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Current Management of Pelvic Fracture

Putu Feryawan Meregawa[1], I Gusti Ngurah Wira Aditya[2]

[1]Department of Orthopaedic & Traumatology, [2]Resident of Orthopaedic & Traumatology, Prof. Dr. IGNG Ngoerah Hospital, Faculty of Medicine, Udayana University, Bali, Indonesia

Corresponding Author: I Gusti Ngurah Wira Aditya

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ABSTRACT

Pelvic fractures are complex injuries that occur as a result of high-energy trauma and can have severe consequences. This review provides an overview of the classification, management, and surgical approaches for pelvic fractures. The Tile and Young-Burgess classification systems are commonly used to classify pelvic fractures based on the stability and severity of the injury. Management strategies include both non-operative and operative methods, depending on the stability of the fracture. Surgical approaches such as open reduction and internal fixation or external fixation may be used to stabilize the pelvis. The choice of approach is determined by factors such as fracture pattern and patient characteristics. Overall, effective management of pelvic fractures requires a multidisciplinary approach involving orthopedic surgeons, trauma specialists, and other medical professionals to ensure optimal outcomes for patients.

Keywords: *Pelvic Fracture, Current Management*

INTRODUCTION

Pelvis can be defined as a complex ring-shaped bone formed by three main bones, the sacrum, innominates, and ilium. Pelvic fractures occur when the bone structure of the bones that form the pelvis are disrupted, such as the pelvic bones, sacrum and coccygeus. Due to the strength and stability of the pelvis, fractures of the pelvis usually result from high-energy trauma. Most pelvic fractures occur due to crush trauma (10%), falls (30%), and traffic accidents (60%). Approximately 30% of people die from pelvic fractures associated with hemodynamic instability, often caused by severe retroperitoneal bleeding or extrapelvic injuries such as chest or central nervous system injuries[1].

The Tile and Young-Burgess classification system is widely used to assess pelvic ring injuries. In the United States, pelvic fractures occur at a rate of 37 per 100,000 individuals annually, with the highest incidence in those aged 15 to 28 years. Men are more often affected under the age of 35 years, while women are more often affected over 35 years[2]. Intrapelvic and abdominal bleeding remain the leading causes of death, with overall mortality rates between 6% and 35% in high-energy pelvic fractures.

Pelvic fractures represent a significant challenge in trauma care due to their complexity and potential for life-threatening complications. Significant progress has been made in managing these fractures, from initial assessment and resuscitation to definitive treatment strategies. This review outlines current approaches to managing pelvic fractures, including non-operative and operative methods, the importance of early stabilization, minimally invasive procedures, and collaboration across medical disciplines. Additionally, emerging technologies and innovative treatment options that hold promise in improving the management of pelvic fractures are discussed. This review serves as a valuable resource for physicians, surgeons, and researchers caring for patients with pelvic fractures.

CLASSIFICATION

Pelvic fractures can be classified using a number of classification systems to help recognize injury patterns and make management decisions, with the most well-known being those by Tile and Burgess et al. Based on these classification schemes, management recommendations are provided based on the function of the posterior ligamentous structures that support the pelvis. The anatomical location of pelvic ring injuries and the associated displacements and instability are often used to classify injuries. According to Pennal and Tile, pelvic fractures are classified by vectors of the forces that cause them. Initially, injuries are classified as either anteroposterior compression (APC) or lateral compression (LC). Radiographic evidence of pelvic stability or instability has been incorporated into the classification system[3].

The Tile classification scheme for pelvic fractures identifies type A injuries as rotational and vertically stable, with the following categories: A1 - Avulsion fractures, A2 - Stable iliac wings or minimally displaced pelvic rings, and A3 - Transverse sacral or coccyx fractures. Rotationally unstable and vertically stable injuries of type B occur. There are three categories of type B injuries: type B1 - Open-book injuries, type B2 - Localized Injury, and type B3 - Bilateral injuries. Injuries of type C are rotationally and vertically unstable and can be divided into three types: type C1 - unilateral injuries, type C2 - bilateral injuries where one side is type B and the other is type C, type C3 - bilateral injuries where both sides are type C. This diagram shows how pelvic fractures are classified and sub-classified according to the Tile system, providing a visual guide to the different types of injuries and their particular stability[3].

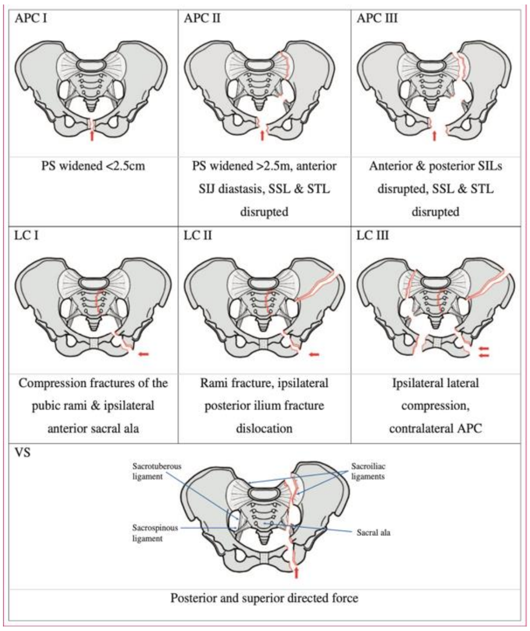

Figure. 1 Marvin Tile classification of pelvic injuries

As part of the Young-Burgess classification system, pelvic ring injuries are classified according to the mechanism of injury, by calculating the pattern of fractures based on the direction of the trauma force[4]. Orthopedic trauma surgeons use this framework to assess pelvic ring injuries primarily, providing critical guidance for initial management. It forms an anatomical ring with the sacrum when formed from the ilium and the ischium. An area with a fracture may result in additional fractures, ligament damage, or damage to nearby structures due to the substantial force required to disrupt this ring[5,6]. Young-Burgess has identified three primary mechanisms of injury: anterior-posterior compression (APC), lateral compression (LC), and vertical shear (VS).

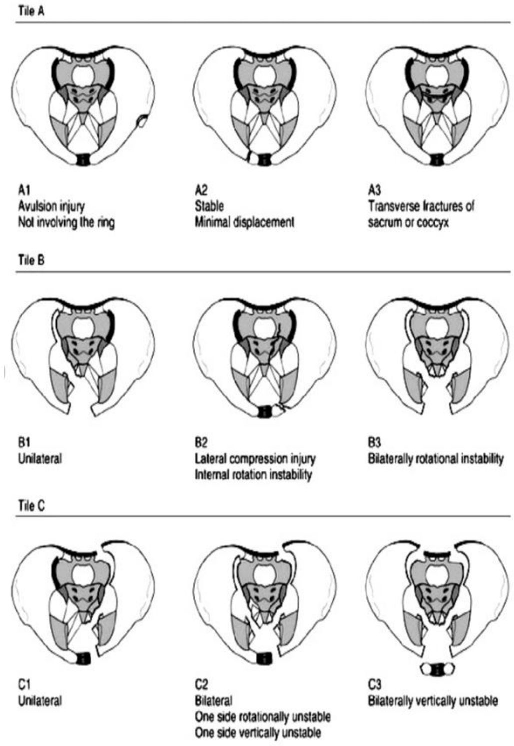

Figure. 2 Young Burgess Classification

Anterior to Posterior Compression Injuries (APC)

In APC injuries, ligamentous failure progresses from front to back. Initially, As a result, the symphyseal ligaments at the pubic symphysis are compromised, and the pelvic floor ligaments are disrupted then as well, including the sacrospinous and sacrotuberous ligaments. Eventually, the posterior sacroiliac complex is involved7. This sequence divides APC-type injuries into three categories:

APC Type I: Symphyseal ligament disruption occurring in an isolated area.

APC Type II: It is characterized by an increase in symphyseal ligament width by more than 2.5 cm and disruption of the sacrospinous and sacrotuberous ligaments of the pelvis.

APC Type III: In this category, both the posterior sacroiliac ligament complex and the anterior sacroiliac ligaments can be damaged. APC III injuries have the highest mortality rate, the greatest blood loss, and the greatest need for transfusion.

Lateral Compression Injuries (LC)

LC injuries result in a higher incidence of fractures compared to APC injuries, typically producing coronal plane fractures of the rami. These injuries often involve additional fractures of the sacral ala or iliac wing.

LC Type I: A lateral impact on the posterior pelvis caused rami fractures with ipsilateral sacral wing fractures.

LC Type II: Due to an anteriorly directed lateral compression force, rami fractures occurred as well as an ipsilateral crescent fracture of the ilium.

LC Type III: A high-energy injury known as a "windswept pelvis" presents as either an ipsilateral LC I or II fracture and a contralateral external rotation injury. A closed head injury is the most common cause of death associated with LC fractures.

Vertical Shear Injuries (VS)

Injuries to the VS occur when an axial load affects one hemipelvis, for example, falls from height or motorcycle accidents in which the force is greater on one leg. As the iliac wing is driven upwards relative to the sacrum, symphyseal ligaments, pelvic floor, and posterior sacroiliac complexes are all affected[8].

INITIAL MANAGEMENT

Patients presenting to the trauma room with multiple traumas are initially cared for according to Advanced Trauma Life Support (ATLS) principles, which include airway (A), breathing (B), circulation (C), neurological status (D), and temperature (E). It is known that abnormalities in coagulation can worsen bleeding in trauma. The acute traumatic coagulopathy (ATC) is characterized by an uncontrolled bleeding problem following injury that is hypocoagulable. In types A, B, and C, pelvic rings that are unstable are more likely to develop ATC (36.1% for type A, 50.4% for type B, and 53.1% for type C). In order to determine the next therapeutic step based on vital parameters and responses to fluid or blood administration, Tscherne and Pohlemann developed a pelvic-specific algorithm[9].

Pelvic binders are recommended for the initial treatment of pelvic ring stabilization and to decrease bleeding during the early stages of resuscitation, since they are non-invasive. Binding should be placed between the greater trochanter and pubic symphysis to reduce internal pelvic volume and provide pressure. Keeping the binder in place for more than 24 hours could result in skin necrosis or pressure ulceration. During the period of 23 hours, the pressure may exceed 9.3 kPa and cause skin necrosis and pressure ulcers[10].

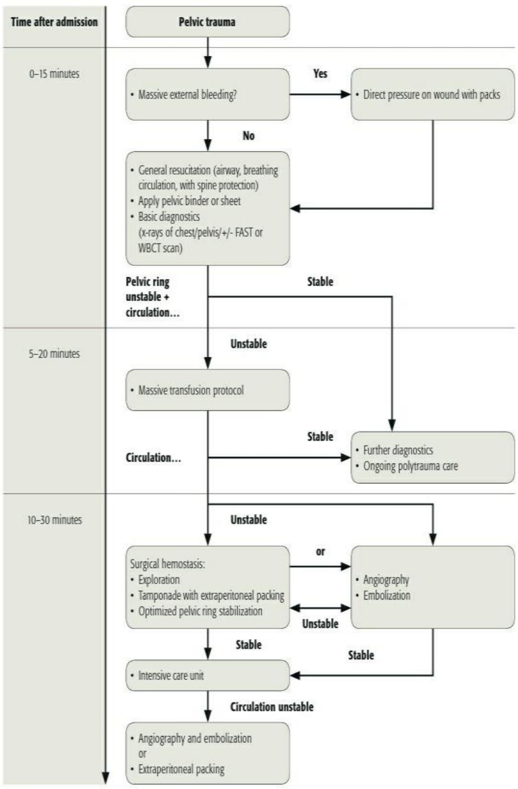

Fig 6.4-7 Emergency algorithm for pelvic injuries. Protocols will vary between medical centers depending upon local facilities and expertise. These situations are dynamic and require flexible senior decision making from the general surgeons, orthopedic surgeons, interventional radiologists, and anesthetists.

Figure. 3 The algorithm for managing pelvic fractures in emergency departement

In patients with pelvic fractures who are hemodynamically unstable and have ongoing bleeding, pelvic angiography/angioembolization is required after pelvic stabilization, aggressive resuscitation, and exclusion of extrapelvic bleeding. Angioembolization is a treatment to control bleeding with a retroperitoneal source of bleeding. In elderly patients, this therapy should be considered without assessing hemodynamic status. The right time to perform definitive internal fixation is still a matter of debate. In hemodynamically unstable and coagulopathic patients, resuscitation must be performed before definitive internal fixation can be attempted. After an injury, definitive internal fixation of a pelvic fracture can be performed within 24 hours if the patient is hemodynamically stable[10].

Based on the concept of damage control surgery, DCO is divided into three phases. The first phase includes temporary stabilization of the unstable fracture and control of bleeding. The second phase includes resuscitation of the patient in the intensive care unit and optimization of conditions. The third phase includes definitive fracture management that is postponed until the patient's condition permits. The favorite tool used to achieve temporary stabilization of pelvic fractures is the application of an external fixator. External fixator is a minimally invasive method that can be used efficiently for early fracture stabilization and delaying biological stress due to prolonged surgical procedures[10].

Embolization and Pelvic Packing

Patient nonresponders were those with blood pressure below 90 mmHg despite receiving crystalloid infusion, PRBC transfusion, and pelvic packing. After ensuring there is no thoracic, intra-abdominal, or extremity bleeding, other methods to control bleeding need to be applied, including preperitoneal pelvic packing and angiographic embolization, as well as application of an external fixator[11]. Arterial bleeding usually occurs in the internal iliac artery and its visceral branches, such as the uterine and superior vesical arteries, as well as parietal branches, such as the iliolumbar and lateral sacral arteries[12]. When a pelvic fracture occurs, the most common cause of bleeding is tears of the extensive venous plexuses in the presacral and paravesical areas, but there is a small risk of arterial bleeding as well. Embolization is useful when angiography indicates a specific arterial source of bleeding, while bilateral internal iliac embolization may be performed for non-specific bleeding.

Preperitoneal pelvic packing helps control venous bleeding and requires re-examination surgery after 48 hours for packing removal. Disadvantages of angiographic embolization include facilities that may not be available 24 hours and the inability to transfer unstable patients to the radiology department[13]. Intraoperative internal artery ligation is rarely performed and only for extreme conditions due to the high risk of soft tissue damage and necrosis. Angioembolization (AE) is the gold standard for reducing pelvic arterial bleeding because it is highly successful, definitive, focused, and minimally invasive. Ideally, AE should be available as soon as possible in a hybrid operating room setting. Pre-peritoneal pelvic packing (PPPP) is used to treat severe venous bleeding, but carries a risk of infection and other problems. A combination of PPPP and AE is required for definitive bleeding control, with AE remaining important for managing arterial bleeding[14-16].

Resuscitative Reduction Strategies

A reduction in the importance of external fixation and C-clamp administration in the control of acute hemorrhage has been suggested in several studies. Adequate support is provided by a pelvic brace until the arteries can be treated. Internal fixation is recommended as soon as it is safe and feasible. When definitive surgery cannot be performed within 24 to 48 hours, or external fixation is the best long-term solution to managing pressure injuries, external fixation may be considered based on fracture patterns if definitive surgery cannot be performed within 24 to 48 hours. Although the C-clamp is effective for stabilizing the posterior pelvic ring, pin migration and incorrect placement remain serious concerns. Aseptic implantation may be a risk when applying a pelvic C-clamp[17].

It has been proven that early definitive internal fixation (within 48 hours) of pelvic ring injuries (PRIs) is a safe and effective method to reduce complications and speed recovery. Even in cases of severe shock, many PRIs can be treated with minimally invasive acute (within 6 hours) definitive internal fixation along with hemostatic resuscitation and rewarming. According to the fracture pattern, a large open approach or pronated position may be needed; however, this procedure should not be performed until all resuscitation efforts are complete and the coagulopathy has been controlled. In most cases, this can be accomplished within 24 to 36 hours after the injury[18].

REBOA technique

REBOA is a recently popular treatment for life-threatening pelvic hemorrhages that involves the occlusion of the aorta by an endovascular balloon. A balloon catheter inserted above the bifurcation of the aorta has shown promise, despite the lack of evidence to prove its superiority over rapid aortic occlusion in available case reports and retrospective series. This catheter can be used for aortic occlusion or selective balloon tamponade. Partial blockage of the caudal aorta could theoretically reduce the risk of severe reperfusion injury, aid clot formation, and limit bleeding[19].

REBOA is also commonly associated with complications at the site of vascular access and further down the lower extremity. These complications may require vascular repair, fasciotomies, or even amputations when REBOA is used in extreme situations. Resuscitated with an endovascular balloon occlusion of the aorta within hours of the initial injury, the patient can sit up and recover within hours. There are, however, complications that may require vascular repair, fasciotomies, or even amputation at the vascular access site and further down the lower extremity[18].

MANAGEMENT

Non-operative

Association for the Study of Internal Fixation (AO) rehabilitation protocols were followed by patients who underwent nonoperative treatment. Their pelvises were stabilized using a pelvic girdle, and they were placed on bed rest while fracture displacement was reduced through bone traction. In order to prevent complications such as bedsores, deep vein thrombosis, and pneumonia, oral pain medications were used and early functional exercises were implemented[20]. Monthly X-ray or CT scans were conducted to monitor fracture healing. Patients began mobilization using a walker, progressing to crutches or a cane with gradually increasing weight-bearing. For stable pelvic injuries (Type A), conservative management is typically recommended unless the injury is open. In such cases, bed rest or traction is avoided due to the risk of complications. The fracture should be mobilized with a walker as soon as possible to allow partial weight-bearing on the affected side. Avulsion fractures and LC I types are managed conservatively.

Conservative treatment of unstable pelvic fractures, however, carries numerous complications. An internal fixation is performed as a means of mitigating these complications and facilitating early sitting and mobilization. It is usually performed after about four days of stabilization from anesthetic perspective and when the soft tissue condition permits. External fixation is an effective treatment for anterior ring fractures when soft tissue is compromised, anesthetic risk is poor, or bilateral internal iliac artery ligation or embolization is required. Studies indicate that non-minimally displaced posterior pelvic ring fractures significantly impact patient well-being, reflected in various clinical scores. In general, pain relief occurs rapidly, often within six weeks, and occurs slightly more quickly in the surgical group. An established method of treating unstable pelvic fractures caused by high-velocity trauma is surgical stabilization of the posterior pelvic ring[21]. Among elderly patients, With minimally invasive techniques, rapid pain relief and early mobility have been achieved in cases involving little or no energy trauma[22]. There is evidence, however, that the use of surgical versus non-surgical treatments does not result in significant differences in pain and morphine consumption[23].

Operative

External Fixator

There are two types of external fixators available for treating pelvic injuries, especially hemodynamic instability. An external fixator is a posterior fixator and an anterior fixator. An anterior external fixator is used in patients with anterior pubic diastasis, rami fractures, and intact posterior ligaments with pins inserted in the iliac blade or anteriorly to the anterioinferior iliac spine. Supra-acetabular pin placement is preferred as it provides a stronger grip and favorable biomechanical position compared to iliac crest pins[24]. At the level of the tubercle and gluteus medius pillar, the Iliac Crest site provides easy access to the site for pin placement. This frame can be revised for permanent fixation or left in place for 6-8 weeks.

The external fixator procedure is minimally invasive, preserves the biology of the fracture site, and is easy to remove. However, its stability is usually lower than with ORIF (open reduction and internal fixation) due to the distance from the bone. A posterior injury is closed with two lateral pins inserted over the sacroiliac joint to apply compression in the coronal plane. Although effective, this application is limited by high costs and potential complications such as penetration of the pelvic cavity and neurovascular injury[11]. C-clamps, used in posterior fixation, are not suitable for patients with osteoporosis or hemodynamically stable patients, and are usually used temporarily to treat acute hemodynamic instability in hip fractures.

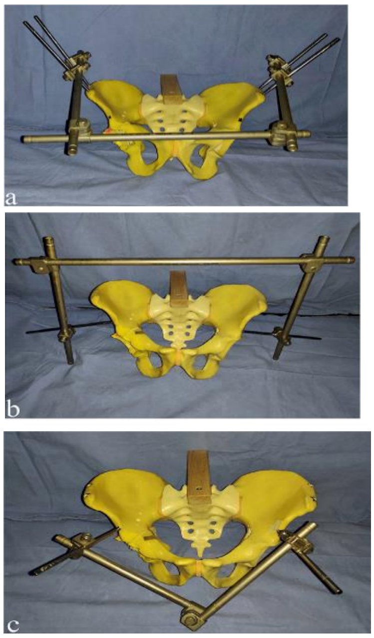

Figure 4. In the pelvic EXFIX, pins are positioned through the following areas: a) Iliac Crest, b) supraacetabular area, and c) anterior inferior iliac spine.

Open Reduction and Internal Fixation (ORIF)

If the pubic ligament is pure dislocated and parasymphyseal or rami fractures are severe, open reduction and internal fixation (ORIF) with plates is recommended. To avoid the additional dissection required for exposure, many surgeons prefer to use a minimally invasive or external fixation method. ORIF can be successful using reconstruction plates and screws for both small and large fragments[25]. The ORIF method provides superior biomechanical stability, returns the fracture to a more anatomic position, and allows patients to ambulate more quickly than external fixation.

The indications for ORIF include symphyseal diastasis of more than 2.5 cm, difficult-to-reduce oblique fractures, dislocations of the SI joint, fractures of the iliac crest, and unstable fractures of the acetabulum. For anterior approaches, the patient should be supinated on the operating table, for posterior approaches, and for cases requiring both anterior and posterior fixation, the patient should be pronated. An anterior approach may be desired when there is insufficient reduction of the SI joint, or when there is a concomitant sacral fracture, but it is associated with significant wound complications. There are a variety of approaches available to access anterior structures, including the Pfannenstiel, Stoppa, and ilioinguinal approaches. According to cadaveric studies by Tornetta et al., 84% of specimens had a corona mortis, a connection between the external iliac artery and the obturator artery, spaced 6.2 cm from the lateral symphysis[26].

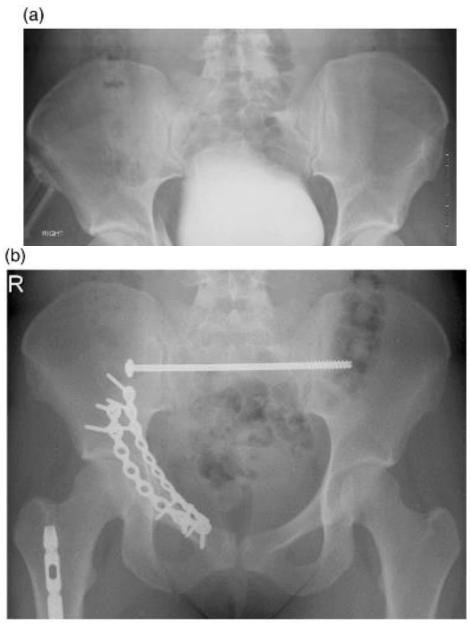

Figure 5. In the case of open reduction and internal fixation (ORIF), the radiographs are shown as follows: (a) Preoperative anteroposterior radiograph of a pelvic fracture with bladder contrast. (b) Postoperative pelvic radiograph with internal fixation after open reduction.

Percutaneous Fixation

Percutaneous fixation has become an increasingly popular method of treating posterior pelvic ring instability, particularly through percutaneous iliosacral fixation. This technique offers several advantages, including a shorter surgery time, a reduced exposure risk, and minimal soft tissue disruption. Percutaneous fixation maintains soft tissue integrity and facilitates future hip arthroplasty if necessary. For patients with comminuted fractures, osteopenia, or femoral head injuries, this procedure is especially useful, as it prevents decompression of the pelvic hematoma, thus allowing surgical stabilization without the risk of further bleeding. As a result, blood loss and infection risks are significantly reduced, especially in cases of polytrauma, and this approach is ideal for accurate closed reduction and early stable fixation.

As a result of a retrospective study of 32 patients with posterior pelvic ring instability treated with percutaneous iliosacral screws or conservative methods, percutaneous fixation resulted in significantly lower residual displacements, improved pain relief, and improved functional and general health outcomes after one year[27]. It was reported by Schweitzer et al. that 86% of patients treated with posterior screw fixation for Tile B1 and C fractures returned to their pre-injury work and leisure activities 8 months after surgery[28]. Following percutaneous iliosacral screw fixation in 25 patients suffering from LC1 and LCII fractures, Osterhoff et al. found that only two patients (8%) required additional anterior stabilization[29]. Percutaneous fixation can also cause loss of reduction in addition to nerve root injury and screw misplacement.

After percutaneous fixation, patients are usually able to begin weight-bearing within two weeks, avoiding the need for long recuperation periods after major surgery. Performing this technique within five days of an unstable pelvic ring injury is recommended if important criteria are met and after achieving accurate reduction to avoid residual displacement that could compromise adjacent nerves and vascular structures. Younger patients should only undergo percutaneous fixation for simple fracture patterns that are manageable with closed or limited open methods, and failure could require traditional open surgery[30].

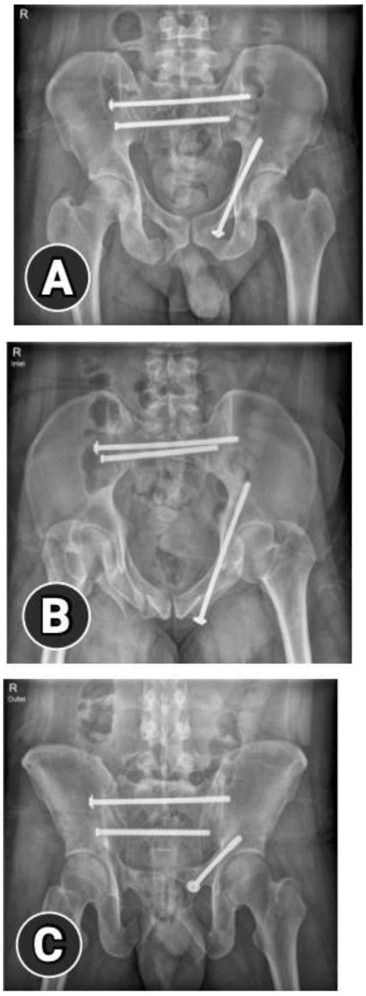

Figure 6. X-rays show no displacement after removal of the external fixator on (A) anteroposterior, (B) inlet, and (C) outlet

Anterior Pelvic Fixation Technique

The INFIX, also known as the "Pelvic Bridge," is a new method that uses an external fixator to stabilize the front of the pelvis just below the skin. This fixator is stronger than traditional ones because it has an internal structure. It provides more comfort and mobility for the patient, reduces the risk of infection, and can be used as a temporary or permanent fixator once the back of the pelvis is stable. It is an ideal solution for stabilizing injuries in war and disaster zones, where temporary treatments may be needed for extended periods before definitive care. The INFIX can function solely as an internal fixator, along with an external fixator (INFIX/EXFIX), or as a complete external fixator, demonstrating greater strength compared to 2-pin supra-acetabular external fixators due to its slim design.

This procedure involves inserting screws into the ilium on both sides and connecting them with rods just below the skin, sometimes with additional fixation to the symphysis area. It is classified as a minimally invasive osteosynthesis (MIO) technique. Benefits include fewer soft tissue infections, better pain control, increased patient mobility, and quicker recovery. This technique is especially advantageous for complicated fractures of the front part of the pelvis, reducing complications during surgery compared to traditional methods. Previously, methods for fixing the front part of the pelvis included plating, percutaneous screws, and external fixators. Although plating is effective for symphyseal injuries, it is challenging for cases involving vertical shear, lateral compression, or combined injuries, which result in complex fractures. These cases require extensive exposure, prolonged discontinuation, and are associated with higher complications[31].

An INFIX can be used to treat unstable pelvic rings with a single front fracture and intact tension bands in the back. Suitable for patients with fragility fractures who are immobilized after unsuccessful demands or thin patients who may be irritated by pedicle screws, it enhances front stability after sufficient back fixation. Furthermore, the INFIX is effective for medial pubic rami fractures, which limit the ability to fixate the Pelvic Bridge on the medial side[32].

INFIX should not be used when the iliac wings are dissociated, the pubic symphysis is diastasised (pure ligament injury), the iliac crest has been degloved or fractured, the pelvis has been contaminated with peritoneum, the patient is hemodynamically unstable and needs rapid pelvic stabilization, or INFIX will be used alone when front and back instability are combined[33].

Figure 7. Fracture reduction with compression or distraction instruments

Figure 8. AP radiograph with anterior sacroiliac screw fixation and posterior Bridging Infix

APPROACH

The anterior ilioinguinal approach is the most preferred technique to expose, reduce, and fix fractures affecting the anterior column of the acetabulum and the inner surface of the innominate bone[36]. These structures can be accessed via the ilioinguinal approach after the inguinal canal is opened, the external iliac vessels are mobilized, and the three "windows" are expanded. The first or lateral window protrudes from the sacroiliac joint, providing access to the joint, internal iliac fossa, and proximal pelvis. Second or middle windows are located medial to the external iliac artery, and provide access to the distal pelvic brim, quadrilateral surface, anterior acetabular wall, iliopsoas gutter, and iliopectineal eminences, which are bound by the iliopsoas muscle and femoral nerve. Third or medial window, the external iliac vein runs between lateral and medial rectus abdominis muscles, allowing access to Retzius, pubic symphysis, and superior pubic ramus. Extending the hips exposes the anterior wall, anterior hip capsule, quadrilateral surface, and external iliac fossa more readily[36].

Using the improved ilioinguinal approach, which exposes the muscle anatomically, you are able to gain extensive access to the acetabulum, which is associated with a speedy recovery. There are disadvantages to this procedure, including mobilization of the external iliac neurovascular bundle and opening the inguinal canal, along with limited access to the deep posterior column and inferior quadrilateral surface. Moreover, the ilioinguinal approach is not capable of providing direct visualization of the acetabular articular surface. An anterior intrapelvic approach is recommended for the treatment of an anteromedial dome impaction. A separate iliac corticotomy is required if an ilioinguinal approach is used. A posterior marginal impaction or posterior wall fracture can be difficult to treat using the traditional ilioinguinal approach, so surgeons should consider alternative approaches, such as anterior and posterior approaches to the acetabulum[35].

Indications for surgical incision are appropriate for various types of acetabular fractures. There are three types of acetabular fractures: anterior wall fractures, anterior column fractures, and transverse acetabular fractures that involve large displacements in the anterior column. In addition to treating acetabular fractures, it is also useful for reducing and stabilizing the anterior elements in T-type fractures. As well as treating hemitransverse acetabular fractures of the anterior column and anterior wall, this approach is also particularly effective for treating anterior and posterior acetabular fractures. A posterior wall acetabular fracture, an anterior column acetabular fracture, and a combined posterior column and posterior wall acetabular fracture may be problematic when this approach is used. A fracture of the posterior wall or transverse acetabulum, or a fracture of the posterior column in a transverse acetabular fracture, may also be less suitable for this approach. Moreover, it presents significant challenges to reduce and fix the posterior elements in T-type acetabular fractures, which makes this approach less efficient for this particular fracture type[34].

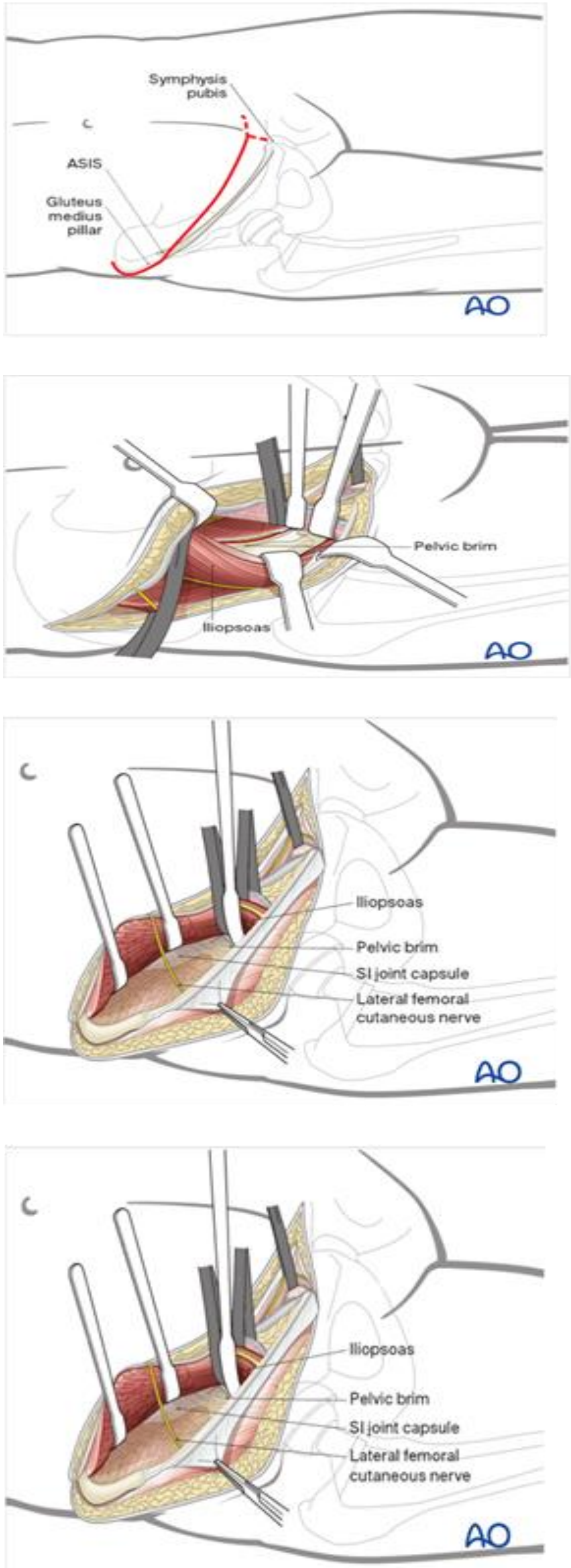

Figure 9. As indicated in the image, there are three windows and an incision in the approach

Modified Stoppa

In 1973, the Stoppa approach for groin hernias was described as a median subperitoneal approach. Adapting this approach for acetabular fractures in 1994, Cole and Bolhofner instructed the surgeon to stand in front of the involved hip joint in order to get a better view of the medial wall, dome, quad plate, and sacroiliac joint. This approach, however, does not allow for anatomical reduction of the iliac wings, which is crucial for restoring the anterior wall of the pelvis.

This problem is addressed by the modified Stoppa approach, which incorporates a lateral iliac wing window to provide comprehensive access to treat acetabular and pelvic ring fractures. The use of this technique is becoming increasingly popular in the treatment of anterior column fractures, as it provides excellent visualization and access to the quad plate and portions of the posterior column[34]. Modified Stoppa approaches typically involve a horizontal incision, approximately 10 cm in length, located 2 cm above the pubic symphysis using a Pfannenstiel type incision. During superficial dissection, the rectus abdominis muscles are exposed, followed by a vertical incision along the linea alba which exposes the pubic ramus, bladder, and true pelvis. Due to the limited visibility of the greater and lesser sciatic notch, this approach is not adequate to deal with posterior column fractures38, despite optimal exposure of the anterior column and quadrilateral surfaces[38].

The advantages of this approach are multifaceted: it offers easier anatomical dissection compared with the ilioinguinal approach, better visibility of the anterior elements, direct control of the corona mortis, and facilitates precise surgical intervention in the posterior column. Additionally, it allows medial support of the rectangular plate using a reconstruction plate. However, there are challenges, such as the need for two experienced surgeons, one treating the iliac window while the other handles reduction and osteosynthesis. It may not be possible to use traditional acetabular reduction clamps due to differences in soft tissue size, and retraction of the anterior abdominal wall elements may increase the risk of femoral vascular injury.

Anterior column fractures of low, high, and intermediate levels, posterior hemitransverse fractures, and anteriorly displaced transverse fractures are indications for this approach. This approach is also suitable for T-fractures of the acetabulum, fractures of both columns, bilateral acetabular fractures, and pelvic tilt fractures. Contraindications include posterior wall displacement, posterior column comminution, T fracture with significant posterior involvement, history of major lower abdominal surgery, and fractures more than three weeks old.

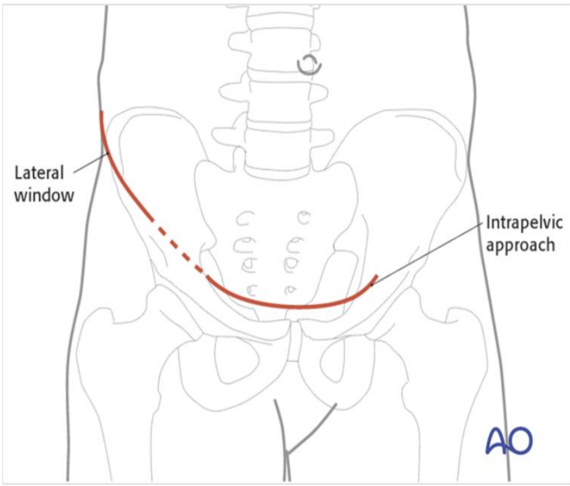

Figure 10. STOPPA approach technique

Comparison Approach

A recent study by Scrivano et al. 2024 evaluated several key factors in the management of acetabular fractures, including the degree of fracture reduction, operative time, blood loss, neuro-vascular complications, infection rate, and functional recovery[39]. It has been the subject of many studies to compare the modified Stoppa approach to the traditional ilioinguinal approach. Taller et al.[40] found in addition to being less invasive, the modified Stoppa approach is associated with a lower risk of peripheral neuropathy, while Fan et al. reported better fracture reduction results and lower complication rates[41]. According to Matta et al., the ilioinguinal approach resulted in a better fracture reduction and a faster muscle recovery[42].

Recent studies show varying results. There were no significant differences between these two approaches in the study conducted by Hammad et al[43]. According to Scrivano et al., the modified Stoppa approach has a shorter operative duration, an average of 146 minutes, with a reduction in operative time of 29 minutes compared with the ilioinguinal approach. Blood loss was also lower in the modified Stoppa group, with a mean hemoglobin loss of 0.9 points less compared with the ilioinguinal group, consistent with findings from the study of Ma et al. Nerve complications tended to be higher with the ilioinguinal approach (16.7%), primarily affecting the femoral-cutaneous and lateral femoral nerves, while the modified Stoppa approach had a lower complication rate (7.1%), primarily affecting the obturator nerve[44].

There are a number of advantages to the modified Stoppa approach, including a shorter operative time, reduced blood loss, and a lower risk of neuropathy after surgery. Through a single incision, this approach provides good access to the entire pelvic ring and allows for early mobilization, although it poses some challenges when it comes to treating posterior column fractures and identifying specific structures of the pelvis[45]. Nevertheless, the ilioinguinal approach is still the standard for anterior acetabular fractures due to its classic approach. However, this approach is associated with longer operating times, increased blood loss, and a higher risk of nerve damage. The choice of technique should be carefully considered according to the clinical needs of each patient.

UNSTABLE INJURIES: CHOOSING THE APPROPRIATE APPROACH AND FIXATION

Pubic Symphysis and Ramus Injuries (Anterior)

In managing pubic symphysis and ramus injuries, the choice between a low midline vertical approach or a Pfannenstiel incision can be crucial[46]. Maintaining a consistent dissection interval internally remains paramount despite the perpendicularity of the superficial incision. Patient history, including prior surgeries and hernias, significantly influences outcomes when employing anterior approaches to the pelvic ring. Subperiosteal elevation of the caudal insertion of the rectus abdominis muscle exposes the bilateral cranial anterior pubic bones, while a bendable retractor safeguards the bladder. During closure, meticulous layering is essential. Bilateral peripheral dissection may be extended along the pelvic brim to the SI joint when necessary. Preoperative computed tomography scanning assists in planning, typically revealing corona mortis vessel communication approximately 6 cm lateral to the pubic symphysis[47].

Pubic Symphysis

External fixation or open reduction with internal fixation (ORIF) are treatment options available for symphysis disruptions. Patients with partial posterior ligament damage and mild symphysis disorders may benefit from anterior pelvic external fixation. The use of anterior external fixation can prevent surgical exposure, potential bleeding from venous plexus injuries, and bladder perforation associated with open stabilization. When a suprapubic catheter is employed to address bladder disturbances, anterior external fixation is instrumental in preventing wound contamination. Postoperatively, external pelvic fixation should remain in place until evident recovery, typically occurring six to twelve weeks later. However, patients may find external pelvic fixation cumbersome, and it has been linked to iliac osteomyelitis and pin tract infections.

Implants such as low-contact dynamic compression 3.5-mm, 4.5-mm screws, 3.5-mm pelvic reconstruction implants, and low-contact dynamic compression 4.5-mm screws are frequently used to stabilize symphysis disorders. Regardless of the implant used, at least two screws should be positioned on both sides of the deformity to prevent further rotational deformity. The 3.5-mm pelvic reconstruction implant is recommended as larger implants do not fit the symphysis area well. The application of a tenaculum clamp on the anterior parasymphyseal bone allows for the minimization of most symphysis disruptions. The clamp is placed away from the intended site of implantation. Various rotational or vertical deformities can be reduced with the use of an oblique clamp[47].

Pubic Ramus

In cases where pubic ramus fractures lead to bladder, vaginal, or perineal impingement or laceration, surgical therapy may be considered. Surgical therapy for pubic ramus fractures is recommended to provide additional stability to the pelvic ring, especially when combined with posterior pelvic ring repair. Pubic ramus stabilization may also be considered when obturator neurovascular canal fractures are associated with neurological damage. Treatment options for pubic ramus fractures include external fixation, ORIF, and percutaneous screw fixation. Additional stability to the pelvic fixation system can be achieved by combining external fixation with posterior pelvic ring injury stabilization.

External fixation for pubic ramus fractures is recommended to provide further stability when percutaneous or open surgery is not feasible following posterior pelvic ring repair. Pubic ramus fractures can be reduced with intramedullary fixation using 4.5-mm cortical screws, which have shown positive outcomes and strength comparable to implant fixation. This can be done through antegrade or retrograde screw insertion using percutaneous or open methods. In cases of noncomminuted displaced fractures, medium-sized reduction clamps are used, with drill holes on both sides of the crack for stability. If concurrent symphysis injuries exist, pubic ramus fractures can be repaired with independent ramus implants or implants extending from the pubic symphysis. Additionally, medullary screws can be used for superior pubic ramus fixation, placed retrograde or antegrade, depending on patient anatomy and soft tissue. The number of screws used depends on the size, shape, and selected screw path for bone fixation.

This comprehensive approach to managing anterior pelvic injuries involving the pubic symphysis and ramus highlights the importance of tailored surgical strategies and meticulous postoperative care to ensure optimal patient outcomes and minimize complications[35].

Ilium Fracture

An iliac wing fracture is a serious injury that can occur due to direct force on the iliac wing. Nonoperative treatment is generally applied to simple fractures without instability of the pelvic ring, while high-energy injuries often result in complex fractures and severe soft tissue injuries, such as open wounds. Surgical therapy is necessary in cases with significant open wounds, skin anomalies, or pelvic ring instability that cannot be treated nonoperatively. Unstable fractures can disrupt normal pelvic function and may even involve herniation of the bowel or superior gluteal nerve, especially in the case of large sciatic notch fractures.

Commonly used surgical techniques include open reduction and internal fixation, where exposure is performed via an ilioinguinal approach to access the iliac wing fracture. The use of a posterior vertical paramedian technique may be necessary for posterior iliac lunate fractures. In many cases, screw fixation between the cortical table at the iliac crest and the use of flexible implants at the pelvic brim have proven effective in repairing biomechanically unstable iliac fractures.

Posterior pelvic ring injuries

Involve complex conditions such as sacroiliac joint (SI) disruptions and sacral fractures. Closed or minimally invasive procedures are often effective for reducing most SI joint injuries and sacral fractures indirectly. Circular pelvic anti-shock sheets help correct malpositioned SI injuries swiftly, reducing pelvic volume. Work portals within these sheets facilitate vascular access, external fixator pin placement, and percutaneous screw insertion. Skeletal traction counters cranial hemipelvic displacement, while external fixators with gluteal pillar and anterior inferior iliac spine fixation pins address rotational deformities as needed for correction vectors[48].

Sacroiliac Joint Disruption

Disruptions of the symphysis pubis or fractures of the pubic ramus can lead to anterior or posterior pelvic forces affecting the SI joint. Typically, anterior SI ligament ruptures are associated with mild symphysis disruptions, manageable through nonoperative methods, ORIF, or external fixation. However, tears involving both anterior and posterior SI ligaments can result in SI joint disruption or complete dislocation, causing instability in rotational and/or vertical movements. Surgical reduction and stabilization are recommended to prevent adverse outcomes associated with persistent dislocation and subluxation at the SI joint.

In open treatment of SI joint disorders, supine and prone positions are utilized. Supine stabilization is usually performed via lateral ilioinguinal surgical exposure, whereas a dorsal vertical paramedian approach is employed with the patient in a prone position. Various methods including distal ipsilateral femoral traction, Schanz pins in the ilium, tenaculum forceps, Farabeuf forceps, pelvic reduction clamps, and femoral distractors are used to achieve reduction in SI joint disruptions. Post-reduction, the SI joint is stabilized using perpendicular placement of 3.5 or 4.5 mm pelvic reconstruction implants. Special care is taken to avoid L5 nerve root damage during SI joint exposure.

Anterior implants such as percutaneous cannulated screws may be employed for temporary or permanent fixation post-reduction through the anterior approach. Comprehensive preoperative imaging is essential for safe screw fixation planning. Positioning and number of screws should be carefully considered based on desired compression direction and available bone channels for fixation, often recommending multi-level screw usage to enhance construct strength[49].

Sacrum

Sacral fractures often accompany pelvic ring injuries and are classified based on location (type I, II, III) and Roy-Camille classification for central sacral fractures. Operative stabilization is necessary in cases of fracture displacement, pelvic ring instability, or neurologic deficits due to foraminal remnants. Indirect reduction techniques are commonly employed, with foraminal decompression possibly needed if initial attempts fail. Open treatment involves dorsal vertical paramedian surgery with the patient in a prone position, providing direct access to the posterior sacrum for sacral foraminal decompression[50]. Post-reduction stabilization includes transiliac rods, transiliac screws, transiliac plates, or iliosacral screws.

Careful attention is crucial to avoid sacral nerve root damage. If closed manipulation is unsuccessful, iliosacral screws can be inserted to stabilize sacral fractures. Anterior fracture reduction facilitates sacral reduction and safe iliosacral screw placement. If reduction proves challenging or spinopelvic injuries require additional fixation, percutaneous iliosacral screw procedures are not recommended. Vertical posterior paramedian incision techniques are often used for direct sacral fracture reduction, using various implants including iliosacral screws for sacral fracture fixation[50].

CONCLUSION

Pelvic fractures present a significant challenge in orthopedics due to their high rates of morbidity and mortality. The primary treatment for unstable pelvic fractures involves percutaneous fixation and closed reduction procedures. However, when an open approach is necessary, it is chosen based on the patient's specific needs, preferred fixation techniques, and the nature of the fracture. Ensuring precise reduction and stable fixation at all sites of instability is crucial for improving outcomes. Effective initial resuscitation using established protocols, controlling hemorrhage through various methods, managing soft tissues well, and providing stable definitive treatment while avoiding complications can significantly enhance the prognosis for pelvic injuries.

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