(iii) Management of open pelvic fractures

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Summary

Open pelvic fractures are potentially devastating injuries. Although rare, they are frequently associated with other system injuries. Their early, aggressive and multidisciplinary management has contributed over the years to reduced mortality rates. This review article is focused in the current concepts of the management of these fractures and their outcome.

Introduction

Pelvic fractures account for approximately 3% of all skeletal fractures and their associated mortality ranges from 10% to 16%.1–5 They range from low-energy stable fractures to high-energy unstable ones and they can be classified as closed and open (2–4% of all pelvic fractures in adults).1,6–10

In children, the bone, cartilage and joints of the pelvis are more pliant and they can provide a significant buffer for energy absorption. The fractures are more frequently sustained at the chondro-osseous interface than on the bony parts of the pelvis (50% of the osseous pelvic ring fractures in children are ramus fractures with most of them being unilateral and primarily involving the superior ramus).11

By definition, an open pelvic fracture is a fracture that communicates with the rectum, vagina or the environment through a break in the skin. They usually result from a high-energy trauma from either direct or transmitted forces.12 The adult patients are usually males involved in road traffic accidents.1,8 Falls, crush injuries and penetrating trauma are less frequent causes.8,13

Classifications describing the variety of pelvic fractures patterns include the original Pennal classification modified by Tile in 198814 and the Young–Burgess classification.15 Recently, one comprehensive classification by Bircher and Hargrove (awaiting validation) was proposed for the classification of open pelvic injury patterns.16 The mortality rate following open pelvic fractures was as high as 50% in the 1970s and 1980s, being then significantly higher than the 10–15% mortality of closed pelvic fractures.9,10,17,18 In the early 1990s, there was an improvement in the management of these injuries and the mortality dropped to 25–30%, although some authors described mortality rates as low as 5%.6,19
Several factors have been shown to influence mortality including age, injury severity score (ISS), pelvic instability, size and status of the wound, presence of rectal injury, number of blood units transfused and other associated injuries.\textsuperscript{1,7–10,20–22} The overall ISS in open pelvic fractures ranges from 25 to 48.\textsuperscript{1,6–8,20,23–25} Only one direct comparison of the ISS in open and closed pelvic fractures is available in the literature and no significant difference was found.\textsuperscript{1}

The overall improvement of the mortality in open pelvic fractures could be attributed to the advances made in modern critical care medicine, the implementation of early multidisciplinary protocols, the aggressive fracture stabilization and selective faecal diversion.

Emergency management

The initial assessment and management of these patients should be carried out according to the ATLS protocol\textsuperscript{26} with special attention to be given to the haemodynamic parameters (Fig. 1). The resuscitation should be aggressive, with intravenous fluids, blood products and clotting factors.\textsuperscript{27} Brenneman et al. reported that in open pelvic fractures (because of the loss of tamponade effect) patients need four times more blood during the first 24 h than in the closed ones.\textsuperscript{1,7} If possible, a swab and a photograph of the wounds should be taken initially and a sterile pressure dressing with antiseptic solution should be applied in order to reduce the blood loss, primarily, and the risk of infection.\textsuperscript{1} Before radiological assessment, two steps will guide further management\textsuperscript{28}:

- The haemodynamic status of the patient.
- A single bimanual compression-distraction of the pelvis should assess the mechanical instability.

An anteroposterior plain radiograph will help identify the fracture pattern and the stability of it.\textsuperscript{26,29} In case of a haemodynamically unstable patient, an abdominal ultrasound scan or a diagnostic peritoneal lavage could contribute to the diagnosis of the source of bleeding. Because of the higher energy related to open pelvic fractures, intraabdominal injuries have a higher incidence than in closed ones.\textsuperscript{8,25,30,31}

If the patient remains in an unstable haemodynamic condition and the abdominal or chest cavity have been excluded as the source of bleeding, urgent temporary stabilization of the pelvis is indicated. The venous tamponade effect can be obtained by different means, including: application of a circumferential sheet, pelvic binder, internal rotation of both legs, traction of the lower limbs, and application of an external fixator or the C-clamp.\textsuperscript{9,32–35}

Assessment of osseous and ligamentous structures

In most cases, the anteroposterior plain radiograph can identify the ligamento-osseous injuries and can provide information about pelvic stability. If the patient is haemodynamically stable, inlet (beam directed caudad at 60°), outlet (beam directed cephalad at 45°)\textsuperscript{36} and Judet (iliac and obturator oblique) pelvic radiographs will help more with the fracture identification.

As open pelvic fractures are high-energy fractures and other organs and soft tissues are involved, a computed tomography scan (CT scan) is used for the assessment of pelvis in the haemodynamically stable patients; osseous and soft tissue windows are used as well as 3D reconstruction of the pelvis.\textsuperscript{37} Extraluminal gas, haemorrhage or bowel wall thickening will help in the assessment of the intestinal injuries. Vaginal lacerations or previous diagnostic peritoneal lavage can provide false positive results and should be taken into account.\textsuperscript{38–42}

Also, independently of the patient’s consciousness, it must not be neglected the assessment of all four limbs, thorax and spine is essential in order to identify any fractures that will need immobilization and could influence the decision making process.

Depending on the available publications, the distribution of the type of open pelvic fractures is type B\textsuperscript{5,43} or type B and C with an equal distribution amongst them.\textsuperscript{1} The incidence of associated acetabular fractures in unstable open pelvic fractures ranges between 40% and 60%.\textsuperscript{1,24}

The presence of a pelvic fracture in a child, particularly if displaced, assumes even more clinical significance. During the initial assessment of paediatric pelvic fractures, one must be more aware of the intraabdominal and intrapelvic injuries rather than the osseous injuries that are of a secondary importance.

Assessment of the soft tissue injury

Two systems can be used for this assessment:

- The Gustilo—Anderson classification for the extent of the soft tissue injury.\textsuperscript{44,45}
Management of open pelvic fractures

Figure 1 (a) Management of open pelvic fractures. (b) Forty-five year old female sustained an APII open pelvic fracture following a motor cycle accident. (c) Following debridement and diverting colostomy the fracture was stabilized with an external fixator.
The site of the soft tissue injury classified as Zone 1 (perineum, anterior pubis, medial buttocck, posterior sacrum), Zone 2 (medial thigh, groin crease) and Zone 3 (posterolateral buttock, iliac crest).1,46

Because of the forces applied during the accident, most of the open pelvic fractures are Gustilo type III8 and most of the wounds are situated in the perineal region, Zone 1.1,12,25

A high level of suspicion is necessary because missed injuries are not uncommon. Inspection of the soft tissues both anteriorly and posteriorly is essential.38,39,47

Rectal injuries
Their incidence varies from 17% to 64%.6–8,23–25 They can be assessed first by inspection and secondly by digital examination (anal sphincter tone, contents of the rectal ampulla, blood on the examination glove, rectal wall weakness). Cases of assessment by sigmoidoscopy and rectoscopy had already been described and rigid sigmoidoscopy has already been suggested as a mandatory investigation.41

Urogenital tract injuries
They have an incidence from 23% to 57%.6–8,23–25 Urethral and vaginal injuries are the commonest.33 Vaginal lacerations result from either penetration of a bony fragment or from indirect forces from diastasis of symphysis pubis.53 Delayed diagnosis is associated with mortality and infections.50,53 Injuries to cervix, uterus and ovaries are rare.23,54 Inspection of the external genitalia is the first action to take and then a more meticulous digital examination can reveal lacerations, blood at the external urethral meatus, a high riding prostate, perineal haematoma, haematuria and vaginal bleeding. Any of these findings or the inability to urinate in association with an anterior pelvic ring fracture should be an indication for a retrograde urethrogram52,55–57 and a cystogram should follow through an eventual suprapubic catheter if a urethral injury has been diagnosed. In this way we can assess both the urethral and bladder integrity.

Sepsis control
The same principles of open fracture management of the extremities apply in the pelvis as well. A swab for microbiological examination and a photograph of the wound (for later decision-making, without re-exposure of the wound) can be taken initially, independently of the haemodynamic status of the patient. Once the patient is stable, a meticulous irrigation can be instituted and the wounds should be packed open in order to prevent the development of gas gangrene.

Broad-spectrum intravenous antibiotics against aerobic and anaerobic organisms can be administered. At a later stage, after the microbiological sensitivity testing, the antibiotics can be adjusted accordingly.9,12,58 Also, the antitetanus vaccinal status of the patient should not be neglected.

The perineal wounds must be judged (because of their location) for the potential to contaminate the fracture site and/or a retroperitoneal haematoma. The presence of a rectal laceration is an absolute indication for urgent diverting colostomy (end or loop colostomy) with rectal washout. Most centres now accept that a distal loop washout is appropriate as soon as practical.

Urethral injuries generally are managed conservatively, by primary realignment or suprapubic catheter insertion. In case of intraperitoneal bladder rupture, direct repair is undertaken whereas extraperitoneal bladder ruptures are often managed by urethral catheter drainage alone. Suprapubic catheters should be discouraged if surgery for anterior pelvic ring injury or acetabular fracture repair will be undertaken.

Surgical management
A multidisciplinary team approach is needed as the surgical management includes wound irrigation and debridement, fracture stabilization (temporary or definitive), laparotomy for repair of any intrapelvic and or intraabdominal injury, repair of urogenital injuries and plastic surgical techniques for covering of the soft tissue defects.

In cases where ongoing haemodynamic instability is encountered, pelvic packing can complement the external fixation. It is effected through a lower abdominal laparotomy, adjusted to the pelvic wound. Packs have to be inserted in the prevesical and presacral spaces and have to be removed or changed within 48 h.2,23,59 In cases of large vessel bleeding, operative control of haemorrhage should be considered. For such patients, being in extremis clinical condition, clamping of iliac vessels or distal aorta can be performed.59 The aortic clamp should be placed below the L3 level as the Radicularis Magna Artery, communicating with the Spinalis Anterior Artery, emerges from the aorta between T12 and L3 level.

Another adjunct to haemorrhage control (when fracture stabilization is insufficient) is the angio-
Split or full thickness skin grafts are used as well as approximately 10% of cases.\(^3^4,5^9\) Time consuming and can be performed in only bleeding is suspected. However, this technique is graphic embolization in cases where arterial complications.\(^2^,2^7,3^2,7^9\)

The initial fracture management of the patient assuming that end points of resuscitation have been achieved will depend on the location of the soft tissue injury and the degree of contamination. The plan for the definitive stabilization should be effectuated according to the principles of “damage control orthopaedics”.\(^6^3-6^6\)

Temporary stabilization can be achieved as previously stated with either an anterior external fixator or a C-clamp.\(^6^7-7^3\) Application of an external fixator involves two to three pins inserted in each iliac crest, a simple frame is constructed and is generally turned down in order to permit the general surgeons to perform a laparotomy if needed.\(^3^5,7^4,7^2\) In unstable patterns, skeletal traction could supplement the external fixator in order to prevent shortening or malrotation of the hemipelvis.

Definitive stabilization in closed pelvic fractures with internal fixation is recommended between the third and seventh day post-injury. In open fractures, the timing is not adequately covered and fixation techniques are controversial. Traditionally, only external fixation has been used\(^7^6,7^7\) but there are authors publishing good results after internal fixation\(^2^4\) or suggesting internal fixation when there is no gross contamination of the fracture site.\(^2^8\) In comminuted iliac wing fractures, early open internal fixation is preferred since external fixation cannot be applied.\(^7^8\) Combinations of internal and external fixation have been also described by Leenen et al.\(^2^4\) and percutaneous internal fixation has been used for open fractures with less complications.\(^2^,2^7,3^2,7^9-8^4\)

The surgical treatment of pelvic fracture wounds includes extensive irrigation, debridements (up to healthy tissue with capillary bleeding) and removal of foreign bodies and bony fragments. For the washout, either free flow or pulsed lavage techniques can be used. The wounds can either be left open or vacuum-sealed dressings can be used in order to drain them. A second look, with or without closure, should be done after 48–72 h.\(^2^8,4^3,7^8,8^5-9^0\)

The possibility of a compartment syndrome associated with the above-mentioned injuries should not be neglected. The major pelvic compartments are the iliopsoas, the gluteus maximus and the gluteus medius/minimus. Measurement of their pressure is mandatory.\(^9^1\) Plastic surgical techniques can be undertaken in order to treat these wounds and eliminate dead spaces.\(^1^2,9^2-9^4\) Split or full thickness skin grafts are used as well as suction drains, vacuum-sealed drainage or free flaps.

Diverting colostomy (end or loop)\(^1,4^3,9^5,9^6\) or ileostomy with washout of residual rectal faeces\(^7^5,9^6\) is a widely accepted treatment for all open pelvic fractures, with rectal, vaginal and perineal wounds.\(^1^0,1^8,1^9,2^5,2^3,4^6\) Perineal wounds also require early sphincter repair.\(^2^9,8^3\) When placing the stoma, we should bear in mind the eventual location of any orthopaedic incision, suprapubic catheter and external fixator pins.\(^4^6,9^7\)

With this technique, both pelvic sepsis and the related mortality are reduced\(^1,4^3\) although in Woods et al. study, the incidence of local infection was not necessarily reduced by the selective colostomy and he suggested that only patients with extensive soft tissue injury might benefit from it.\(^9^8\)

The colostomy is traditionally taken down and the continuity restored 6 weeks to 3 months after the injury.\(^9^9,1^0^0,1^0^1\) Recently, the trend is to rely on the patient’s condition and reverse the colostomy early.\(^9^5,9^6\) But, until now there are no clinical studies available evaluating the ideal timing. The restoration of continuity has an important rate of complications and therefore awareness of the patient with regards to this issue is of paramount importance.\(^1^0^1-1^0^4\)

In case of vaginal lacerations, surgical repair with absorbable sutures, in order to prevent abscess formations, is indicated.\(^5^3,1^0^5\) Care must be taken not to injure the uterine arteries laying along the lateral borders of the vaginal vault.

Early assessment of urethral or bladder injuries is essential,\(^1^0^6-1^0^8\) as previously stated using a retrograde cysto-urethrogram. If a partial or complete tear is present, a suprapubic catheter needs to be inserted in order to ensure and measure the urinary output and prevent sepsis from infected urine.\(^3^5,9^7,1^0^9\) If possible, early realignment is considered today as the choice of treatment.\(^1^1^0\) Delayed end-to-end repair is undertaken 3 months post-trauma and generally a transperineal approach is used.\(^7^3,1^1^1-1^1^4\) The intraperitoneal rupture of the bladder is an emergency and has to be treated surgically.\(^1^0^9\)

**Complications**

Complications following open pelvic fractures can be classified as early and late ones. The early complications include perineal intraoperative injury (from prolonged traction against a pudendal post),\(^6^0,1^1^5,1^1^6\) paralytic ileus, deep vein thrombosis and pulmonary embolism (2–10%).\(^5^8\)
acute respiratory distress syndrome and multiple organ failure, infection (deep sepsis has an incidence of around 2%) and neurological injuries as a result of the initial injury or following the surgical procedure. The overall prevalence of neurologic injury in pelvic trauma, including temporary neurological injuries, is between 10% and 15%. Iatrogenic neurological injuries have an overall range from 3% to 10%. Sacral fractures and sacroiliac joint (SIJ) disruptions have a high prevalence of neurological injuries, including avulsion of the lumbar nerve roots, avulsion of the superior gluteal nerve, femoral nerve lesion, involvement of the obturator and sciatic nerves as well as cauda equina syndrome. The incidence of neurological injuries in sacral fractures is approximately, 6% for the Zone 1, 28% for the Zone 2 and 57% for the Zone 3. The diagnosis and evaluation of such injuries can be helped by nerve conduction studies and electromyography. The long-term prognosis depends on the level and degree of the nerve root involved.

Late complications include abdominal herniation, non-union/mal-union of the fractures (the incidence is around 3%, causing severe disability, complaints of constant pain, problems with sitting, leg-length discrepancy). Complex major operations are required and they are often associated with high co-morbidity. Chronic pain is present in approximately 30% of patients having had an unstable pelvic fracture. The pain is usually situated at the posterior SIJ and the lower lumbar spine. Calcification of the sacrotuberosous (ST) ligament after pelvic trauma can be another source of pain. Non-union and residual SIJ dislocation has to be excluded before attributing the pain to a calcified ST ligament.

Other complications that could present following open pelvic fractures include infections (perineal wound infection, pelvic abscess, sepsis, osteomyelitis), rectal incontinence and septic arthritis of the hip following rectal tear associated with pelvic fracture (rare).

Outcome

There is a lack of information in the literature regarding the long-term outcome of patients after open pelvic fracture. Assessment of patients with the SF-36 evaluation tool suggested some differences between closed and open pelvic fractures and long-term survivors require longer periods in rehabilitation. Brenneman et al. reported the outcome of 44 patients with open pelvic fractures after a 4-year follow-up. More than the half of them had chronic sequelae (urinary and faecal incontinence, impotence and dyspareunia) and slightly more than half of the employed ones returned to work. They scored worse on body pain, physical functioning and physical role scales compared to a closed pelvic fracture female group.

Fallat et al. described a good outcome in 8/15 patients and a fair outcome in 7/15 patients requiring assistance with their daily activities. Ferrera et al. described 2/6 women with genital injuries having minor dyspareunia.

In general terms, further studies are required to evaluate accurately the long-term outcome following open pelvic fractures.

Conclusion

Open pelvic fractures are frequently associated with other system injuries. They require an early aggressive multidisciplinary approach in order to reduce the mortality rate and improve the outcome.

Their management consists of an "early treatment phase" (external pelvic stabilization, pelvic packing, faecal diversion, wound/soft tissue management, urogenital injury treatment) and a "definitive treatment phase" (fracture stabilization according to the "damage control orthopaedic principles", definitive soft tissue management). Long-term complications could prevail including chronic pain, residual disability in physical functioning, incontinence, impotence, and dyspareunia.

References


