

Orthopedic Management of Pelvic Trauma

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Patients with a suspected pelvic fracture should be managed according to the principles of Advanced Trauma Life Support. The mechanism of trauma determines the pattern of pelvic lesions and the likelihood of associated injuries. The most common classification to describe pelvic lesions is the Young–Burgess system. This classification describes the radiographic images by analyzing the mechanism of injury that leads to predictable patterns of injury and displacement. It is useful in describing injuries and in helping guide both initial treatment and definitive fixation. The initial treatment in case of pelvic lesion is the application of a pelvic binder. An external fixator is recommended in hemodynamically unstable patients with unstable pelvic lesions to prevent further bleeding and to support measures of hemorrhage control. Definitive treatment of pelvic ring lesions requires anterior stabilization or a posterior fixation, or both, depending on the type of injury.

Keywords: *Pelvic Trauma; Hemorrhagic Shock; Pelvic Fracture; Pelvic External Fixator; Pelvic Osteosynthesis*

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INTRODUCTION

Patients with a suspected pelvic fracture should be managed according to the principles of Advanced Trauma Life Support (ATLS) [1].

The mechanism of trauma determines the pattern of pelvic lesions and the likelihood of associated injuries. In the case of pelvic fractures, it is crucial to ascertain the mechanism of trauma as it drives the assessment and management of the patient concerned [2].

For low-energy injuries, they usually occur in elderly osteoporotic patients as a result of falls from a standing height.

In contrast, the most common mechanisms of high-energy injuries are motor vehicle accidents, motorcycle accidents, pedestrian versus vehicle incidents, or falls from height. Associated injuries are very common. There is a high probability of concomitant hemorrhage and hypovolemic shock. Management of these lesions requires prompt evaluation and treatment [1,3].

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PHYSICAL EXAMINATION AND IMAGING

Primary inspection of the undressed patient should focus on pelvic asymmetry, differences in leg length, injured soft tissue around the pelvis to detect open wounds, swelling, contusions, or degloving (Morel–Levallè lesion), including the perineum to rule out urethral or vaginal bleeding, as well as the observation of potential differences in the color of the feet, which might be due to vascular impairments [2].

A significant leg length discrepancy in the absence of an obvious long bone fracture may indicate a vertically unstable and displaced pelvic fracture. In addition to identifying the regions of pain, pelvic instability should be assessed by clinical examination. The pelvic ring may be quite stable at the initial examination in lateral compression injuries [2,4].

In open book injuries, more severe rotational instability in the horizontal plane may occur with or without additional instability in the craniocaudal direction. The combination of rotational instability in the lateral and anterior posterior directions, as well as craniocaudal instability, is the most serious instability. Physical examination without fluoroscopy is not sensitive enough to detect minor instability, the presence of gross instability suspected for a severely unstable fracture may also be associated with significant bleeding. The stability of the pelvis is assessed by firmly grasping the iliac wings, pushing and pulling them apart and then back together [2]. Repeated maneuvers of stability testing should be avoided as these could increase or cause potential bleeding [4].

While the above-mentioned signs allow the examiner to detect mechanical pelvic instability, it remains

difficult to determine the severity of additional hemorrhage and blood loss and the extent of soft-tissue injuries. Immediate analysis of the primary hemoglobin concentration can be performed using capillary, venous, and arterial whole blood by bedside hemoglobinometry (photometry) [5,6]. Results are then available within 40 seconds. Our observations have shown that vital hemorrhage is possible at a primary hemoglobin concentration of 8 g/dL [7].

The inspection of capillary refill and palpation of peripheral pulses of lower extremities allow assessment of the vascular status. An abnormal capillary refill is defined as more than three seconds. A doppler examination of foot pulses should be performed in all suspected cases.

Neurological assessment of the lower extremities is mandatory and consists of an accurate sensory examination, testing of toe and foot extension, plantar flexion of the foot and knee extension, and patellar and Achilles tendon reflexes in the awake patient.

A connective patient warming system can be used to avoid hypothermia during the diagnostic phase [8,9].

An anteroposterior pelvic X-ray, without pelvic binder if the patient's condition allows it, is the first radiological assessment. As long as the patient is stable, an additional spiral computed tomography (CT) scan should be performed as early as possible, depending on the patient's general condition. This consists of a cranial CT, neck CT, chest, abdominal, and pelvis CT ("trauma scan") with 50 mL iodine contrast medium (Isovist) given 15 minutes before scanning. Inlet and outlet views are no longer taken as they can be reconstructed from the CT data set [10].

CLASSIFICATION

Imaging can be used to classify pelvic fractures and can be achieved using the Arbeitsgemeinschaft für Osteosynthesefragen (AO), Tile or Young–Burgess classification systems [11].

The most common classification to describe pelvic lesions is the Young–Burgess system [12]. This classification describes the radiographic images by analyzing the mechanism of injury that leads to predictable patterns of injury and displacement [12,13]. It is useful in describing injuries and in helping guide both initial treatment and definitive fixation (Figure 1).

Antero posterior compression (APC) injuries are more frequently defined as "open book" injuries. APC pelvic lesions are classified as more instable on a scale from 1 to 3. Symphysis disruption of more than 2.5 cm indicates disruption of the pelvic floor and the anterior sacroiliac ligaments. It is important to differentiate APC-1 injuries from APC-2 injuries; sometimes this is only possible by testing the patient's pelvis under fluoroscopy while they are under anesthesia (examination under anesthesia (EUA)). Stability is defined as more than 2.5 cm of horizontal displacement and 1 cm of vertical displacement

under stress. If the pelvis is stable on EUA, the injuries are treated non-operatively and the patient is allowed to weight-bear as tolerated. If, on the contrary, the pelvis is unstable on EUA, it needs anterior and posterior fixations with protected weight-bearing on the posteriorly injured side for up to 8–12 weeks [14]. Significant bleeding is frequently the most common cause of death in patients affected by displaced APC-2 and APC-3 lesions [13].

In lateral compression (LC) injuries, significant bleeding is likely, although less common, and it is typically the result of an arterial injury. The associated visceral lesions are the most frequent causes of death in patients with LC-type injury patterns. LC injuries are classified from 1 to 3 with each designation representing increasing instability. It is challenging for surgeons to predict which non-operatively managed LC fractures will result in symptomatic malunion based on static imaging [15].

Sagi et al. applied EUA to LC fractures. The authors developed a protocol consisting of surgical treatment of posterior pelvic ring injuries in the case of >1 cm of displacement for LC-1 lesions or any pelvic displacement for LC-2 and LC-3 injuries. After posterior fixation, further EUA is performed and anterior pelvic fixation is carried out in the case of anterior displacement of >1 cm [16].

In vertical shear (VS) lesions, the injury can involve ligaments, bone, or a combination of both; consequently proximal migration of one hemipelvis is the main characteristic of these lesions. Vertical shear fractures are typically very unstable.

In some cases, acetabular fractures can be associated. Here the treatment is tailored to the specific pattern of injury and displacement.

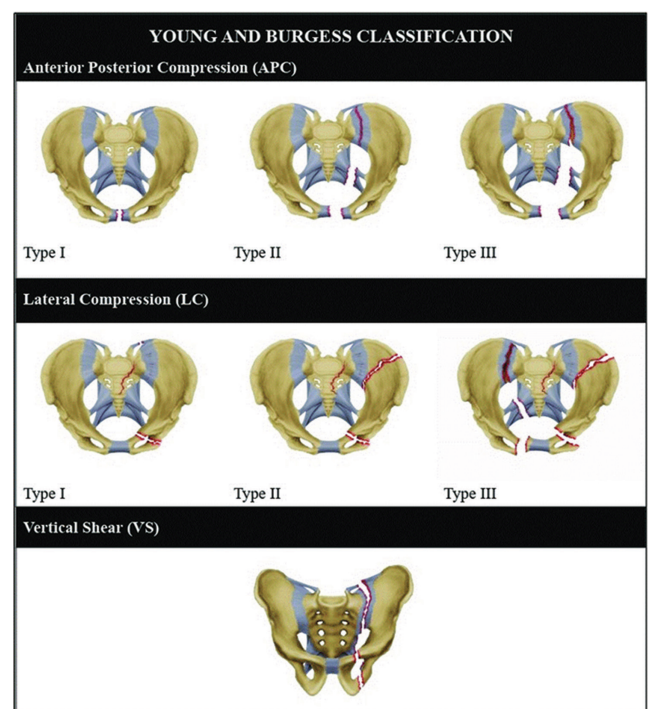


Figure 1 Young–Burgess classification.

TREATMENT

The initial treatment in the case of pelvic lesion is the application of a pelvic binder [17], which should be tightened over the greater trochanters. This device stabilizes the pelvic ring, reducing bleeding from the fracture sites and preventing disruption of formed clots [3]. The contraindication to the use of a pelvic binder is a hypothetical risk of over-intrarotation of the hemipelvis with consequent visceral injury (the bladder) in LC pelvic fractures, but no clinical evidence on this topic exists. The pelvic binder should be removed in the case of confirmation of a mechanically stable pelvic fracture [18]. All binders should be removed within 24–48 hours to prevent pressure sores (Figure 2); this should be managed and arranged with the orthopedic pelvic surgeon in the case of mechanically unstable fractures [18].



Figure 2 Pelvic binder skin lesion.

Recently, use of external fixation and C-clamp application as life saving procedures in acute bleeding control has been re-considered.

External fixation can be applied to the pelvis (depending on the fracture pattern) if the patient is taken to the operating room for surgical treatment of extra-pelvic injuries and/or if definitive fixation of the pelvis is expected to be delayed by more than 24–48 hours [18]. External fixation is recommended by many authors (with grade 1a evidence) in hemodynamically unstable patients with unstable pelvic lesions to prevent further bleeding and to support measures of hemorrhage control, including angiography and pelvic packing (Figure 3) [19,20].

External pelvic fixation aims to reduce the intrapelvic volume in “open book” injuries, so as to decrease the retroperitoneal bleeding space and to provide stable counterpressure to the “packed” lap sponges in the case of preperitoneal pelvic packing. In fact, preperitoneal pelvic packing alone is not effective without adequate counterpressure by posterior pelvic elements, obtained by a pelvic binder or by surgical devices (C-clamp or



Figure 3 Anterior external fixator and pelvic packing for unstable pelvic lesion.

external fixator) [21]. The pins of the external fixator can be placed in the iliac crest or in the supracetabular region. Contraindications to anterior external fixator are fractures that involve the acetabular region or the iliac ala.

Otherwise, a posterior C-clamp is indicated in “vertical shear” injuries with sacroiliac joint disruptions for hemorrhage control, but malposition and pin migration are a real concern [22,23]. Absolute contraindications are posterior iliac wing fractures, while relative contraindications are comminuted sacral fractures (in the case of strong compression, a C-clamp may cause lesions of sacral nerve roots) [24,25]. Furthermore, the area of pin insertion of the C-clamp is the same as the percutaneous definitive internal fixation (ileosacral screws) and the device itself can impede log-rolling of the patient during care nursing [18]. For these reasons, a C-clamp is rarely used today.

Some authors have agreed on the effectiveness of an emergency technique to address posterior pelvic ring instability, with the insertion of a percutaneous iliosacral screw, called a “resuscitation screw”. This can be associated with external fixation, using a C-clamp or binders, with the aim of effectively reducing pelvic volume. This technique is effective but very risky, and should only be used in selected cases and performed by experienced surgeons [26,27].

Definitive treatment of pelvic ring lesions requires anterior stabilization and/or a posterior fixation, depending on the type of injury [2].

The British Orthopaedics Association recommends definitive fixation of pelvic ring injuries within 72 hours if the general status of the patient allows for major surgery procedures [28].

Current indications for surgical stabilization of pelvic ring injuries include pain and mechanical instability.

Anterior fixation can be achieved with open reduction and internal fixation (ORIF) using plate and screws by different surgical approaches (Pfannenstiel, ilioinguinal, intrapelvic) or with screws alone (pubic rami

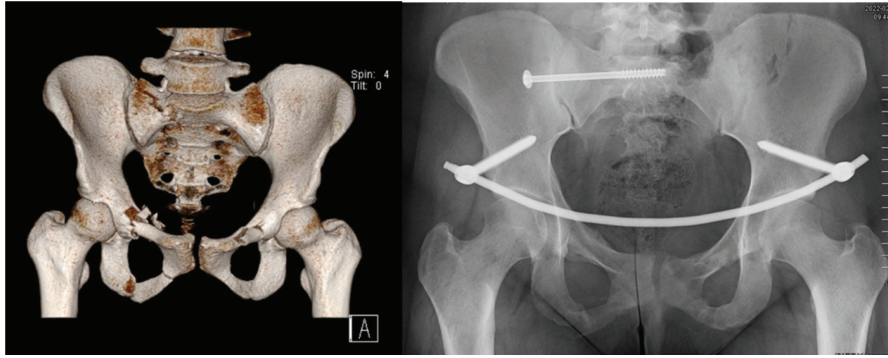


Figure 4 Pelvic lesion with instability treated with a posterior sacroiliac screw and anterior INFIX.

screws). Anterior fixation may also be achieved percutaneously using an external fixator as the definitive treatment or an anterior subcutaneous internal pelvic fixator (INFIX) [29,30]. There are some particular indications for INFIX, especially in patients with concomitant skin or soft tissue lesions, or in the case of bladder injury or abdominal infection [26].

Most lesions of the posterior pelvic ring (sacroiliac joint fracture, and dislocation and sacral fractures) can be indirectly reduced with closed or minimally invasive techniques. When indirect reduction is insufficient to obtain anatomic reduction, it is mandatory to reduce the lesion with a formal open procedure, i.e. with an anterior (first window of the ilioinguinal approach) or a posterior approach (midline or parasacral approaches). Posterior fixation is normally obtained with sacroiliac or trans-sacral screws. However, this procedure may put some key structures at risk, such as L5, S1 and upper sacral nerve roots, presacral venous plexus, cauda equina, etc [2]. Alternative methods of fixation are posterior plating (tension band plating), posterior INFIX, or lumbopelvic instrumentation, especially in the presence of sacral dysmorphism or in specific situations (obesity, lumbopelvic dissociation, etc.) (Figure 4).

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was not required.

CONCLUSION

High-energy traumas causing pelvic displaced lesions are a relevant cause of morbidity and mortality. Acute stabilization of a mechanically unstable pelvis is crucial for patient resuscitation in the presence of active bleeding and hemodynamic instability.

The correct understanding of the complexity of pelvic injuries can guide the surgeon to follow the right steps to address the lesion and thus reduce the probability of complications and death.

Ethics Statement

- (1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
- (2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

All authors have no conflicts of interest.

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Author Contributions

All authors have made substantial contributions to the study and manuscript writing.

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