# Pelvic fracture bleeding control: What you need to know

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**ABSTRACT:** Significant bleeding due to pelvic fracture is associated with high mortality and must be treated promptly to optimize outcomes. The initial evaluation should focus on hemostatic resuscitation, placement of a pelvic binder, and evaluation for additional nonpelvic sources of hemorrhage. There are several options for pelvic hemorrhage control including external fixator placement, angioembolization, preperitoneal pelvic packing, and open internal iliac ligation or surgical embolization of the internal iliac artery. The specific hemorrhage control intervention selected to control pelvic bleeding must be tailored to the patient's physiologic status and local resource availability. This article discusses "What You Need to Know" to provide optimal care for patients with hemorrhage due to severe pelvic fracture. (*J Trauma Acute Care Surg.* 2025;00: 00–00. 

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**KEY WORDS:** Pelvic hemorrhage; pelvic packing; angioembolization; external fixation; hemorrhage control.

Pelvic fracture after blunt injury is a common occurrence, often without significant hemorrhage, and managed by either weight-bearing restrictions or operative fixation. In a subset of patients, pelvic fracture is a life-threatening injury because of significant pelvic hemorrhage from arterial, venous, and bony sources. Despite decades of research, improved hemostatic resuscitation, techniques for endovascular hemorrhage control, and new treatment paradigms, mortality remains high in patients with severe pelvic fractures who present in shock.[1–3] In fact, a recent American Association for the Surgery of Trauma, multicenter, observational study of patients with pelvic fractures from 11 centers demonstrated a mortality of 32% in the 178 patients presenting in shock.[1] An important finding from this study was the significant variability in hemorrhage control interventions performed between various centers.

Optimizing care pathways for patients with severe pelvic fractures was identified by subject matter experts as a high-priority research topic in a recent research gap analysis using a Delphi approach as part of the National Trauma Research Action Plan.[4] Improving care for patients with severe pelvic fractures requires an organized systematic approach that takes into account the patient's hemodynamic status, potential for concurrent nonpelvic hemorrhage, and the availability of local resources for hemorrhage control. Here, we will highlight "What You Need to Know" to provide optimal care for patients with severe pelvic fractures associated with hemodynamic instability.

## INITIAL EVALUATION AND RESUSCITATION

As with all trauma patients, the initial evaluation should focus on assessing and treating any potentially life-threatening conditions. For patients presenting with hypotension or shock, hemostatic resuscitation should be initiated promptly. An initial pelvis x-ray in the trauma resuscitation area will identify a pelvic fracture. While certain pelvic fracture patterns are more associated with a need for hemorrhage control, including open-book and vertical shear (VS) fractures, any pelvic fracture can cause significant hemorrhage (Fig. 1).[5] The physical examination must evaluate for perineal or genitourinary injury associated with the pelvic fracture. Open wounds in the perineum because of open pelvic fractures are at risk for significant hemorrhage and should be packed promptly.

Resuscitation should be, preferentially, with whole blood or blood components in a ratio of 1:1:1 (packed red blood cells [PRBCs]/plasma/platelets) to minimize the deleterious effects of trauma-induced coagulopathy and following the principles of hemostatic resuscitation.[6–8]

### Pelvic Binder Placement

In the event of a suspected pelvic fracture, the immediate application of pelvic binders or sheets is recommended for the initial hemostasis.[9] A 5-cm opening of the pelvic ring is associated with an increase in pelvic volume of 10% to 20%.[10] Furthermore, bleeding from dislocated bone fragments also contributes

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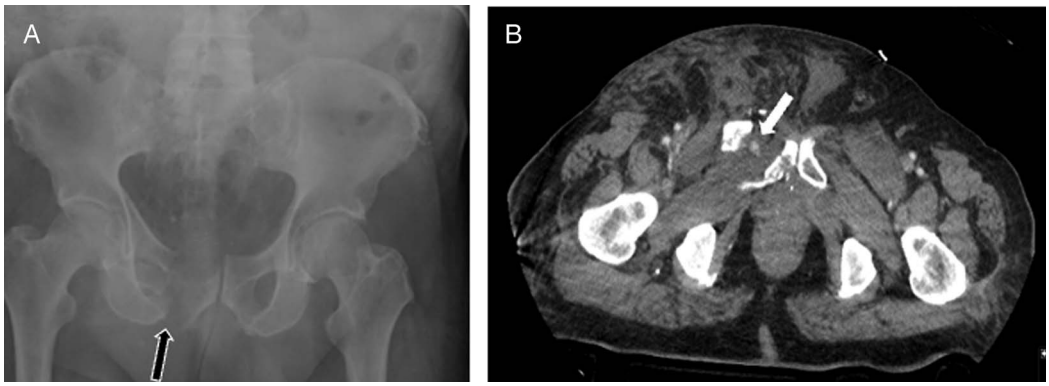


**Figure 1.** (*A*) Pelvic x-ray demonstrating pelvic fracture (black arrow). (*B*) Computed tomography angiogram of the pelvis demonstrating arterial blush (white arrow) consistent with active hemorrhage.

to retroperitoneal hematomas. The application of pelvic binders at the level of the greater trochanter is recommended. In addition, both legs should be internally rotated for optimal benefit; this can be stabilized by securing the ankles together.[11] Both clinical and biomechanical studies have demonstrated that pelvic binders/sheets provide adequate initial stability, affect initial blood pressure, improve hemostasis, and reduce mortality.[12–14] The optimal duration of treatment with pelvic binders/sheets remains under discussion. Local soft tissue injuries (e.g., Morel-Lavallée lesions, open fractures, etc.) represent a limitation for prolonged use, and patients with prolonged binder placement should be continuously examined for skin lesions.

## Obtaining Hemorrhage Control

Patients with pelvic fractures who present in shock often have associated injuries and carry a risk for additional sites of nonpelvic hemorrhage.[1] The evaluation must promptly assess for the nonpelvic hemorrhage sources, as this may dictate the next steps in care. Focused assessment with sonography for trauma should be performed to evaluate for intraperitoneal bleeding. Focused assessment with sonography for trauma is highly specific for detecting intraperitoneal hemorrhage in patients with pelvic fracture ,[15] with a positive focused assessment with sonography for trauma potentially dictating a need to promptly address both intra-abdominal and pelvic hemorrhage in the operating room. Several options for pelvic hemorrhage control can be used and must be tailored to the patient's physiologic status and resource availability.[16] Time to hemorrhage control is a predictor of mortality in patients with severe pelvic fractures; therefore, deciding where to transport the patient for hemorrhage control intervention is critical in these high-risk patients.[17]

# PELVIC EXTERNAL FIXATION

Severe high-energy pelvic ring disruptures are frequently associated with significant hemorrhage, even in the absence of concomitant abdominal or great vessel injuries.[18,19] The term *unstable pelvic ring*, as defined by Young and Burgess, is based on the mechanism of injury and refers to anterior-posterior compression (APC) type II/III, lateral compression (LC) type III, VS, and combined mechanism (Fig. 2).[20,21] The AO/Tile classification, based on vertical and rotational stability, indicates that types B (partially unstable) and C (completely unstable) are unstable pelvic ring fractures.[22] The early recognition and treatment of life-threatening hemorrhage are of paramount importance in the management of patients with hemodynamically unstable pelvic ring injuries. It has been demonstrated that typical fracture and dislocation patterns of the pelvic ring are associated with significant pelvic hemorrhage. This is evidenced by 30% of APC II patients and 66.3% of APC III patients presenting with circulatory shock, while 31.8% of LC II patients present with circulatory shock. This is due to severe disruption of the pelvic floor, venous plexus, and major ligament ruptures.[18]

The temporary external fixation of a disrupted pelvic ring is regarded as a component of the acute resuscitation strategy.[23,24] The reduction of bone fragments and stabilization of the fracture reduces local bleeding and allows blood clots to form.[24,25] In the event of a complete rupture of the parapelvic fascia (gluteal muscles and iliopsoas compartment), the tamponade effect of the external stabilization may be insufficient to control the bleeding, as the so-called "chimney effect" occurs: the pelvic bleeding is extended into the retroperitoneal space. For hemodynamically unstable patients undergoing preperitoneal pelvic packing (PPP), placement of an external fixator prior to packing is recommended.[26] The application of a pelvic fixator provides a stable pelvic frame into which packing can provide and effective tamponade of pelvic space bleeding.

External fixation represents the most frequently used technique for the emergency stabilization of an unstable pelvic ring on a global scale.[27] In particular, temporal stabilization with external fixation is an effective provisional treatment for APC II, APC III, LC II, and LC III injuries, providing adequate reduction and retention of the malrotated pelvis.[28] The two most common external fixation techniques for the pelvis are the iliac crest and the supra-acetabular stabilization. Hereby, Schanz pins (5–6 mm in size) are either inserted into the iliac crest (two Schanz pins are recommended) or one pin through the supra-acetabular corridor (Fig. 3).[29] Biomechanical studies favor the supra-acetabular route for higher stability and good bone quality.[24,30] Furthermore, the utilization of two parallel connecting rods appears to offer enhanced translational and rotational stabilization.[31] Positioning the Schanz pin in the iliac crest is a more straightforward process; however, there is a higher prevalence of complications such as loosening and dislocation.[32]

In cases of severe posterior dislocation or comminution, such as those involving VS or combined mechanism fractures,

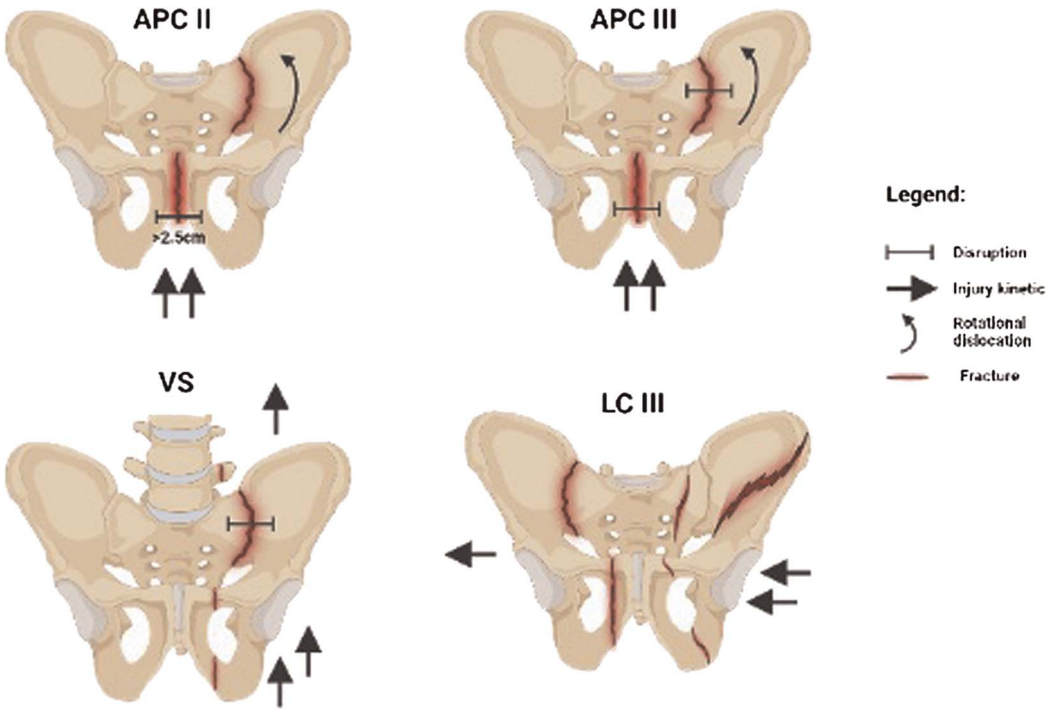


**Figure 2.** Unstable pelvic fractures according to Young and Burgess includes APC II, APC III, VS, and LC III (figure created with Biorender).

anterior fixation of the pelvic ring may not be sufficient.[33,34] The same applies to patients with bilateral spinopelvic dissociation. In these cases, additional posterior stabilization of the pelvis may be necessary to effectively control the associated retroperitoneal hemorrhage. The literature indicates that the use of temporal fixation of the posterior pelvic ring with C-clamps is rarely used.[27] However, a recent study reported a positive effect of C-clamp application in hemodynamically unstable patients with regard to hemodynamic stabilization.[35] It is important to note that applying high forces with a C-clamp may increase the risk of sacroiliac displacement or overcompression.[36] The aforementioned side effects have resulted in the C-clamp being used with great restraint. Other studies have proposed the use of the so-called "antishock" screws for the less invasive stabilization of the posterior pelvic ring.[37–39] A recent biomechanical study reports that even a single sacroiliac screw at the S1 level provides greater stability than most common external fixation configurations.[40] This procedure requires expertise in percutaneous pelvic surgery and is predominantly used in institutions with a high patient load.[27] Nevertheless, there is a paucity of large-scale studies, and the level of evidence remains low. Future analyses may provide insight into the role of this strategy in the emergency stabilization of unstable pelvic injuries.

## PELVIC ANGIOEMBOLLIZATION

The practice of pelvic angioembolization (AE) is far from new; the first description of the practice in the injury context was more than 50 years ago.[41] That report discussed the use of the patient's own clotted blood as an embolic agent. Other techniques, as old or even older, include coil embolization and Gelfoam injection.[42,43] Even newer techniques using liquid agents or vascular plugs are at least 20 years old.[44,45] While major advancements in the technology and methods of pelvic AE have been made, they are trivial compared with the evolution of the decision-making and logistics surrounding the treatment. Components of optimal pelvic AE practice are prioritization of speed, proper selection of patients for angiography and embolization, and coordination of endovascular intervention with other needed operative procedures.

### Angiography Patient Selection

Multiple studies have shown that delays in pelvic AE are associated with increases in length of stay and mortality, even if those delays are attributable to resuscitation.[46–48] While the role of computed tomography (CT) angiography in detecting arterial bleeding has been well established, a lack of axial imaging does not provide a contraindication to emergent angiography.[49] If a patient is hypotensive with a concerning pelvic fracture on plain radiography and has no more plausible reason for their shock, angiography in the absence of CT imaging is reasonable. In fact, given the variable sensitivities of CT angiography in predicting the need for AE, angiography in hypotensive patients if CT shows no active extravasation but substantial pelvic hematoma is generally prudent.[50,51]

The use of the hybrid operating room enables several therapeutic options if no bleeding is seen on the angiogram, including visceral angiography, exploratory laparotomy, or, if pelvic venous hemorrhage is suspected, preperitoneal packing and external fixation.[52,53]

Typical pelvic angiography involves femoral arterial access, aortoiliac angiography, and selective angiography of the bilateral common and external iliac arteries and the anterior and posterior divisions of both internal iliac arteries. When possible, power injection is used for standardization of injection

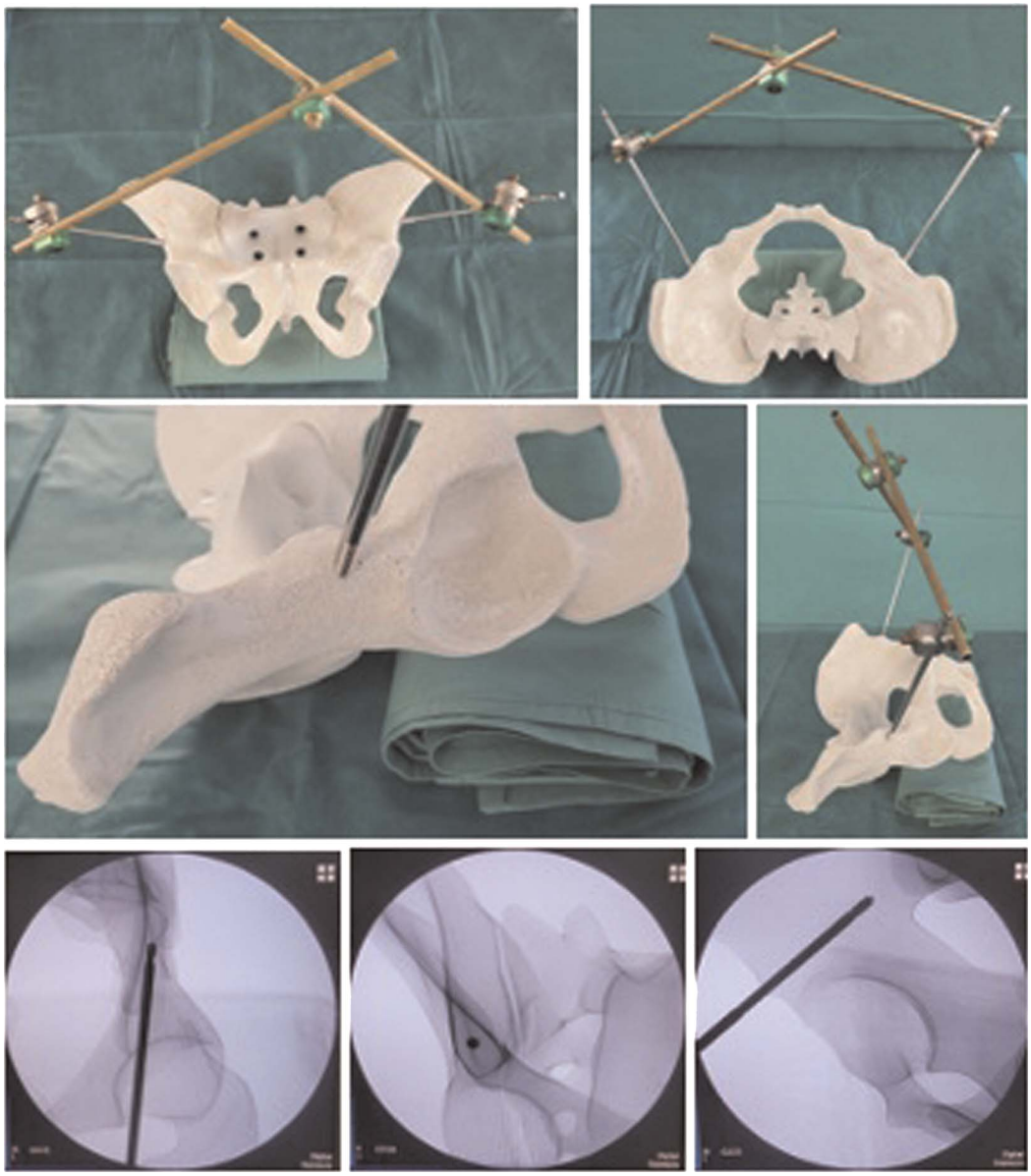

**Figure 3.** Photographic and radiographic images of supra-acetabular external fixation.

dynamics and the ability to generate sufficient injection pressure to overcome any transient temporizing effects in place. While some have advocated radial access, the sheath and catheter lengths of this approach necessarily limit therapeutic options should they be required. The added challenge of ipsilateral internal iliac cannulation with femoral access is trivial and does not justify avoiding the technique.

Angiography should include injection of the external iliac arteries and the bilateral common femoral arteries. The ascending branch of the lateral femoral circumflex artery, the superficial and inferior epigastric arteries, and the external pudendal arteries can all be injured. Pelvic vascular trauma is by no means limited to the branches of the internal iliac arteries. If a pelvic binder precludes femoral access, replacing the binder with one around the upper thighs, still enabling effective reduction, is more rapid than cutting a window in the existing binder.

## Embolization Patient Selection

Empiric embolization in the absence of some evidence of arterial abnormality is vehemently discouraged. While the endovascular literature describes only minimal consequences from an internal iliac artery embolization in the setting of aneurysmal or occlusive arterial disease, their application to the injured patient is unwise. The patient with blunt pelvic injury has suffered disruption of the dense network of pelvic collateral vessels that allows, in the uninjured patient, persistent perfusion of the hemipelvis with proximal occlusion.[54]

The angiographic appearance of blunt arterial injury is not limited to extravasation. Abnormalities such as abrupt truncation of the flow lumen, a substantial discrepancy in size compared with the contralateral vessel, or even localized areas of spasm are all indicators of severe injury. Direct and selective angiography often reveals the extravasation that was not apparent with more proximal contrast injection.

### Methods of Embolization

The guiding principle of embolization for trauma is to maximize precision and minimize the chances of ischemia. This manifests as distal selective embolization whenever possible and as the use of microcatheter coils over liquid embolic agents, especially since the latter often requires prolonged preparatory time. If the vessel to be embolized is sufficiently proximal to allow cannulation by a 0.035″ catheter, a thrombin-Gelfoam slurry is an attractive option. If proximal embolization is unavoidable, Amplatzer plugs are rapidly deployed to good effect.

The goal in embolization, whether pelvic or otherwise, is not to obliterate the lumen of the target vessel with a solid and extended mass of platinum. Rather, judicious delivery of a few coils results in sufficient blood flow stasis to allow thrombosis within 15 to 20 minutes.

### Zone III REBOA and Embolization

Occasionally, a patient's hemodynamic instability requires the deployment of a Zone III resuscitative endovascular balloon occlusion of the aorta (REBOA) before angiography. Access to the contralateral common femoral artery is preferable to "double sticking" the ipsilateral vessel. Deflation of the balloon is helpful to allow adequate flow for angiographic demonstration of the injury, but it is not mandatory. Power injection with a low rate and high volume followed by a heparinized saline "chaser" bolus can usually guide the more selective injection.

### Hybrid Operating Rooms and an Endovascular Trauma Service

The benefits of the hybrid operating room cannot be overstated. Hybrid operating rooms allow active and aggressive resuscitation, while angiography is underway and enables seamless transitions from exploratory laparotomy to angiography to external fixator placement. Similarly, the presence of trauma surgeons who are skilled at endovascular intervention ensures that any procedure will be tailored to the patient's other injuries and physiology rather than guided by a desire to obtain a satisfying completion angiogram.

## PREPERITONEAL PELVIC PACKING

Preperitoneal pelvic packing is optimally suited for patients with pelvic fractures in persistent shock, defined as a systolic blood pressure less than 90 mm Hg, despite the placement of a pelvic binder and transfusion of 2 U of PRBCs.[55,56] This approach to control pelvic hemorrhage becomes especially important in hospital settings without emergent AE services.[23] The benefits of PPP include (1) shortened time to bleeding control; (2) decreased mortality; (3) rapid cessation of hemorrhage through control of venous, arterial, and bony sources of bleeding; (4) the ability to perform additional lifesaving operative interventions concurrently; and (5) the ability to use other adjuncts, such as REBOA and AE, in a complimentary manner.

One of the main advantages of PPP is that it can be performed rapidly. It has been repeatedly demonstrated that both the time to intervention and the time required for intervention are significantly shorter for PPP than for AE. The average time to initiation of the procedure ranges from 44 to 77 minutes for PPP versus 102 to 286 minutes for AE.[55,57–61] The average time required to complete operative intervention was 5 to 87 minutes for PPP and 50 to 330 minutes for AE.[56,59,62–64] The rapidity with which PPP can be performed is associated with reduced mortality rates and transfusion requirements.[26,55,57,63,65,66]

Approximately 80% of all bleeding associated with pelvic fractures is due to venous and bony sources, and only 20% is of arterial origin.[67] While AE is very effective for controlling arterial hemorrhage, it is less effective for managing venous and bony bleeding.[28] Preperitoneal pelvic packing, however, creates tamponade in the preperitoneal/extraperitoneal space, effectively managing all three sources of bleeding. In a study by Osborn et al.,[65] 50% of the angiography group underwent embolization as opposed to only 15% of the PPP group. This suggests that PPP is effective at halting the venous and bony sources of hemorrhage, which account for up to 85% of the primary source in patients. For the 15% of patients with significant arterial sources of hemorrhage, PPP permits stabilization of the patient. For this small group of pelvic fracture patients who have persistent transfusion requirements heralding arterial bleeding, PPP results in hemodynamic stabilization and the ability to effectively resuscitate the patient, resulting in less emergent transport to IR.[65]

Management of pelvic hemorrhage with PPP has the advantage of being performed in the operating room, where multiple surgical interventions may be performed concurrently. Approximately 50% of patients with pelvic fractures and hemodynamic instability have significant sources of bleeding other than the pelvis.[59] In addition, 43% to 87% of patients undergoing PPP require additional procedures (laparotomy, thoracotomy, craniotomy, external fixation of fractures, fasciotomy, etc.) other than control of pelvic hemorrhage.[26,59,61] Earlier hemorrhage control achieved by performing multiple operative procedures concurrently or in rapid succession may contribute to improved resuscitation, decreased 24-hour postprocedure transfusion requirements, and improved early mortality.[65]

Preperitoneal pelvic packing should be used in combination with other indicated adjuncts, including REBOA and AE, for the optimal management of pelvic fracture-associated hemorrhage. The full advantages of these complimentary procedures are discussed elsewhere in this article. Briefly, REBOA should be used for temporary hemorrhage control in patients with persistent systolic blood pressure below 70 to 80 mm Hg.[66,68] Werner et al.[68] examined the use of REBOA in combination with PPP and demonstrated no significant difference in the mortality rate between patients managed with and without REBOA prior to PPP despite a significantly higher injury severity score and more severe physiologic derangements in the REBOA group. This suggests that there may be a mortality benefit associated with the use of REBOA in combination with PPP for early hemorrhage control in patients with severe shock. In addition, the mortality rate after adding REBOA to the Denver pelvic fracture protocol was lower than historically reported mortality rates for

pelvic fracture patients in hemorrhagic shock (14% vs. 21%), and there were no deaths due to hemorrhage in their most recent patient cohort.[68]

Angioembolization is complementary to PPP and should be performed in patients with evidence of ongoing bleeding after external skeletal fixation and PPP are performed. Angioembolization is recommended for PPP patients who receive ≥4 U of PRBCs postoperatively after their coagulopathy has been corrected. Approximately 13% of patients with pelvic fracture-related hemorrhage initially managed with PPP will require AE, but this can be delayed, allowing for additional procedures and resuscitation; in fact, the mean time to AE was actually 10 hours after PPP completion.[26,55,56,62] Performing PPP prior to AE temporizes arterial bleeding, allows time for resuscitation and stabilization prior to sequestration of the patient in the angiography suite, provides time for interventional radiology to prepare for AE, and decreases mortality as compared with patients who do not undergo PPP prior to AE.[55,58,62]

### Technique for Performing PPP

To perform PPP, an external fixator or a pelvic C-clamp is ideally applied to stabilize the pelvis prior to beginning the operation. External pelvic stabilization prior to PPP provides a stable surface to pack against and reduces the pelvic volume, both of which aid in achieving tamponade. If neither external fixation nor C-clamp is available, one should move the pelvic binder inferiorly below the symphysis so that it is not in the operative field. After standard sterile prep is performed, a 6- to 8-cm midline incision is made, extending from the pubic symphysis superiorly. If a laparotomy is also required, it is important to make the laparotomy incision separate from the PPP incision to prevent decompression of the pelvic hematoma into the abdomen. The subcutaneous tissue and midline fascia are divided, but the peritoneum is left intact. Generally, the pelvic hematoma has dissected the preperitoneal space. If the hematoma is not readily visible upon entering the preperitoneal space, gentle blunt dissection posterior to the pubic symphysis and then laterally into the paravesical space (i.e., around the bladder toward the sacrum) will access the hematoma. Three laparotomy pads are placed on either side of the pelvis. The first laparotomy pad is placed down to the presacral space, and the other two laparotomy pads are packed on top of the first around the bladder. This is repeated on the opposite side of the pelvis. Infrequently, one or two additional laparotomy pads must be inserted to achieve tamponade. If a suprapubic tube is required for bladder drainage due to a urethral injury, it should be placed at this point in the operation. A separate stab incision lateral to the midline should be used for the suprapubic tube. This prevents decompression of the pelvic hematoma along the tube. The midline fascia is then closed with running heavy-weight monofilament sutures, and staples are used to close the skin.

The pelvic packs are removed approximately 24 to 48 hours after PPP is performed. The packs should not be removed until the patient's coagulopathy and physiologic derangements have been corrected. If the packs are adherent to the surrounding tissues, soak them with saline prior to removal. Gently remove the packs from one side of the pelvis at a time and explore the space for ongoing bleeding. Hemostasis using clips, sutures, topical hemostatic agents, or electrocautery should be achieved, and repacking the pelvis should be avoided because of the increased risk of infectious complications. If any large venous injuries are encountered, repair or ligation is performed. Once all packs have been removed and ongoing bleeding has been controlled, the fascia and skin are closed in the standard fashion.

### Risks of PPP

The most common complication associated with PPP is pelvic space infection, which is most commonly seen in patients with bladder or bowel injuries or with open fractures. One of the major risk factors associated with pelvic infection in this patient population is the need for repacking the pelvic space. In patients who had repacking of the pelvic space (i.e., there was bleeding identified at the time of the first unpacking that led to repeat packing as a temporizing measure), 45% to 47% of patients developed infection; this highlights the importance of normalizing physiology and correcting coagulopathy before removing the pelvic packs. Only 4% to 6% of patients with a single episode of PPP develop pelvic space infections, similar to the 3.7% pelvic infection rate reported by Li et al.[69] for patients undergoing AE.[26,55,57,60]

## INTRAOPERATIVE BLEEDING CONTROL

In the unusual circumstance of a large pelvic hematoma ruptured into the peritoneal cavity with massive bleeding found during an exploratory laparotomy for shock and free abdominal fluid, an astute surgeon must first realize that packing the pelvis in the face of massive pelvic bleeding will not be effective, as the blood flowing from the pelvic and retroperitoneal space into the peritoneal cavity will quickly displace all the packs from the pelvic region. Therefore, an attempt to obtain surgical hemostasis is indicated.

There are two methods that can be utilized to obtain surgical hemostasis. The first is (bilateral) internal iliac artery ligation, which can be permanent or temporary. The second is to perform an intraoperative embolization of the iliac arteries to achieve results similar to those of the catheter-based AE in the angio suite or a hybrid operating room.

### Internal Iliac Artery Ligation

In patients with pelvic fractures undergoing laparotomy for intraperitoneal sources of hemorrhage, ligation of bilateral internal iliac arteries is a useful approach to aid with pelvic hemorrhage control.[2,70,71] This technique requires exploration of the pelvic hematoma and dissection of bilateral internal iliac arteries just past the bifurcation from the common iliac artery. The internal iliac arteries can be encircled with a vessel loop.[72] Alternatively, vascular clamps or Rummel tourniquets can also be applied to the origin of the internal iliac arteries for temporary occlusion. The pelvic hematoma can then be treated with topical hemostatic agents and packed for added hemorrhage control. The abdomen is temporarily closed, and the patient returns to the operating room when appropriate for removal of the vessel loops or vascular clamps to restore flow to the bilateral internal iliac arteries. Alternatively, a definitive ligature applied to the proximal internal iliac artery is performed, the pelvis is packed, and a reoperation occurs when the physiologic derangements

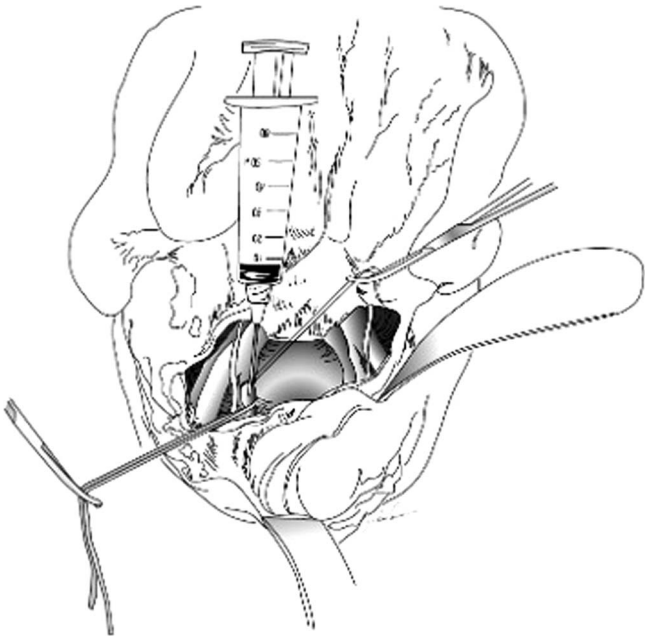

**Figure 4.** Intraoperative surgical embolization of the internal iliac artery. The internal iliac artery is isolated, and a 60-mL syringe with a blunt tip is inserted into the arterial lumen for injection of a solution of blood clot mixed with a sterile thrombotic gelatin hemostatic agent. Illustration by Sara Edwards, MD, FACS.

have improved. There are two issues with the internal iliac temporary or permanent occlusion strategy. First is the issue related to the inability to perform AE if the patient rebleeds or continues to bleed while in the intensive care unit, as the internal iliac artery can no longer be cannulated, requiring an emergent return to the operating room. The second is related to ineffective hemostasis, which occurs more often when the surgical occlusion (temporary or permanent) of the internal iliac artery is done unilaterally. In this circumstance, because of the natural anastomosis between both sides of the internal iliac artery system, blood from the nonligated side will fill the ligated side, leading to bleeding. However, even after proximal bilateral occlusion of the internal iliac arteries, bleeding may occur because of the natural collateral circulation communicating the distal lumbar arteries with the internal iliac arterial system and this system with branches of the common and deep femoral arteries.[73]

## Intraoperative (Surgical) Embolization of the Internal Iliac Arteries

The intraoperative (surgical) embolization of the internal iliac arteries to control exanguinating pelvic hemorrhage due to trauma was initially described by Saueracker et al.,[74] in 1987. The authors reported on four patients, two after penetrating trauma (stab wounds to the buttocks) and two after a motor vehicle crash sustaining pelvic fractures. The procedure included identification of the proximal internal iliac artery, which was ligated, and embolization of the distal iliac artery with 30 to 40 mL of a slurry of clot, microfibrillar collagen, topical thrombin, and calcium chloride, injected via a transverse arteriotomy distal to the ligation of the internal iliac artery over a period of 20 minutes. The pelvic bleeding was controlled in all four patients, although three died of other causes.

**TABLE 1.** Summary of "What You Need to Know" to Provide Optimal Care for Patients With Severe Bleeding Pelvic Fractures

| | |
|---|---|
| Initial evaluation and resuscitation | |
| Initiate hemostatic resuscitation | Massive transfusion protocol, whole blood, 1:1:1 transfusion |
| Obtain pelvis radiograph | Assess pelvic fracture pattern |
| Evaluate for perineal wounds | Examine for GU or rectal injury, pack open wounds |
| Place pelvic binder | Internally rotate ankles, decrease pelvic volume if open book fracture pattern |
| Evaluate for nonpelvic sources of hemorrhage | Chest radiograph, FAST examination to evaluate for intraperitoneal bleeding |
| Assess physiologic status and response to resuscitation | |
| Hemodynamically stable | Determine if patient is safe for CT scan, consider mobilizing interventional radiology based on CT scan findings |
| Hemodynamically unstable, transient responder | Consider immediate angiography or preperitoneal packing in OR. Consider REBOA placement prior to transport. |
| Concern for intraperitoneal hemorrhage | OR for laparotomy to address intraperitoneal bleeding with PPP for pelvic hemorrhage |
| Obtain pelvic hemorrhage control | |
| External pelvic fixator placement | Stabilize fracture to decrease pelvic bleeding, use as an adjunct to PPP |
| AE | Consider hemodynamic status, may be performed without prior CT scan; distal, selective AE is preferred |
| PPP | Should be used for patients with pelvic fractures in persistent shock; also used in patients with concomitant intraperitoneal injury and as a "bridge" to angiography |
| Internal iliac artery ligation | Can be useful during laparotomy for significant pelvic hemorrhage; perform permanent ligation or temporary occlusion and remove it during the reoperation |
| Surgical embolization of the internal iliac artery | Option for treating significant pelvic bleeding during laparotomy; inject slurry of clot and sterile thrombotic gelatin into arterial lumen via a transverse arteriotomy |

FAST, focused assessment with sonography for trauma; GU, genitourinary; OR, operating room.

One of the authors of the present article has reported 14 cases of massive pelvic hemorrhage (R. Coimbra, MD, PhD, oral communication, November 10, 2015), treated by a similar technique (Fig. 4) over a period of 30 years. Thirteen patients had complex, unstable pelvic fractures, and one patient sustained an AK-47 injury to the left lower quadrant. The injection of clot mixed with a sterile thrombotic gelatin sponge (i.e., Gelforam) in a 60-mL syringe attached to a blunt tip needle inserted in the arterial lumen through a small arteriotomy arrested the hemorrhage in all 14 patients. There were no intraoperative deaths, and the overall mortality rate was 50% (seven patients). Two survivors developed impotence, but there was no ischemic insult to the rectum, bladder, or buttocks. It seems that, if a patient is bleeding profusely from the pelvis into the abdomen because of a ruptured retroperitoneum, an intraoperative (surgical) embolization, similar to a catheter-based AE, is preferable to a simple ligation, either temporary or definitive, of the internal iliac artery.

## CONCLUSION

Patients with hemorrhage from pelvic fractures are at high risk for serious complications and death. Several potential interventions for pelvic bleeding control can be deployed successfully depending on the patient's clinical status and resource availability. Understanding the benefits and limitations of these therapeutic strategies for hemorrhage control is critical in providing timely intervention and addressing nonpelvic hemorrhage when present. A systemic, organized, multidisciplinary approach is required to provide optimal care for patients with severe pelvic fractures presenting in shock (Table 1).

### AUTHORSHIP

R.C. contributed in the conception and study design. T.W.C., C.C.B., W.R.J., R.P., F.K.-L.K., R.K., T.M.S., and R.C. contributed in the literature review. T.W.C., C.C.B., W.R.J., R.P., F.K.-L.K., R.K., T.M.S., and R.C. contributed in the drafting of the manuscript. T.W.C. and R.C. contributed in the critical revision.

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### DISCLOSURE

Conflicts of Interest: Author Disclosure forms have been supplied and are provided as Supplemental Digital Content (http://links.lww.com/TA/E389).

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