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Unstable Pelvic Ring Fractures: From Bleeding Control to Bone Repair Along the Trauma Pathway

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Rezumat

Fracturile instabile ale centurii pelvine: de la controlul hemoragiei la vindecarea osoasă

Fracturile instabile ale centurii pelvine reprezintă provocări clinice majore, din cauza anatomiei complexe, a riscului crescut de sângerare şi a implicării frecvente a mai multor sisteme. În faza pre-spitalicească, controlul precoce al hemoragiei prin pre-peritoneal pelvic packing (PPP) şi angioembolizare (AE) este esențial: PPP permite controlul rapid al sângerării venoase, în timp ce AE vizează sursele arteriale. După resuscitarea inițială, stabilizarea osoasă promptă prin fixare externă temporară (ExFix), urmată de stabilizarea definitivă prin reducere deschisă şi fixare internă (ORIF), este crucială pentru scăderea complicațiilor pe termen lung. Prin urmare, pentru coordonarea acestor intervenții - de la îngrijirea pre-spitalicească până la tratamentul chirurgical - este necesară o abordare multidisciplinară integrată pe tot parcursul managementului traumatologic. Dezvoltarea şi optimizarea rețelelor de traumă pot contribui, de asemenea, la îmbunătățirea supraviețuirii şi recuperării funcționale. Astfel, acest review de literatură evaluează critic indicațiile, momentul optim şi utilizarea sinergică a PPP, AE, ExFix şi ORIF în vederea optimizării rezultatelor la pacienții cu fracturi instabile ale centurii pelvine.

Cuvinte cheie: sângerare pelvină, fractură pelvină, centură pelvină, traumatism

Abstract

Unstable pelvic ring fractures pose significant clinical challenges due to their intricate anatomy, substantial bleeding risk and frequent involvement of multiple organ systems. In the prehospital setting, early haemorrhage control with pre-peritoneal pelvic packing (PPP) and angioembolisation (AE) is critical: PPP rapidly controls venous bleeding, while AE targets arterial sources. Following initial resuscitation, timely bone repair with temporary

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external fixation (ExFix) and definitive bone repair, with open reduction and internal fixation (ORIF), is vital in minimising long-term complications. Hence, to coordinate these approaches from prehospital care to surgical intervention, a multidisciplinary approach is required along the trauma pathway. Advancements in trauma network systems may also offer improvements in survival and functional recovery. Therefore, this literature review critically evaluates the indications, timing and synergistic use of PPP, AE, ExFix and ORIF to optimise outcomes for patients with unstable pelvic ring fractures.

Keywords: pelvic bleeding, pelvic fracture, pelvic ring, trauma

Introduction

The pelvis is an integral part of the human skeleton, providing a robust foundation for structural support, stability and weight-bearing. This ring-like bone structure consists of the sacrum, 2 innominate bones both consisting of an ilium, ischium and pubis. Due to its closed anatomy, it also houses a complex neurovascular system whilst acting as an attachment point for various muscles and protecting underlying viscera (1). As such, this bony structure is a vital yet vulnerable region; if injured or fractured by high-energy trauma, most commonly road traffic accidents (RTAs), stabilising the pelvis is one of the most complex challenges in trauma care (2).

Pelvic ring fractures commonly present in individuals between the ages of 18 and 44, with a higher incidence in males than females. These fractures tend to present as a broad spectrum, with some fractures solely displacing the sacrum or pubis whilst high-energy mechanisms of injury disrupt multiple segments of bony ring (3). The Tile or Young-Burgess systems can be used to classify the type of pelvic injury. In the Tile classification, Type B (rotationally unstable) and Type C (rotationally and vertically unstable) fractures are considered unstable and almost always require operative intervention (4,5). These unstable pelvic ring fractures pose a serious challenge for trauma surgeons not only due to the bony injury but also from associated vascular, urogenital, and neurologic trauma (5). Despite a low incidence rate of 37 per 100,000, pelvic ring fractures are frequently accompanied by severe haemorrhage, haemodynamic instability and high mortality risk of up to 50% (4,6). In such cases, a multidisciplinary approach is essential to ensure urgent resuscitation and fracture fixation in this group of patients.

Early recognition of pelvic ring fractures and timely intervention is critical in stabilising the skeletal ring, reducing pain, enabling mobilisation, and preventing long-term complications (5). Since the implementation of the Major Trauma Network in England, significant progress in prehospital pelvic immobilisation and definitive management of unstable pelvic fractures has improved long-term functional outcomes (7). In cases of major trauma, haemorrhage control is the primary goal during the early stages of resuscitation, as it remains the leading cause of preventable death (2). Two primary interventions exist: pre-peritoneal pelvic packing (PPP) and angioembolisation (AE). They are widely used to achieve haemostasis in these scenarios (2). Following initial stabilisation or in the absence of severe haemorrhage, surgical management with external fixation (ExFix) or open reduction and internal fixation (ORIF) prepares patients for onward care and rehabilitation (2).

Several unresolved challenges remain in current practice and research. There is no standardised algorithm for selecting PPP versus AE in unstable patients, and the optimal timing for converting from ExFix to ORIF remains uncertain. (4) Additionally, unequal global access to interventional radiology and limited reporting of functional or quality-of-life outcomes continue to hinder consistent evidence-based management. A structured narrative literature review was conducted using PubMed, Embase, Scopus, and the Cochrane Library to identify studies published between 2000 and 2025 on the management of unstable pelvic ring fractures. Only English-language human studies addressing the indications, timing, or outcomes of PPP, AE, ExFix, or ORIF were included. Exclusion criteria comprised case reports, conference abstracts, and papers without outcome data.

This review therefore aims to provide an in-depth, critical analysis of the current evidence underpinning PPP, AE, ExFix, and ORIF in the management of unstable pelvic ring fractures. It

will explore the indications, timing, and combined use of these techniques within a multidisciplinary trauma framework, highlighting both their complementary roles and their limitations. This paper seeks to inform best practice and propose directions for future research into optimising survival and functional recovery for patients with unstable pelvic ring fractures.

Prehospital Care

In any major trauma, an A-E assessment of the patient, along with secondary surveys following Advanced Trauma Life Support (ATLS) principles should be prioritised, beginning with external catastrophic haemorrhage control. Any airway, breathing and then circulatory compromise must be adequately managed prior to inspection of neck or pelvic injuries (8). Cervical spine immobilisation with head blocks may be utilised to restrict movement and prevent further spinal cord or nerve injury. If an unstable pelvic fracture is suspected, initial management often involves temporary stabilisation with pelvic binders for haemostatic control (9,10). British Orthopaedic Association Audit Standards for Trauma (BOAST) guidelines also emphasise that all patients should receive IV Tranexamic Acid within the first hour post-injury. Collectively, these approaches aim to reduce pelvic volume and limit ongoing haemorrhage during the acute phase of resuscitation (10). It is therefore imperative that these binders are kept in place until radiological confirmation of the presence/absence of a pelvic fracture (11). Although each trauma network should clearly define protocol for binder removal, BOAST guidelines for pelvic fractures recommend removal within 24 hours of pelvic injury. Following this, BOAST and Getting It Right First Time (GIRFT) guidelines advise that definitive pelvic reconstruction should occur within three days of trauma if the patient's injuries allow (9,12).

However, it is widely recognised that the pre-hospital diagnosis of unstable pelvic ring fractures can be challenging, particularly in the absence of obvious bleeding or deformity (8). In cases where the mechanism of injury suggests a pelvic fracture, but patients are haemodynamically stable and have a Glasgow Coma Scale (GCS) above 13, the use of pelvic binders is no longer recommended. This practice is largely avoided in this group of patients due to concerns that compression of the pelvis can conversely exacerbate haemorrhage, especially in injuries that already appear to be clinically stable (11,13). Therefore, guidance to limit the unnecessary use of splints is neatly summarised in the pelvic injury flow diagram (*Fig. 1*) (14), which can be used to determine the appropriate intervention.

Haemorrhage Control

When patients have been safely extricated and transferred to the hospital, identifying and managing internal haemorrhage because of unstable pelvic ring fractures is time sensitive. Understanding the source of bleeding is essential for selecting the appropriate intervention. In pelvic fractures, approximately 80% of haemorrhage is venous or osseous in origin, with the remainder being arterial (15). Venous bleeding typically arises from disrupted venous plexuses in the retro-peritoneal space, whereas arterial bleeding results from injury to branches of the internal iliac artery or its subdivisions (15,16). The decision to achieve haemorrhage control with PPP or AE is therefore closely linked to the presumed source of bleeding, guided by clinical examination, haemodynamic response to resuscitation, and imaging.

Pre-peritoneal pelvic packing is a surgical technique designed to address venous and bony bleeding. Through a vertical infra-umbilical incision, surgical pads are placed in the pre-peritoneal space to tamponade bleeding vessels in the pelvis (16). One of the primary advantages of PPP is its rapid implementation, particularly in facilities without 24-hour access to interventional radiology. It can be performed simultaneously with other critical procedures such as laparotomy or external pelvic fixation, making it an ideal choice in patients with multiple injuries (16).

The indications for PPP include persistent haemodynamic instability despite initial resuscitation, when there is a high likelihood of venous or osseous bleeding, or when AE is delayed or unavailable (17). Clinical studies support its efficacy. Cothren et al. demonstrated a reduction in haemorrhage-related mortality from 40% to 15% following the implementation of PPP in the trauma algorithm (18). The technique provides a rapid and effective solution to control bleeding in the acute setting, buying critical time for definitive treatment. Hauschild et al. observed that centres using a PPP-first strategy showed significantly reduced ICU length of stay and transfusion requirements (19).

Nevertheless, PPP is not without limitations. It does not address arterial bleeding and may be

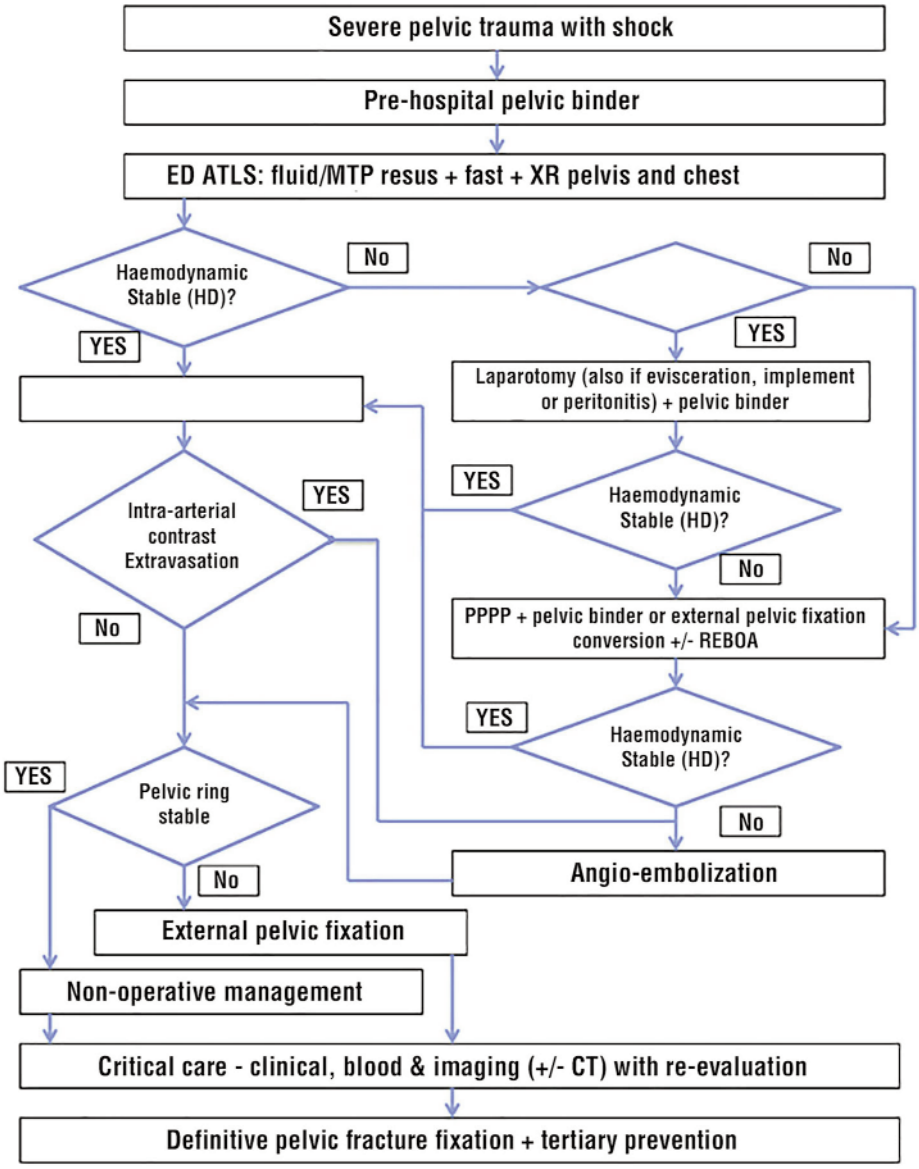

Figure 1. This diagram provides a step-by-step approach to managing severe pelvic fractures, including the use of pelvic binder, laparotomy, PPP, and angiography, tailored to the patient's hemodynamic response (14).

insufficient in cases of ongoing arterial haemorrhage (19,20). It is also invasive, carries the risk of infection, and requires a second procedure to remove the packing materials (16). Despite these concerns, its life-saving potential in the early phase of trauma care is widely acknowledged, particularly when performed as part of a coordinated damage control strategy.

In contrast, angioembolisation is a minimally invasive technique that selectively occludes bleeding arteries using coils or embolic agents delivered via catheter under fluoroscopic guidance (21). AE is particularly effective for patients with contrast extravasation on CT or persistent haemodynamic instability after initial interventions (21). It is the gold standard for controlling arterial bleeding and can be repeated if rebleeding occurs (22). Its precision allows for preservation of adjacent vascular territories and avoids unnecessary tissue damage (21,22).

The indications for AE are more specific than those for PPP. It is primarily used in active arterial bleeding evident on imaging, haemodynamically stable patients with a contrast blush, or patients who remain unstable after PPP (22). Hagiwara et al. found AE effective in controlling haemorrhage in up to 95% of cases, highlighting its critical role in trauma care (23). However, AE is often limited by logistical factors. It requires transport to a radiology suite, availability of staff and imaging confirmation of bleeding. In urgent situations, these requirements can introduce delays. Burlew et al. noted that even in Level 1 trauma centres, the time from patient arrival to successful AE often exceeds 3 hours (16).

Comparative analyses have examined the benefits and limitations of PPP vs AE. Osborn et al. found that PPP resulted in improved early survival rates compared to AE in patients presenting with profound hypotension (24). Hsu et al. compared PPP-first and AE-first approaches in 72 patients and concluded that the PPP-first strategy was associated with significantly shorter time to haemorrhage control and improved 24-hour survival (25). However, a recent meta-analysis by Migliorini et al. found no significant differences between AE and PPP with regard to in-hospital mortality, volume of blood transfused, or the duration of stay in ICU and overall hospitalisation (26). Although this analysis pools data from observational studies and thus, may be deemed unreliable, these findings suggest that the two approaches should not be viewed as competitors but rather as complementary tools in a staged, context-dependent strategy until stronger evidence suggests otherwise (27).

Real-world application of these techniques must consider resource availability, institutional protocols and ever-evolving research. In well-equipped trauma centres, AE may be available around the clock. However, in resource-limited settings, PPP may be the only viable option in the acute phase. Thus, clinical judgment, team coordination, and systems-based thinking are crucial. The decision to perform PPP or AE must factor in the patient's physiology, imaging findings, and the speed with which each intervention can be delivered (19,21,27). Hybrid operating rooms that are equipped for both surgery and interventional radiology can be implemented to allow simultaneous use of PPP and AE without moving the patient (16,27).

Despite their proven efficacy, both PPP and AE carry risks. PPP may lead to pelvic infection, pressure necrosis, or intra-abdominal sepsis if not managed carefully (16). AE carries risks of gluteal muscle necrosis, nerve damage, and impaired wound healing, particularly when embolisation is non-selective or bilateral (21). Therefore, a tailored, patient-specific approach is essential, one that weighs the urgency of intervention against the potential for complications (28,29).

Overall, pre-peritoneal pelvic packing and angioembolisation are both essential components of haemorrhage control, particularly in the early resuscitation of patients with unstable pelvic ring fractures. While PPP is the intervention of choice in the emergent management of haemodynamically unstable patients due to its rapid application and efficacy in venous bleeding, AE is invaluable for targeting arterial haemorrhage with high precision. The best outcomes are achieved not by choosing one over the other but by integrating them within a structured, evidence-based trauma protocol with the aim to optimise patients for definitive management pathways.

Definitive Management

Unstable pelvic ring fractures represent one of the most complex challenges in orthopaedic trauma and require coordinated surgical intervention to restore stability and prevent long-term disability. The principal options for operative management are external fixation (ExFix) and open reduction and internal fixation (ORIF). Although ExFix has traditionally been used both as a temporary and, in select cases, definitive measure, the balance of evidence increasingly supports ORIF as the preferred approach for restoring pelvic integrity and function (10,30). The choice between these interventions must be individualised, guided by haemodynamic stability, injury pattern, available expertise, and timing within the trauma pathway.

External fixation provides rapid mechanical stability, reduces pelvic volume, and mitigates ongoing haemorrhage, particularly when applied alongside pre-peritoneal pelvic packing (PPP). It is invaluable in the acute “damage-control” phase, especially for patients who remain haemodynamically unstable or are unfit for lengthy procedures (31). ExFix also facilitates simultaneous access for abdominal or vascular surgery. However, its limitations are increasingly recognised. The stabilising effect of external fixators is predominantly anterior, offering little control of posterior displacement or vertical shear injuries. As a result, maintenance of reduction can be

problematic, and secondary loss of alignment occurs frequently once physiological stability is restored. Long-term reliance on ExFix is further complicated by pin-site infections, skin tethering, patient discomfort, and difficulties with nursing care (31). Consequently, most trauma algorithms now consider ExFix a bridge to definitive fixation rather than an end point of treatment.

In contrast, ORIF allows anatomical reconstruction of the disrupted pelvic ring and provides rigid internal stabilisation of both anterior and posterior components. This results in superior biomechanical stability, more predictable bone healing, and earlier mobilisation (32,33). Matta and Saucedo (33) reported anatomical reduction (<1 cm displacement) in 74% of cases, achieving good or excellent clinical outcomes in nearly 80%. Their findings established the principle that restoration of normal pelvic anatomy is directly associated with functional recovery. Systematic reviews and multicentre studies by Papakostidis et al. and Gansslen et al. confirmed that internal fixation yields better radiological alignment, fewer malunions, and improved long-term function compared with external fixation (34,35). Percutaneous and minimally invasive variants of ORIF are now increasingly used to reduce blood loss and operative time while maintaining bio-mechanical strength.

Although the superiority of ORIF is widely accepted, the supporting evidence base still has methodological limitations. Much of the literature consists of retrospective or single-centre series, and direct randomised comparisons between ExFix and ORIF are scarce. This restricts the generalisability of outcomes and underscores the need for multicentre prospective trials with functional and quality-of-life endpoints rather than radiographic metrics alone. The optimal timing of definitive fixation remains contentious. Early fixation - ideally within 72 hours - has been associated with improved survival, shorter intensive-care stays, and fewer complications such as deep vein thrombosis and pneumonia (36). Yet, early surgery may heighten physiological stress in unstable or polytrauma patients. Decisions must therefore be made collaboratively by orthopaedic, trauma, and anaesthetic teams, balancing the benefits of early mobilisation against peri-operative risk. Hybrid operating rooms and integrated trauma networks can support such decision-making by allowing staged management within a single setting.

While ORIF provides biomechanical superiority, it carries technical and clinical risks. Complex posterior approaches are associated with increased operative time, blood loss, and potential neurovascular injury (37). Infection, implant failure, and hardware irritation remain notable post-operative challenges. Despite these risks, most studies demonstrate that the long-term functional benefits outweigh peri-operative complications. ORIF enables earlier weight-bearing, faster return to pre-injury activity, and reduced chronic pelvic pain compared with prolonged external fixation (38). Functional scoring systems such as the Majeed Pelvic Score consistently show higher satisfaction and return-to-work rates following ORIF, particularly in Tile B and C injury patterns (39-41). Importantly, the quality of fracture reduction, rather than the fixation method alone, remains the strongest predictor of functional recovery.

Definitive management of unstable pelvic ring fractures requires a stratified, patient-centred strategy. External fixation remains indispensable as a rapid, temporising measure to control haemorrhage and stabilise the pelvis, but its mechanical limitations restrict its role as a final solution. ORIF, when performed by experienced teams within an optimised trauma pathway, provides superior anatomical restoration, mechanical stability, and long-term function (37). Future research should focus on standardising timing protocols, evaluating minimally invasive fixation techniques, and integrating patient-reported outcome measures into routine assessment. The evolution of multidisciplinary trauma care - including the development of hybrid theatres and coordinated resuscitation-to-repair workflows - will continue to refine how ExFix and ORIF are used in tandem to improve both survival and quality of life for patients with unstable pelvic ring fractures.

Conclusion

In conclusion, unstable pelvic ring fractures remain amongst the most challenging injuries in trauma care due to their complex anatomy, high haemorrhage risk and associated multisystem injuries. PPP and AE continue to be invaluable tools for haemorrhage control, with PPP offering rapid control of venous bleeding and AE targeting arterial haemorrhage. For fracture stabilisation, although ExFix helps in the temporary stabilisation of the pelvic, especially in patients who have sustained major trauma, ORIF is the definitive management. As surgical expertise, imaging, and

implant technology continue to evolve, the role of ORIF in pelvic trauma will remain central to the multidisciplinary care of these complex injuries. As such, the trajectory of care for patients with unstable pelvic ring fractures rely on a coordinated, multidisciplinary approach across the prehospital, resuscitative and definitive management phases. Integration of haemorrhage control with best practices in definitive fixation, prioritisation of early diagnosis and investment in hybrid trauma care systems can aid trauma teams to optimise survival in this high-risk patient population.

Author's Contributions

Kayaththery Varathan: conception, methodology, data curation, writing - original draft preparation; Adele Zacken: writing-original draft, methodology, conception, data curation; Mustafa Albayati: writing - original draft, reviewing and editing, supervision; Vishwajeet Singh: supervision, conceptualization, methodology; Uzair Khan: writing - reviewing and editing; Janusha Ganesthasan: writing - reviewing and editing; Shanmuka Koppolu: writing - reviewing and editing; Havil Stephen Alexander Bakka: writing - reviewing and editing, supervision; Ruqaiya Al-Habsi: writing - reviewing and editing.

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Conflicts of Interests

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Ethical Statement

This study is a literature review and did not involve direct research with human participants or animals. All sources used were appropriately cited, and the review was conducted in accordance with ethical standards for academic integrity and research transparency.

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