placement. b. Tile type C pelvic ring disruption with translation of the hemipelvis. c The external fixator reduces pelvic volume and controls haemorrhage before laparotomy. d. Exchange to definitive management at 48 hours is not prejudiced. e. Care should be taken not to achieve over-reduction with an external fixator device. f. Definitive stabilization using a posterior sacral bridging plate.



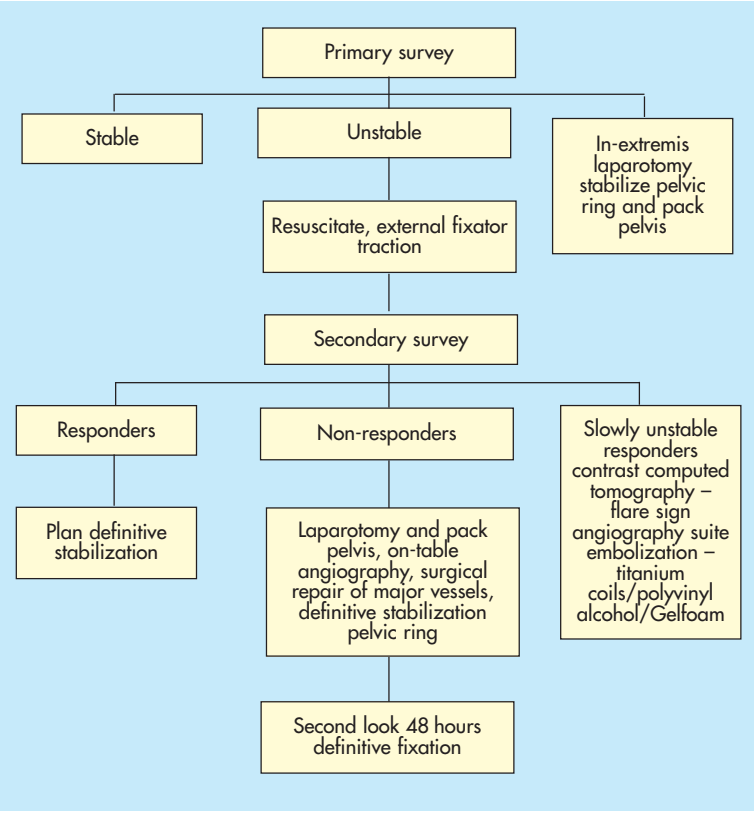


Figure 4. Management protocol.

injury occurs much more commonly than urinary bladder injuries. The ureter and kidney are rarely thought to be involved. A review of the literature paints a rather different picture (*Table 1*).

Further analysis demonstrates an overall incidence of 16.5% (bladder = 6.8%; urethra = 7.7%; combined = 2.0%). Injury to the urinary tract is therefore relatively common and should both be anticipated and investigated appropriately.

Microscopic haematuria was recognized in 120 out of 234 patients by Antoci and Schiff (1982). No urological injury requiring intervention was subsequently identified. Patients with this finding do not therefore require further investigation.

Investigations

The following are recommended as a minimum investigation of suspected urinary tract trauma: retrograde urethrogram, cystogram with post-drainage radiograph, pericatheter urethrogram (if catheter already in situ) and intravenous urogram. Suspicion of a urinary tract injury is in general raised by the inability to pass urine, blood at the urethral meatus, a scrotal or perineal haematoma and a high riding prostate on rectal examination. A large retroperitoneal haematoma should raise the possibility of urethral obstruction.

Bladder injuries

Intraperitoneal rupture occurs in 40% of cases. Extraperitoneal rupture occurs in 50% of cases. Both intra- and extraperitoneal rupture occurs in 10% of cases.

Treatment: Extraperitoneal ruptures may be treated non-operatively and will, on the whole, heal spontaneously. It is generally advisable to sit patients up following pelvic stabilization as the space of Retzius will then be compressed. The exception to this rule is when the anterior pelvic ring requires open reduction and internal fixation. The extraperitoneal rupture should probably then be repaired and covered by both a urethral catheter and a tunneled non-suction (Robinson) drain to the space of Retzius. There is an increased infection rate associated with internal fixation of the anterior pelvic ring in such circumstances but pelvic stabilization may be of paramount importance. Low grade infection more often than not settles following removal of metalwork when the pelvic ring has healed. This optimistic prognosis does not apply to infection elsewhere in the pelvis. Intraperitoneal ruptures require surgical repair.

Urethral injuries

Complete disruption occurs in 58% of cases, with partial disruption in 42% of cases.

TABLE 1.
The pattern of urinary tract injuries

Reference	n	Bladder	Urethra	Combined
Weems (1979)	286	24	24	–
Pokorny et al (1979)	100	6	4	–
Antoci and Schiff (1982)	234	16	12	–
Palmer et al (1983)	200	18	7	2
Fallon et al (1984)	200	14	12	5
Perry and Husmann (1992)	130	–	6	–
Koraitim et al (1996)	203	5	39	12

Treatment: Blood at the urethral meatus, associated with a scrotal and perineal haematoma, should suggest a partial or complete rupture of the urethra. This is often at the level of the membranous urethra. A high riding prostate identified on the mandatory rectal examination would suggest a complete rupture. The safest way of dealing with a complete rupture is to pass a suprapubic catheter under ultrasound control. A single and gentle attempt at the passage of a silastic urethral catheter by an experienced practitioner is probably acceptable for a partial rupture. Catheter traction is not indicated. Closed urethral catheterization is contraindicated in complete rupture and differentiation between one type of rupture and the other becomes a subtle judgment call. If in doubt, refer to the safe technique. Catheterization of any form should be covered by appropriate antibiotic prophylaxis. Although the urinary tract is in theory sterile, the extensive haematoma formation and soft tissue trauma resulting from pelvic ring disruption leads to a high incidence of contamination and the risk of an infected haematoma is thereby increased.

Morehouse et al (1972) described an excessively high rate of impotence and incontinence following failed early attempts at urethral reconstruction. Webster et al (1983) reported 34% impotence and 20% incontinence following early urethral repair which compares with 12% impotence and 2% incontinence following delayed repair. The tissues following pelvic ring disruption, as opposed to sharp or even direct blunt trauma, are friable. The peri-prostatic nerve and vascular plexus is liable to further trauma as the result of attempted surgical intervention.

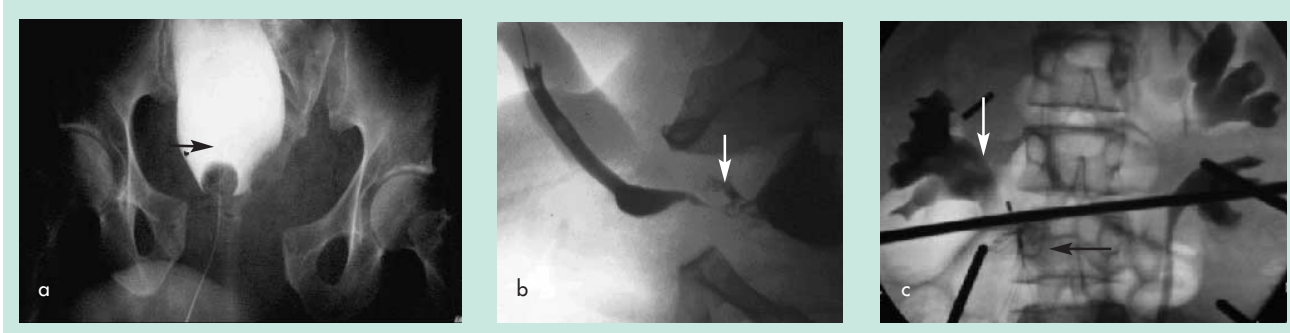
Herschorn et al (1992) assessed 16 cases of which 13 were realigned but not repaired. Follis et al (1992) reported 33 cases of which 20 were realigned. The pooled results demonstrate a stricture rate of 35% for aligned cases *vs* 54% for non-aligned cases. The impotence rates were 42% and 20% respectively. There was no report of incontinence. The numbers are small, however, and there remains some difference of opinion as to the optimal technique of acute management.

On balance, realignment with delayed urethral repair would seem a logical approach. There is much to recommend open reduction and internal fixation. It is remarkable how a high riding bladder (*Figure 5*) will reduce and the peri-prostatic tissues relax with the application of a simple anterior plate. This allows urethral alignment by the gentle passage of a silastic urethral catheter into the space of Retzius and subsequently into the bladder by means of a 'rail-roading' technique, or a bougie of catheter inserted through a small cystotomy and the bladder base. There should be minimal disruption of the pelvic haematoma, no traction, no dissection and no anastomosis. The bladder neck should, however, be carefully repaired if it is torn. This avoids extraversation of the catheter balloon which will lead in turn to an 'unreliable catheter' and sump pooling of urine in the pelvis (Iselin and Webster, 1999). The realignment should always be covered by a supra-pubic catheter and this should preferably be tunneled. Definitive reconstruction should then be undertaken, if necessary, on a delayed and elective basis when the pelvis is stable, the soft tissue envelope healed and the acute inflammatory process has resolved.

OPEN PELVIC FRACTURES

Open pelvic fractures are associated with a mortality rate of between 25 and 50% in different series. The principal causes of death are sepsis and haemorrhage. Raffa and Christensen (1976) reported a series of 26 open pelvic fractures of which 16 were the result of blunt trauma (12 had urological injuries and 7 had gastrointestinal injuries). Eight patients died, 7 from sepsis and 1 from haemorrhage. A clear pattern emerges. Patients who survive these severe

Figure 5. a. A 'high-riding' bladder with secondary urethral disruption. b. A leak from rupture of the prostato-membranous urethra. c. A filter in the inferior vena cava and dilation of the pelvi-calyceal system with secondary retroperitoneal haematoma.



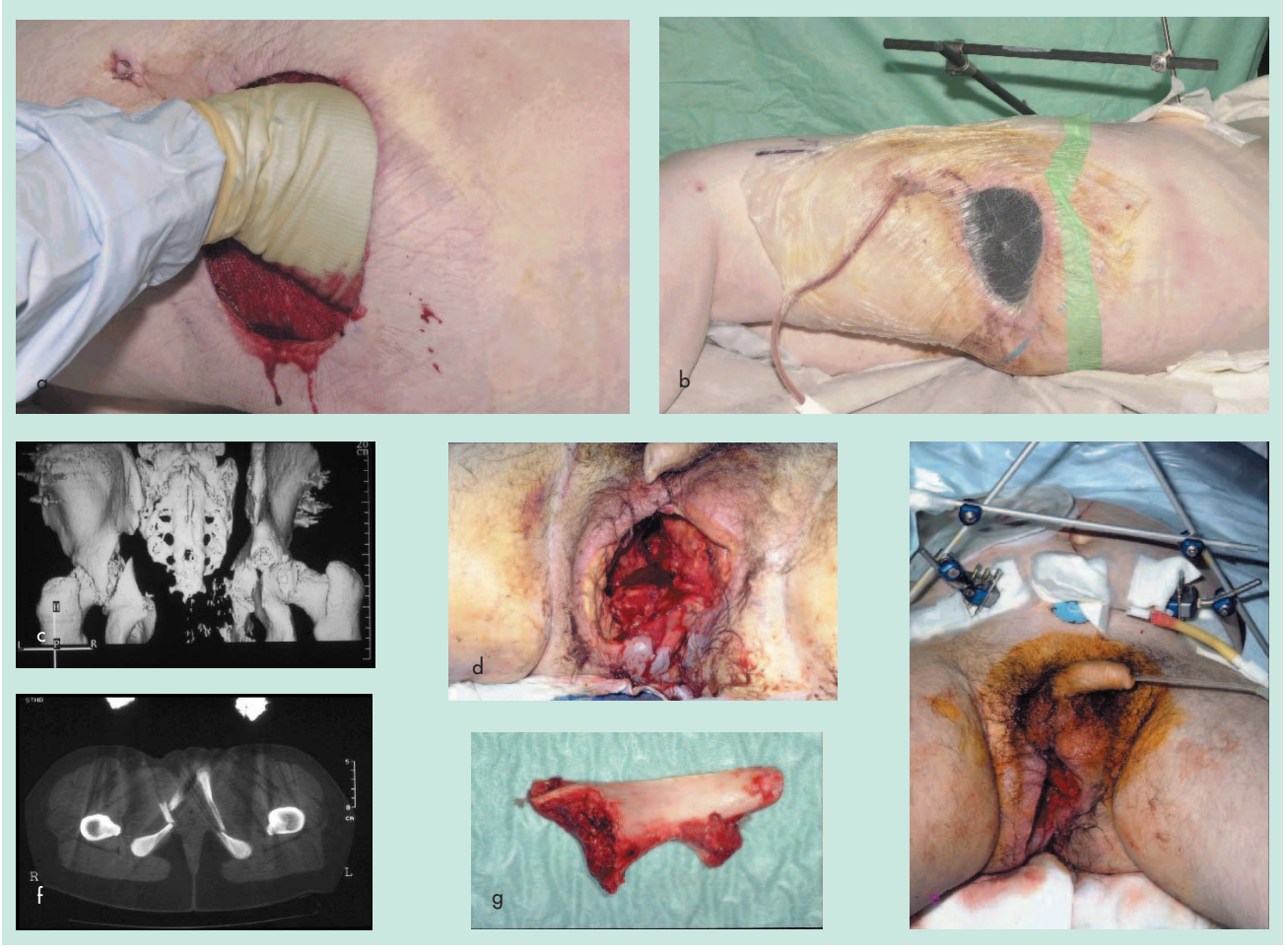
injuries for long enough to present in a hospital emergency department are more likely to succumb to sepsis than haemorrhage. These injuries may be obvious at the most extreme end of the spectrum but many are subtle and will only be identified following a thorough and informed secondary survey. The following issues should be considered:

- Rectal examination
- Vaginal examination
- Examine the groin and perineum
- Turn the patient and observe posterior wounds (observing spinal stabilization protocols)
- Take small wounds seriously.

Considerable disruption of the pelvic soft tissues may occur with little external evidence. The skin facilitates quite remarkable elastic deformation before failing. A closed hemipelvectomy may therefore occur in the absence of a skin laceration. Disruption of a hollow viscus may still occur. Failure to identify and address this may prove fatal.

There are certain features of a pelvic ring disruption which may raise the index of suspicion. A greater degree of ligamentous disruption is more likely to be associated with disruption of a hollow viscus. A closed degloving injury of the skin through the interface between deep fascia and subcutaneous fat suggests either direct shear or indirect shear secondary to pelvic ring displacement. This phenomenon is known as the Morel–Lavelle lesion (*Figure 6*). Small skin lacerations in the groin, perineum or sacral region are often the tip of a degloving iceberg. Disruptions of the genitourinary tract are more common with severe lateral compression (Tile type B2) injuries. The recoil position of the affected

Figure 6. a. A Morel–Lavelle lesion of the left thigh. b. Debridement and suction dressing. c. A complex open pelvic ring fracture. d. Obvious disruption and widening of the perineum of the patient from 6c. e. Debridement, double-barrel colostomy, distal loop washout, urethral apposition and external fixator. f. A lateral compression 'tilt' fracture associated with a vaginal laceration and therefore technically an open fracture. g. The offending shard of devascularized bone was removed through the medical window of anilioinguinal approach and the vaginal tear was repaired following through debridement. In this case, an external fixator was applied in 'distraction mode' as the mechanism of injury is internal rotation.



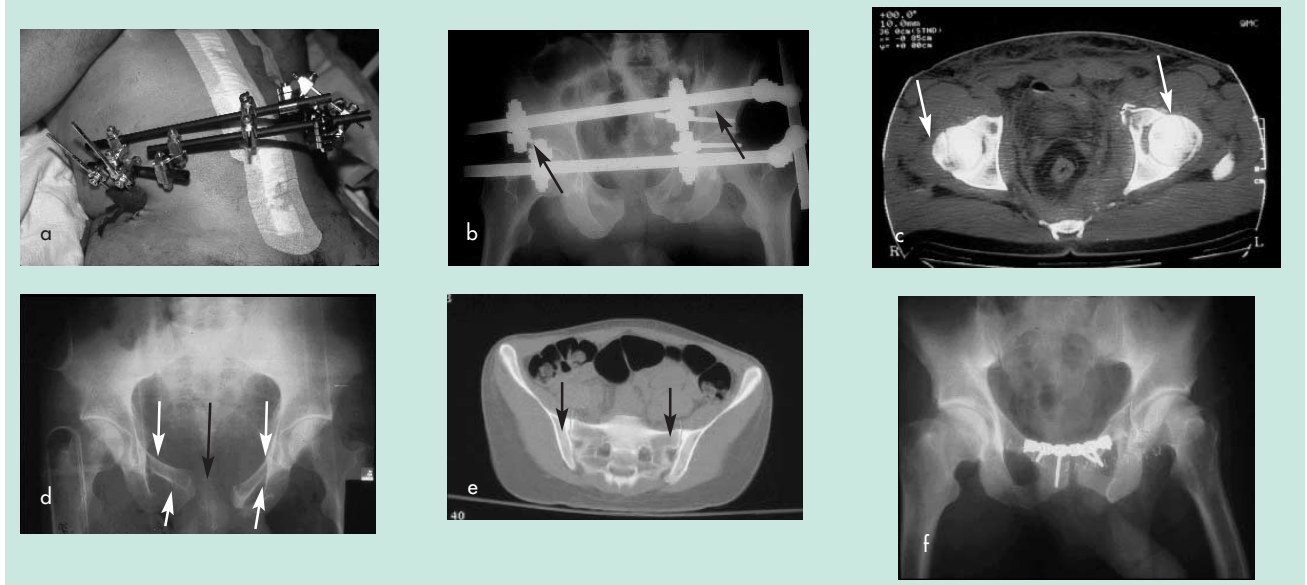


Figure 7. a. The preferred 'high' application of a pelvic external fixator device. b. The 'low' approach is to be avoided unless the technique is undertaken in theatre with image intensifier control. Note the bilateral femoral head penetration by the external fixator pins. c. A computed tomography scan confirms femoral head penetration by the external fixator pins. d. A pelvic 'pseudo-diastasis' (black arrow) may be misleading. The symphyseal diastasis is associated with fractures of all four pubic rami (white arrows). There is no disruption of the posterior pelvic ring and no external fixator is required. This fracture is typically caused by a motorbike's petrol tank. It is not usually associated with haemorrhage. e. A computed tomography scan confirms that no disruption of the posterior pelvic ring has occurred. f. A pseudo-diastasis may be treated with an anterior reconstruction plate in order to restore normal anatomy. The application technique is outlined in **Table 2.**

hemipelvis on the trauma room radiograph may belie the degree of displacement at the time of impact.

Urethral injuries are much more common in males than females as discussed above but vaginal lacerations are associated with pelvic ring injuries, particularly with the so-called 'tilt fracture'. The pelvis may therefore have sustained an open injury as a result of either disruption of the skin or a hollow viscus. The management of such injuries follows exactly the same principles as those of any other open fracture but there are, in addition, certain special requirements. It is mandatory in the presence of an anorectal disruption to defunction the bowel. This requires a double-barrel colostomy with distal colonic irrigation in order to clear residual faecal matter. The proximal bowel thus forms a faecal fistula and the distal bowel a mucous fistula. There is no place for the so-called 'loop' colostomy. The requirements for urinary tract disruption do not differ from those listed above.

Antibiotic prophylaxis is no substitute for adequate debridement but should cover the appropriate spectrum of organisms, including those from the skin, urinary tract and bowel. Antitetanus prophylaxis should be reviewed and implemented if required. A relative indication for defunctioning of the bowel is an open wound in and around the perineum, groin and sacral area. Avoid operating through a Morel–Lavelle lesion. A thorough debridement should be carried out as soon as possible and in any case within 6 hours of the injury. The aim is a clinically clean wound, devoid of devital-

TABLE 2.
Guidelines for the safe and effective application of a pelvic external fixator device

A 'pins first' technique is recommended
Remember that the iliac crest may not be in the anatomical position. It may be vertically displaced and either internally or externally rotated according to the mechanism of injury
The pelvis should first be reduced by internally rotating the legs and applying a pelvic belt at the level of the greater trochanters. Traction should simultaneously be applied where appropriate by means of a Denheim skeletal traction pin, sited just distal to the level of the tibial tubercle. These techniques will avoid problems caused by tenting of the skin
The operator should place an index finger and thumb on either side of the iliac crest to assess orientation and tension the tissues. Apply the Schanz pins or equivalent through a percutaneous approach using a sheath and drill guide technique. Avoid longitudinal incisions and laddering resulting from transverse 'release' incisions
Perforate only the cortex of the iliac crest with a drill and then apply a Schanz pin with minimal pressure through the sheath, using a 'Quick-Chuck' and allowing the pin to find its own way between the inner and outer tables
Two pins are generally adequate and should gently converge in the thick bone of the gluteal ridge in both the anteroposterior and lateral planes from entry points just anterior and posterior to the ridge
An appropriate external fixator device should then be applied using an 'A' frame construct and should allow independent pin placement.

ized tissue. Debridement should continue until this has been achieved. Use of proprietary suction dressings is recommended as these allow the wound to be sealed and remove cytotoxic exudate, allowing healthy granulation tissue to form. They also encourage contraction of the wound and should be changed regularly. Debridement must be repeated until safe delayed secondary closure is possible or until it is appropriate to consider plastic surgical interventions such as split skin grafting, local flaps or free tissue transfer with microvascular anastomosis. The plastic surgery team should be involved in wound assessment on the first day of management. In common with other open fractures, the soft tissue injuries are much better managed with stable skeletal fixation. An external fixator (*Figure 7*) may be appropriate for the initial debridement phase but is biomechanically inferior.

With respect to external and internal fixation devices, McBroom and Tile (1982) demonstrated that an anterior frame construct achieve an ultimate load to failure of < 40N, whereas two anterior plates with percutaneous sacro-iliac screws achieve an ultimate load to failure of >2000 N.

CONCLUSION

This article has outlined safe practice for the acute management of bleeding, urological injuries and open wounds in association with pelvic fractures. It is not intended to be comprehensive but reflects the experience of a large tertiary referral unit. HM

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KEY POINTS

- Haemorrhage associated with pelvic fractures is predominantly of venous and osseous origin.
- Haemorrhage may be controlled by reducing pelvic volume. Techniques include a pelvic belt, traction and application of an external fixator device. Pelvic packing may be applied in extremis.
- Angiography plays a valuable role in the management of arterial bleeding but is not indicated in the haemodynamically unstable group who do not respond to resuscitation.
- Intraperitoneal rupture of the urinary bladder requires operative repair. Extraperitoneal rupture may be managed non-operatively.
- Rupture of the prostatomembranous urethra may be safely managed by the 'apposition technique' in association with internal fixation of the pelvic ring injury.
- Open pelvic fractures involving the anorectal canal require a mandatory defunctioning end colostomy and mucous fistula with distal loop washout.

Conflict of interest: none.

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