■ REVIEW ARTICLE

An unstable pelvic ring

THE KILLING FRACTURE

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An unstable pelvic fracture may be life threatening and can be seen as 'the killing' fracture. Even if this is the only injury, it may be a serious problem. In the initial management of this type of fracture, the principles of advanced trauma life support (ATLS)¹ must be observed, with management of the airway and control of breathing as the primary aims, while protecting the cervical spine. Many of these patients have multiple injuries and require definitive control of the airway, mechanical ventilation and drainage with a thoracic tube.

Attention must be paid to signs of hypovolaemic shock. This can be a silent killer, as 30% of the blood volume (up to 1500 ml in a 75 kg adult) will be lost before hypotension is noted. Loss of up to this volume from bleeding may only cause tachycardia. If there is hypotension with a systolic blood pressure of 90 mmHg or less, at least 1500 to 2000 ml of blood loss has occurred. Adequate access to the venous system for transfusion and fluid replacement must be achieved in the first hour of management.

The primary assessment must focus on possible sources of bleeding, such as external blood loss and internal bleeding in the thorax, abdomen or retroperitoneal space, including disruption of the pelvic ring and multiple long-bone fractures, especially of the femoral shaft. Physical examination of the thorax will reveal conditions such as a tension pneumothorax or a massive haemothorax, but the abdomen is more difficult to assess.² An anteroposterior (AP) radiograph of the thorax and abdominal ultrasonography should be undertaken without delay. Ultrasonography is a reliable indicator of massive intra-abdominal bleeding, which will necessitate direct surgical intervention by emergency laparotomy.³

The pelvic rock manoeuvre can demonstrate clinical instability of the pelvic ring, especially when the instability is gross, but an apparently normal examination does not exclude severe pelvic injury. Therefore, an AP view of the pelvic ring should be included in the primary survey

in all patients with blunt trauma who have signs of hypovolaemic shock.

The treatment of choice in hypovolaemic shock is control of the bleeding. In the ATLS concept, the simple statement of 'early surgical consultation' does not reflect the complexity of the control of bleeding due to pelvic ring disruption. In severe pelvic injury there is a high incidence of combined intra-abdominal trauma, which will influence the therapeutic strategies to be followed.⁴ After exclusion or control of the intra-abdominal bleeding, it must be determined whether the pelvic bleeding is located in the anterior or the posterior part of the ring, whether it is mainly from the fracture site and whether it is venous or arterial.

Systemic adverse effects such as hypothermia, metabolic acidosis and clotting disturbances, which are not uncommon in polytraumatised patients,⁵ must be considered as they may play a major part in the therapeutic strategy. In such extreme cases, the concept of damage control surgery should be followed.^{6,7} After initial life-saving procedures with control of the bleeding in the acute phase, the second phase in the intensive care unit requires that all the physiological parameters mentioned above be adequately stabilised, followed by the third phase of definitive treatment. This three-phase approach significantly improves the mortality rate in the severely injured.⁸

Mechanism of injury and type of fracture

Although in the elderly a low-energy impact in osteoporotic bone can result in complex pelvic fractures, in most cases a high-energy impact is needed to disrupt the pelvic ring.

Tile^{9,10} classified these injuries into three groups: type A, stable fractures, type B, rotational unstable fractures with partial stability of the posterior pelvic ring and type C, in which there is a complete disruption of the anterior and posterior pelvic rings. Therapeutic interventions to stabilise the pelvic ring can be tailored to the degree of instability.

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©2006 British Editorial Society
of Bone and Joint Surgery
doi:10.1302/0301-620X.88B4.
16693 \$2.00
J Bone Joint Surg [Br] 2006;
88-B:427-33.

Fig. 1a

Fig. 1b

Fig. 1c

Use of internal rotation of the legs and a pelvic-wrap device in the emergency room. a) clinical application directly in the emergency room, b) anteroposterior (AP) view of the pelvis: type B open book injury with severe disruption of the symphysis pubis and c) AP view of the pelvis: closure of the book after application of the wrap (on urethrography no leakage is seen).

The type of fracture and the magnitude of the initial displacement can be related to the severity of hypovolaemic shock, but massive bleeding can occur in any type of fracture.¹¹ Although plain radiographs can lead to the sus-

pected location of the major source of bleeding, sites of posterior haemorrhage vary widely.¹² In an AP compression injury with an open book configuration (type B2), bleeding within the enlarged volume of the pelvic cavity

Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Use of the C clamp. a) clinical application directly in the emergency room, b) anteroposterior (AP) view of the pelvis: type C injury with disruption of the symphysis pubis, pubic fracture and a posterior sacral fracture with moderate displacement and contralateral sacroiliac disruption, c) AP view of the pelvis: reduction of the fracture with the C clamp, and d) CT scan of the pelvis: direct compression of the posterior pelvic ring by the C clamp.

will almost certainly have a venous origin, but arterial bleeding cannot be excluded. With a lateral impaction injury (type B1), the pelvic ring is usually clinically stable, with impaction of the posterior ring and a fracture of the pubic arc. There may be anterior venous bleeding from the fracture site, as well as arterial bleeding if there is complete disruption of the pelvic floor. Shearing forces that result in a complete unstable type C fracture can result in bleeding from the posterior as well as the anterior part of the pelvic ring.

Pelvic wrap

As shown in Figure 1, a pelvic wrap is a simple non-invasive means of obtaining external stabilisation of the pelvic ring.^{13,14} In an incomplete unstable type of fracture, such as an open book injury, internal rotation of the legs, if intact, will reduce the volume of the pelvic cavity and significantly improve the clinical condition. Such a device can be useful before the patient reaches hospital where there are clinical

signs of hypovolaemic shock and clinical suspicion of instability of the pelvic ring.¹⁵ In the emergency department the only delay in the use of such a device will be when an injury to the vertebral column cannot be excluded within the first few minutes. A log-roll manoeuvre is then needed to place the pelvic wrap under the patient's body.

C clamp

In Figure 2 the clinical use and principles of the C clamp (Synthes, Solothurn, Switzerland) are demonstrated. An AP view of the pelvis is needed to exclude a transiliac fracture. In these cases, insertion of the fixator pins will result in penetration of the pelvic cavity instead of prompt stabilisation of the pelvic ring with direct posterior compression. The use of this method has been shown to have a good effect on hypovolaemic shock in the early phase.¹⁶⁻²⁰ External devices such as the C clamp should be available in the emergency department, as in hypovolaemic shock due to pelvic ring disruption, immediate attempts at stabilisa-

tion are mandatory and a decision to use pelvic compression should be made immediately after the primary assessment.

External fixation

In the acute phase many advocate external fixation as a temporary device to achieve stabilisation of the fracture and a positive effect on haemorrhage.²¹ For placement of the pins in the anterior ring, other sites as well as the usual ones on the iliac crest should be considered. Placing the pins in the supra-acetabular bone improves stability and is safe if insertion is carried out under fluoroscopic guidance.²²

Definitive control of fracture-dislocation by a frame is insufficient in a complete unstable fracture^{23,24} and should be combined with fixation of the anterior arch.²⁵

Anterior approach with peri-pelvic packing

The concept of damage control surgery can be applied to orthopaedics when, in the acute and first stage of treatment, a minimally-invasive approach should focus exclusively on life-saving procedures. There is no place for extensive surgery and definitive fracture care. Stabilisation of the fracture should be carried out without loss of time and through minimal exposure. In a non-complex symphyseolysis, simple open reduction and plate fixation is easy even in inexperienced hands.²⁶ Pelvic packing and stabilisation of the pelvic ring will result in effective control of haemorrhage when the major source of bleeding is the fracture site or the bleeding is venous in origin. Even in severe bleeding with arterial involvement some advocate this approach as the treatment of choice.¹⁶

Techniques of posterior fixation in an emergency

Although involvement of the iliac bone, sacroiliac subluxation and fractures of the sacrum can be suspected on the emergency AP radiograph of the pelvis, classification of posterior fractures requires a CT scan. Definitive fixation of the posterior ring needs an extensive pre-operative work-up and in most acute cases optimal stabilisation cannot be carried out safely. Exceptionally, in experienced hands a minimally-invasive technique with percutaneous screw fixation can be carried out for sacroiliac subluxation, as closed reduction is often possible.

If the fracture can be accurately identified by CT scanning in the early phase, optimal definitive fixation can be planned, provided an experienced surgeon is available 24 hours a day. Therefore, external fixation still plays an important role in acute care, especially if combined with adequate fixation of the anterior ring. Manipulation of the pins outwards ('opening the book') will result in compression of the posterior parts of the ring and some control of bleeding from the fracture site.

CT scan

Accurate identification of fractures of the pelvic ring requires CT scanning.²⁷ In anterior fractures, standard AP

radiographs, together with inlet and outlet views, will provide information about the suspected instability.

A CT scan also gives useful information about sources of bleeding both intra-abdominally and in the retroperitoneal space. Extension of a retroperitoneal haematoma indicates the need for accurate embolisation,²⁸ but if an arterial blush is seen on the CT scan, this is a very reliable predictor for sources of active arterial bleeding.^{29,30} Arterial leakage on a CT scan is clearly demonstrated in Figure 3a.

Selective angiography and embolisation

In patients with an initial response to volume replacement, radiological intervention by selective angiography offers a non-invasive method of treatment that may remove the need for surgical intervention. This is demonstrated in Figures 3b and 3c. In cases with a positive abdominal ultrasonography for blood loss, or retroperitoneal haematoma due to renal injury, angiography also offers possibilities for selective embolisation of the liver, spleen and kidney.^{31,32}

Non-selective occlusion of the aorta is a promising new development in cases where time is at a premium because of persistent hypovolaemia. CT-guided aortic occlusion provides fast and effective control of bleeding immediately after completion of the diagnostic CT scan. The procedure can be combined with other specific emergency surgical or interventional procedures.³³

Definitive fracture care

Definitive management of the fracture is related to the degree of instability. Clear indications for stabilisation of the pelvic ring are exceptional in type A fractures; stabilisation of the anterior ring is in most cases sufficient for type B fractures and combined posterior and anterior stabilisation is necessary in type C fractures.^{34,35} However, concomitant soft-tissue injuries may result in scar formation, which may be the source of long-term clinical impairment even after anatomical reconstruction of the osteoligamentous structures.³⁶

Although external fixation is still the definitive treatment in selected cases,³⁷ internal fixation in both the anterior and the posterior parts can be achieved by minimally-invasive techniques.³⁸⁻⁴⁰ Even in childhood, percutaneous sacroiliac screw fixation is a useful alternative in early treatment, compared with open techniques.⁴¹ The functional results in the long term seem to be better in patients treated with internal fixation of both the anterior and the posterior pelvic ring than with external fixation or conservative treatment.⁴²

New developments in computer navigation appear to be promising in the placement of screws in the sacroiliac and pubic regions.⁴³ In transforaminal fractures, however, sound compression osteosynthesis with a sacroiliac lag screw cannot be carried out safely, as neurological impairment can cause significant morbidity. In these cases experimental studies have shown increased stability when the fifth lumbar vertebra is included in a triangular reconstruction.⁴⁴ No clinical series has yet been published of patients

Fig. 3a

Fig. 3b

Fig. 3c

Selective angiography and embolisation of active arterial bleeding in a polytrauma patient with a pelvic ring injury and a transient response on volume replacement and a pelvic wrap. a) emergency CT evaluation showing an arterial blush directly ventral to the right sacroiliac joint, b) selective angiography demonstrating active bleeding, and c) after selective embolisation: no further signs of active bleeding are seen.

with primary optimal stabilisation allowing full weight-bearing and mobilisation.

In the care of acute fractures these time-saving and optimal minimally-invasive techniques for both anterior and posterior parts of the pelvic ring will not always be available safely, as experience is needed to apply them. Hence the emergency care of pelvic disruption and definitive fixation of the pelvic ring can be seen as a staged reconstructive procedure.⁴⁵

Discussion

The clinical pathways in haemodynamically unstable patients with pelvic ring disruption have been described by several authors.⁴⁶⁻⁴⁸ A systematic approach related to clinical outcome has shown improved results with the introduction of abdominal ultrasound in the diagnostic work-

up, an aggressive surgical approach and advances in radiological intervention. Although embolisation has increased in popularity during the last decade, especially in fractures giving an enlarged volume of the pelvic cavity, primary surgical treatment remains the strategy of choice.^{49,50} Some advise a primary radiological approach, if sources of intra-abdominal bleeding and persistent signs of shock necessitating laparotomy are excluded.^{51,52} When free intra-abdominal fluid is demonstrated by ultrasonography it is rarely caused by retroperitoneal bleeding, but is due rather to concomitant intra-abdominal injury. Therefore, the role of abdominal ultrasound and laparotomy should be carefully considered.⁵³ Figure 4 presents a clinical pathway with simple guidelines.

One of the major factors influencing the clinical pathway is the trauma profile of the facility receiving the patient. An

Fig. 4

Algorithm for patients with hypovolaemic shock and pelvic ring fracture.

overview of a large region of the United Kingdom revealed that appropriate care within the first hour was available in only eight of 31 hospitals. Therefore, triage by well-trained paramedics or mobile medical teams in the pre-hospital phase should result in the correct choice of hospital to which the patient should be taken for definitive care. In The Netherlands such a system, with ten Level 1 trauma centres and a helicopter emergency medical service, was implemented in 1999.^{54,55} The care of the severely-injured, especially those with blunt trauma and complex pelvic injury

with shock, should be concentrated in Level 1 centres, which have experience in this type of surgery.

An additional problem in the multidisciplinary management of these patients is that in many countries the management of abdominal injury according to damage control principles is carried out by general surgeons, sometimes specialised in trauma care. Pelvic injury is classified as an orthopaedic problem and treated by orthopaedic surgeons, who are not always familiar with the concept of damage control surgery.⁵⁶ Concomitant injuries such as urogenital

and anorectal trauma also require an aggressive surgical approach. Although in The Netherlands and some other European countries the surgeon in a Level 1 trauma centre is a specialist with experience in the fields of both abdominal injury and pelvic fractures, optimum communication and the involvement of many others is mandatory in order to achieve the best outcome.

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