PRACTICE MANAGEMENT GUIDELINES FOR HEMORRHAGE IN PELVIC FRACTURE

The EAST Practice Management Guidelines Work Group:

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I.   Statement of Problem

The problem of pelvic hemorrhage in the face of pelvic fracture after trauma is a broad and difficult topic to address directly. There is a myriad of variations which precludes a direct assessment of the clinical situation. For this reason, the topic was focused on three core questions.
   1. Which patients warrant early external stabilization?
   2. Which patients warrant pelvic angiography and possible embolization?
   3. Which patients warrant urgent or emergent laparotomy?

II.   Process

Identification of References

A computerized search of the world's literature was undertaken using Medline extending back to 1970 using the key words "pelvic fracture". The 459 citations were identified. The abstract for each was reviewed, and all papers having possible applicability to the guideline topic were retrieved and reviewed. General reviews, letters to the Editor, single case reports, and retrospective reviews of poor quality were excluded. This left 35 manuscripts which were felt to have sufficient merit to form the basis for the guidelines. These manuscripts were then specifically reviewed and categorized as Class I, II, or III references.

III.   Recommendations

A.   Level I

There are no Class I references upon which level I recommendations can be made.

B.   Level II

1) Which patients with pelvic fracture warrant early external stabilization?

   a)   Patients with evidence of unstable fractures of the pelvis associated with hypotension should be considered for some form of external pelvic stabilization.
   b)   Patients with evidence of unstable pelvic fractures who warrant laparotomy should receive external pelvic stabilization prior to laparotomy incision.

2) Which patients warrant angiography and possible embolization?

   a)   Patients with a major pelvic fracture who have signs of on going bleeding after non-pelvic sources of blood loss have been ruled out should be

considered for pelvic angiography and possible embolization.

    b)   Patients with major pelvic fracture who are found to have bleeding in the pelvis, which cannot be adequately controlled at laparotomy, should be considered for pelvic angiography and possible embolization.

    c)   Patients with evidence of arterial extravasation of intravenous contrast in the pelvis by computed tomography should be considered for pelvic angiography and possible embolization.

3) Which patients with pelvic fracture warrant urgent or emergent laparotomy?

    a)   Patients with hypotension and gross blood in the abdomen or evidence of intestinal perforation warrant emergent laparotomy.

    b)   The diagnostic peritoneal tap appears to be the most reliable diagnostic test for this purpose. Urgent laparotomy is warranted for patients who demonstrate signs of continued intra-abdominal bleeding after adequate resuscitation, or evidence of intestinal perforation.

C.   **Level III**

1) Which patients with pelvic fracture warrant early external stabilization?

    a)   Patients with evidence of unstable fractures of the pelvis not associated with hypotension but who do require a steady and ongoing resuscitation should be considered for some form of external pelvic stabilization.

2) Which patients warrant angiography and possible embolization?

    a)   There are no level III recommendations.

3) Which patients with pelvic fracture warrant urgent or emergent laparotomy?

    a)   There are no level III recommendations.

IV. Scientific Foundation

A.   General

There are five essential body cavities into which a patient can lose a large volume of blood, the chest, the abdomen, the retroperitoneum, the muscle compartments, and the injury scene. The techniques available to assess blood loss into the chest and abdominal cavities, the muscle compartments and at the scene are reasonably rapid and accurate, but the retroperitoneum has remained obscure. It is well recognized that there is a poor correlation between the architecture of the pelvic fracture and the need for emergency hemostasis, and the plain film radiograph can only

be interpreted in light of dynamic and potentially difficult clinical decision making.[8, 11,22,23,26,27] The consequences of an incorrect assessment are considerable, as celiotomy for the sole indication of pelvic fracture hemorrhage control following blunt trauma is almost never the wisest choice. On the eve of the advent of pelvic angiography, Hawkins et al well summarized the current state of the management options for hemorrhage associated with pelvic fractures.[16] In their own series of 192 patients with pelvic fractures from 1966-1969, 35 required laparotomy for hemorrhage or intra-abdominal injury. Seven of the patients (20%) died, and massive hemorrhage and transfusion requirements appear to have been the primary mortal factor in each. In the discussion, Hawkins iterates well the concern of "becoming involved with massive bleeding deep in the pelvis" as a major reason why surgeons were so loath to undertake laparotomy in this situation, and so dissatisfied with the efficacy of hypogastric artery ligation, that it was recommended to transfuse 20 units of blood before embarking on operative intervention. They outlined six parameters upon which to base the decision for laparotomy: 1) Evidence of intraperitoneal bleeding or visceral perforation, 2) intraperitoneal bladder rupture, 3) the size of a palpable expanding suprapubic hematoma, 4) location and severity of the trauma, 5) x-ray evidence of bony fragments within the pelvis, and 6) blood loss exceeding 2500 cc that can not be attributed to the associated injuries. As the authors lamented that they had no original suggestions to improve controlling deep pelvic bleeding, they re-emphasized the two critical questions that remain with us today: First, is laparotomy indicated, and second, how is bleeding deep in the pelvis best managed?

B.   Which patients with pelvic fracture warrant early stabilization?

There are three basic types of pelvic stabilization to be considered; non-invasive techniques, external stabilization, and internal stabilization. Non-invasive techniques appear to be most appropriate for use in the trauma receiving area on patients found to have unstable pelvic fractures.[5-7,17,18,21,24] The current popular options include the use of a military anti-shock trouser (MAST), the use of a bed sheet tied tightly around the pelvis as manual reduction of the pelvic fracture is performed, or the use of proprietary devices specifically designed and marketed for such use. These options should be considered as temporizing measures bridging the gap from injury to more definitive stabilization.

The application of an external fixating device should be considered as early as possible in the treatment of unstable pelvic fractures associated with hypotension, and may be performed in the trauma receiving area, operating room, or intensive care unit, depending on the institution and the patient's associated injuries.[6,7,13,31] When the anterior external fixation device is being applied, the bridging bars should be placed inferiorly, that is over the groin area rather than over the lower abdomen to allow access into the abdomen should laparotomy be necessary. If laparotomy is to be performed in the presence of an unstable pelvic fracture, the external fixation device should ideally be placed prior to the initial skin incision as the anterior abdominal wall does contribute to limiting the degree of anterior pubic diastasis, and the pelvic volume will increase if the pelvis is not stabilized prior to the midline incision.[9,10]

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Internal stabilization should be considered definitive in nature and as such should be reserved for patients who have demonstrated hemodynamic stability.[13,31] Possible scenarios for which exceptions might be made and early internal stabilization performed may include the open book pelvic fracture with pubic symphysis diastasis who has remained warm and hemodynamically stable through laparotomy, or the lateral compression or malgaigne fractures which remain unstable in spite of external fixation and angiography intervention.

The reason as to why pelvic stabilization is effective in promoting hemodynamic stability in patients with unstable pelvic fractures has not been fully elucidated. It was formerly believed that reducing the pelvis back to its normal conformation reduced pelvic volume, and therefore limited the amount of blood loss to the retroperitoneal pelvic hematoma.[10] Further, keeping the pelvic volume small promoted tamponade of the bleeding sources in the pelvis.[3] Current popular opinion favors a concept that returning the bony pelvic components back into apposition allows the hemostatic pathways to control venous bleeding from small vessels and raw bony surfaces.[12] Maintaining them in stable, non-moving apposition prevents clot dislodgement, re-initiation of the thombotic process, and consumption of clotting factors. It seems likely aspects of all these theories are correct.

C.   Which patients warrant angiography and possible embolization?

The first report by Margolies in 1972 on the use of angiography in the management of pelvic fracture associated hemorrhage represented a fundamental change in the approach to pelvic fracture associate hemorrhage.[1] The frustration with the inadequacies of direct operative exposure and ligation of bleeding sources deep in the pelvis are well conveyed by Hawkins,[16] Fleming,[17] and Rothenberger,[20] and their manuscripts are worth reviewing. The addition of selective angiography and embolization to the armamentarium represented an entirely new modality in the treatment of bleeding secondary to pelvic fracture[19] and rapidly became widespread. Initially, angiography was reserved for those patients who, after initial resuscitation and pelvic immobilization, demonstrated signs of ongoing bleeding without an apparent source.[2,3,5,7,21-23] (It should be remembered that computed tomography was still a new modality as well, and lacked the resolution to identify bleeding sources.) The successes of the early experiences lead to broader indications[4,25,26] and earlier use of angiography.[4,6,11,25,28-30] However, attempts to identify fracture patterns that would be predictive of arterial injuries in the pelvis were unsuccessful.[8,11,22,23,26,27]

As the resolution power of computed tomography improved, CT developed the ability to identify arterial extravasation of intravenous contrast. The recognition of this fact in the pelvis has moved angiography out of the empiric and diagnostic role to a more strictly therapeutic role.[11,15,30,32,34,35]

D.   Which patients with pelvic fracture warrant urgent or emergent laparotomy?

The indications for laparotomy in the face of pelvic fracture and hypotension remain the same indications for laparotomy in the absence of pelvic fracture,

predominantly intra-abdominal hemorrhage and perforation of the gastro-intestinal tract. This discussion focuses on the issue once other sources of hypotension have been ruled out, such as tension pneumothorax, pericardial tamponade, hypovolemia, and volume resuscitation has been initiated.

There are four modalities available to help decide if the hypotensive patient with a pelvic fracture warrants laparotomy to control hemorrhage; diagnostic peritoneal lavage, diagnostic peritoneal tap, ultrasound, and computed tomography.

The use of diagnostic peritoneal lavage to diagnose surgical intra-abdominal bleeding has been demonstrated to be inaccurate based on traditional parameters of a positive lavage in patients with pelvic fracture.[4-6,22] Diapedesis of the red blood cells across the peritoneal renders a high percentage of false positive results. However, basing the decision on the findings of a supra-umbilical diagnostic peritoneal tap is sufficiently accurate to be an appropriate triage tool.[5-7] In the absence of 5-10 cc of gross blood on the tap, the decision to explore should be based on other diagnostic modalities, which may include the microscopic assessment of the lavage effluent for evidence of intestinal perforation.

The use of ultrasound in the form of the focused assessment for the sonographic examination of the trauma patient (FAST) continues to evolve, and the literature of the impact of pelvic fracture on the accuracy of FAST is limited. In 1999, Ballard reported 70 patients with pelvic fractures who were evaluated with FAST, 35 which involved the pelvic ring.[14] Overall, the FAST had an sensitivity of 24%, specificity of 100%, and an accuracy of 81%. The positive predictive value was 1.0 (based on four true positive and no false positive studies) and the negative predictive value was 0.8. Even more significant as the fact that 10 of the 13 patients with false negative studies had pelvic ring fractures. Four required laparotomy, and one patient died, although the authors do not comment whether this death is related to the false negative study. Ultrasound does not appear to be ideal diagnostic modality in the presence of fractures of the pelvic ring.

With strong emphasis on the caveat that the CT scan is not a tool for diagnosis in the acutely hypotensive or unstable patient, computed tomography is highly accurate in identifying intra-abdominal, retro-peritoneal, and pelvic blood and active bleeding.[15,32]

V.   Summary

Hypotension associated with major pelvic fractures continues to represent one of the most challenging injury patterns to address. In conjunction with the potential associated injuries, a straightforward outline to the therapeutic options or treatment algorithm becomes so complex as to not be useful in practice. The fundamental issues in addressing hypotension and hemorrhage associated with pelvic fracture have remained constant, however. First, is laparotomy indicated, and second, how is bleeding deep in the pelvis best managed. Based on the review of the literature, the decision for laparotomy should be based on the traditional signs of intra-abdominal bleeding or intestinal perforation. The supra-umbilical diagnostic peritoneal tap appears to be the most reliable test for intra-abdominal hemorrhage, which requires

laparotomy. Perforation would be addressed through the microscopic evaluation of the lavage fluid. Management of pelvic hemorrhage appears best managed by initial stabilization of the pelvic bones with re-apposition of the fracture followed by pelvic angiography and possible embolization based on the response to pelvic stabilization.

VI.   Future Investigations

A.   Future investigations comparing protocols of external fixation versus angiography seem impractical considering the myriad of fracture patterns that can occur. Prospective randomized trials would require overwhelming time and numbers.

B.   The use of FAST in patients with major pelvic fracture.
The diagnostic phase would be considerably simplified if ultrasonic signs could be identified which had high predictive value for either identifying those patients who require laparotomy, or those who do not.

C.   Placement of external fixation devices in the trauma receiving area by the trauma surgeon.
The placement of an external fixation device in the trauma receiving area by the trauma surgeon may allow a more rapid restoration of pelvic, and therefore, hemodynamic stability, and may obviate the need for the orthopedic surgeon to emergently respond to all but the most severe of pelvic bony injuries.

VII.   References

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PELVIC FRACTURE WITH HEMORRHAGE: EVIDENTIARY TABLE

First Author	Year	Reference Title	Class	Conclusion
Margolies MN	1972	Arteriography in the management of hemorrhage from pelvic fractures.	II	Report of 3 cases of pelvic fracture in which arteriography with pelvic embolization was used to control bleeding from pelvic fracture. The high morbidity and mortality of these cases was attributed to the late decision for embolization.
Slätis P	1972	Double vertical fractures of the pelvis.	II	A review of 163 patients with double vertical fractures of the pelvis, 71% of whom had concomitant abdominal injuries. One hundred patients received between two and 30 units of blood within the first 24 hours. Eighty-four of the 90 patients who received between 2 and 9 units of blood in the first 24 hours had pelvic bleeding as a major source. Of the 10 patients who required more than 10 units of blood, only 4 had a pelvic source of bleeding.
Huittinen VM	1973	Post mortem angiography and dissection of the hypogastric artery in pelvic fractures.	II	The authors performed 27 post mortem pelvic angiographies and identified contrast extravasation in 23 cases. Only 3 involved named branches of the hypogastric artery. The authors suggest that their data supports the belief that the majority of pelvic fracture bleeding comes from the cancellous bone, and therefore should respond to re-approximation and stabilization, with angiography being required only in a minority of cases.
Panetta T	1985	Percutaneous transcatheter embolization for massive bleeding from pelvic fractures.	II	A report of a management scheme for hemodynamically unstable pelvic fractures or controlled surgically, if present. Embolization successfully controlled bleeding in 87% of the patients. Of the 11 deaths in the series, 3 did not respond to embolization.
Moreno C	1986	Hemorrhage associated with major pelvic fracture.	II	A review which encompassed 538 patients. The study group consisted of 92 patients who required greater than 6 units of packed red cells. MAST controlled hemorrhage in 71% of patients in whom it was used, and external fixation controlled 95%. Angiography was only used if stabilization and laparotomy failed to control bleeding. The overall mortality was 26%. The specific indications for the use of each modality were not discussed.
Evers BM	1989	Pelvic fracture hemorrhage.	II	A review of 245 patients with pelvic fractures. DPL was used in 83 patients to drive the treatment protocol. DPL was extremely accurate when negative and a strong indicator of life threatening of intra-abdominal hemorrhage when grossly positive. Microscopic positive DPL was unlikely to reflect intra-abdominal hemorrhage as a source of hemodynamic instability. They suggest that supraumbilical DPL drive the therapeutic protocol. When grossly positive the patient should have immediate laparotomy with placement of an external fixation device either during or after laparotomy and that the patient undergo pelvic angiography if the hemodynamic instability persists or if a large retroperitoneal hematoma is identified at laparotomy. When the supraumbilical is grossly negative, whether microscopically positive or negative, patient should undergo initial placement of an external fixation device in the pelvis followed by pelvic angiography. Laparotomy would be reserved for those patients who remain hemodynamically unstable, having injuries that are not amenable to angiography or develop other signs warranting laparotomy.

First Author	Year	Reference Title	Class	Conclusion
Flint L	1990	Definitive control of mortality from severe pelvic fracture.	II	A report of 279 patients with pelvic fractures, of whom 42 met criteria for A severe bleeding@. These patients were managed with a protocol which first employed pelvic stabilization in the form of MAST or external fixation of the pelvis. Ten patients required further treatment with angiography to control arterial bleeding. The study demonstrated that the vast majority of the patients with severe bleeding from pelvic fractures will stop bleeding with progressive resuscitation including blood products and pelvic stabilization.
Poole GV	1991	Pelvic fracture from major blunt trauma.	II	A retrospective multiple regression analysis correlating outcome with severity of injury in patients with pelvic fractures. 236 patients were reviewed with a 7.6% mortality and only a single death due to hemorrhage. Regression analysis showed pelvic fracture severity correlated with injury severity but not with mortality. They concluded that outcome following pelvic fractures principally related to associated injury.
Ghanayem AJ	1995	The effect of laparotomy and external fixator stabilization on pelvic volume in an unstable pelvic injury.	II	A cadaveric study in which unilateral open-book pelvic ring injuries were created in 5 fresh cadaveric specimens and the pelvic volume measured for the intact pelvis, disrupted pelvis with both a laparotomy incision opened and closed, and disrupted pelvis stabilized and reduced using an external fixator with the laparotomy incision opened. The average volume increase between a non-stabilized pelvis with the abdomen closed and then opened was 15%, or 423 cc. The average volume increase between a stabilized and reduced pelvis and non-stabilized pelvis, both with the abdomen open, was 26% or 692 cc. The public diastasis increased from 3.9 to 9.3 cm in a non-stabilized pelvis with the abdomen closed and then subsequently opened. Application of a single-pin anterior-frame external fixator reduced the public diastasis anatomically and reduced the average pelvic volumes to within 3-8% of the initial volume. They conclude the intact abdominal wall has a somewhat stabilizing effect on the unstable pelvis, and the pelvis should be stabilized prior to laparotomy incision.
Moss MC	1996	Volume changes within the true pelvis during disruption of the pelvic ring.	II	Using a model of cadaver pelvis with balloon in the true pelvis to measure volume, fractures were simulated by opening the symphysis pubis to measure volume by specified distances and measuring the volume. Similar measurements were made with varying sacroiliac joint and combined symphysis sacroiliac joint separations. They concluded that changes in the pelvic volume resulting from pelvic fractures were much smaller than previously reported.
Bassam D	1998	A protocol for the initial management of unstable pelvic fractures.	II	A review of the protocol-driven management of 15 patients with pelvic fracture after abdominal bleeding had been treated or excluded. Anterior fractures underwent external fixation and posterior fractures underwent angiography. Bleeding was primarily controlled in all patients undergoing initial angiography but only 50% of the patients undergoing initial external fixation. The other 50% required angiography, with increased consequent blood requirements because of the delay to definitive control.

First Author	Year	Reference Title	Class	Conclusion
Grimm	1998	Pressure-volume characteristics of the intact and disrupted pelvic retroperitoneum.	II	This is a study performed in nine non-embalmed cadavers assessing pelvic volume in pelvic ring intact, fracture disrupted, and disrupted/external fixated pelvises. They concluded that closure of the pelvic ring with external fixation had little effect on the potential space in the pelvis for blood loss and that external fixation did not help control pelvic bleeding by generating pressure-induced tamponade. A possible explanation for the beneficial effect of external fixation may be the re-apposition of tissue to allow disrupted veins to clot.
Vrahas MS	1998	Comparison of fixation methods for preventing pelvic ring expansion.	II	Three methods of internal fixation and external fixation were compared in a cadaveric study. While open internal antero-posterior fixation provided the greatest control against pelvic expansion overall, external fixation provided the most reliable control of pelvic expansion in the emergency setting.
Ballard RB	1999	An algorithm to reduce the incidence of false negative FAST.	II	A prospective algorithm assessing the accuracy of the FAST exam in patients with pelvic fractures. There were 53 true negative exams and four true positive exams. There were no false positive exams but 13 false negative exams. Most of the false negative exams occurred in patients with pelvic ring fractures. These numbers render a sensitivity of 23.5%, specificity of 100%, accuracy of 81.4%, positive predictive value of 1.0, and a negative predictive value of 0.8. The numbers are too small alone to validate the unity of the specificity or positive predictive value.
Stephen DJG	1999	Early detection of arterial bleeding in acute pelvic trauma.	II	A review of 111 patients who 1) underwent CT scan within 24 hrs of admission, 2) had an abdominal injury score greater than three, and 3) had greater than 20% of blood loss attributable to pelvic fracture. The presence of a high density blush of contrast on CT had a positive predictive value of 80% for predicting which patients would eventually require angiographic embolization and 98% negative predictive value. The authors concluded that CT contrast extravasation is highly suggestive of significant arterial bleeding that requires early angiographic embolization to restore hemodynamic stability.
Hawkins L	1970	Laparotomy at the time of pelvic fracture.	III	A review of 192 patients with pelvic fractures of whom 35 underwent exploratory laparotomy. 30 had surgically correctable intra-abdominal injuries. 20 of the 35 underwent laparotomy based on DPL results. Only 5 patients underwent non-therapeutic laparotomies. Seven patients died, of whom six had a systolic BP of less than 100 and a mean transfusion requirement of 22.4 units of blood. They found no correlation between fracture geometry and the need for laparotomy. They concluded that the inherent difficulty with management of a retroperitoneal hematoma should not dissuade the surgeon from laparotomy if indications of intra-abdominal pathology requiring surgery are present.

First Author	Year	Reference Title	Class	Conclusion
Fleming WH	1973	Control of hemorrhage in pelvic crush injuries.	III	A small case series of 11 patients with pelvic crush injuries, 5 of whom who underwent vascular exploration. Four of the 6 non-explored patients died as compared to 2 of the 5 explored patients. The 80% decrease in blood transfusion requirements of the second 48 hours of hospitalization appear to favor early vascular exploration in this limited case series.
Batalden DJ	1974	Value of the G suit in patients with severe pelvic fracture.	III	A report of 10 patients with pelvic fracture treated with an external compression device. The mean duration of application was 27.75 hours. The only early death occurred in association with a torn thoracic aorta and died in the operating room. Both late deaths were elderly. This appears to be the first report of the use of an external compression device to aid the treatment of unstable pelvic fractures.
van Urk H	1978	Selective arterial embolization for control of traumatic pelvic hemorrhage.	III	A technical manuscript describing what was, at the time, a relatively new modality. It demonstrated the potential efficacy of performing pelvic angiography and embolization in hemodynamically unstable patients with pelvic fractures.
Rothenberger DA	1978	The mortality associated with pelvic fractures.	III	A review of pelvic fracture mortality among 604 patients, of whom 72 died. Although all but one of the 72 deaths had concomitant major injuries, 59.7% of the deaths were attributable, entirely or in part, to the pelvic fracture. In 26 patients (36.1%) death was entirely attributed to the pelvic fractures: 69% died secondary to hemorrhagic shock and 23% secondary to major pelvic vessel disruption. Major pelvic vessel disruption occurred in only 1% of the study group but 8% of the mortalities.
Flint LM	1979	Definitive control of bleeding from severe pelvic fractures.	III	A review of 22 patients with severe pelvic fractures and extraperitoneal hemorrhage treated by a protocol of G-suit pelvic stabilization after surgically correctable had been excluded. Angiographic embolization followed if hemodynamic stabilization did not occur. They were compared to a historical control group of 18 similar cases who did not receive G-suit application or angiographic embolization. The overall mortality for the protocol group was 9% compared to 61% for the historical controls. The authors concluded the G-suit was an effective means of controlling retroperitoneal hemorrhage. The failure of patients to respond promptly suggests arterial bleeding which warrants angiography and embolization.
McMurtry R	1980	Pelvic disruption in the polytraumatized patient.	III	A review of 79 patients, 76 of whom had combined anterior/posterior fractures. 43 had major posterior fracture displacement and a more than two fold increase in transfusion requirements and a 2-1/2 fold increase in mortality. The therapeutic algorithm utilized open DPL in the unstable patient. Positive results were treated with laparotomy and negative results were subjected to angiography. They advocate the surgical repair and ligation for large bore vessels and angiographic embolization for small bore vessels.
Kam J	1981	Vascular injuries in blunt pelvic trauma.	III	A review of 63 patients with pelvic fracture who underwent angiography. The internal pudendal artery was the most frequent bleeding site identified. The authors were unable, however, to correlate angiographic findings to the mechanism of injury or fracture pattern as demonstrated by plain films.

First Author	Year	Reference Title	Class	Conclusion
Namm NH	1983	Major pelvic fractures.	III	A review of 102 patients of whom only 11 had major hemorrhage. This small group had greatly increased blood transfusion requirements. They conclude that MAST, external fixation, and arteriography were useful in management of these patients.
Gordon RL	1983	Control of massive retroperitoneal bleeding associated with pelvic fractures by angiographic embolization.	III	Case series of two hemodynamically unstable patients with pelvic fractures in whom stability was ultimately with angiography and embolization of internal iliac arteries. The authors advocate the use of pelvic angiography and embolization in patients who remain unstable despite massive resuscitation in patients with posterior pelvic ring disruptions.
Mucha P	1984	Analysis of pelvic fracture management.	III	A review of 133 patients with pelvic fractures of whom 36% were considered complicated. 63% of the unstable patients were successfully resuscitated. 12 patients were designated Aexsanguinating@, of whom 11 died shortly after arrival. 7 of 15 Acontrolled hypotensive@ patients went directly to angiography from the Emergency Room. Another 4 went following laparotomy and/or burrholes. Angiography and embolization had an 86% success rate.
Cryer HM	1988	Pelvic fracture classification: Correlation with hemorrhage.	III	A review of 243 consecutive patients with pelvic fractures. Pelvic fractures were classified based on the Pennel and Sutherland classifications scheme and correlated with blood replacement. Patients with unstable fractures had blood loss greater than 4 units between 50 and 70% of the time. Patients with stable fractures required less than 4 units between 75% and 85% of the time. The authors conclude that the pelvic fracture classification based on the initial Emergency Department AP x-ray can predict the patient population at risk for massive hemorrhage.
Klein SR	1992	Management strategy of vascular injuries associated with pelvic fractures.	III	A review of 429 blunt trauma patients with pelvic fractures. The posterior ring fractures and dislocations required more blood transfusions in the first 24 hours, had more associated injuries, and had more vessel injuries as compared to other pelvic fracture types.
Hölting T	1992	Diagnosis and treatment of retroperitoneal hematoma in multiple trauma patients.	III	A review of 20 patients with arterial pelvic bleeding complicating pelvic fracture who underwent pelvic arteriography and embolization. Patients underwent arteriography after failing to achieve hemodynamic stability with aggressive volume resuscitation with or without laparotomy. The 9 survivors had a mean time interval to arteriography of 7 hours, as compared to a mean of 21 hours for the 11 non-survivors, and required less than a third as much blood products.
Gruen GS	1994	The acute management of hemodynamically unstable multiple trauma patients with pelvic ring fractures.	III	A review of 312 patients with pelvic fractures seen over a 5 year period. External fixation was not used. Patients underwent pelvic angiography if hemodynamic instability persisted despite volume resuscitation for 24 hours. This paper demonstrated that unstable pelvic fractures can be successfully managed without the use of external fixation, with the key elements including volume resuscitation and treatment of the associated injuries. The selected use of angiography based on the response to volume and blood components over a 24 hour period was a helpful adjunct in the 10 patients in which it was used.

First Author	Year	Reference Title	Class	Conclusion
Poole GV	1994	Causes of mortality in patients with pelvic fractures.	III	A review of 348 patients with pelvic fractures, 90 of whom were mechanically unstable. External fixation was used in 66 patients. In 10 of these 66 patients, subsequent internal fixation was necessary even though external fixation allowed hemodynamic stability to develop; it provided inadequate mechanical stability for the pelvis. 6 of 18 patients who underwent pelvic angiography had arterial bleeding present. 3 of these patients died.
DiGiacomo JC	1996	Arterial bleeding diagnosed by CT in hemodynamically stable victims of blunt trauma.	III	A series of cases reports demonstrating extravasation of intravenous contrast by CT scan is evidence of active arterial bleeding. One of the cases involved the internal pudendal artery bleeding into a pelvic hematoma and was managed with embolization.
Pohlemann T	1996	Die schwere Beckenverletzung mit pelviner Massenblutung.	III	19 hemodynamically unstable patients with unstable pelvic fractures were managed with aggressive volume resuscitation, external fixation of the pelvis, and laparotomy when appropriate. The 11 patients who died received 30.7% more blood in transfusion than the 8 who survived.
Agolini SF	1997	Arterial embolization is a rapid and effective technique for controlling pelvic fracture hemorrhage.	III	A review of 806 patients with pelvic fractures managed with a algorithm utilizing early angiography on hemodynamically unstable patients with pelvic fracture. 35 patients underwent angiography and 15 required embolization. There was a 100% success rate with embolization.
Perez JV	1998	Angiographic embolization in pelvic fracture.	III	A 10 year review of 721 patients with pelvic fractures of whom 8 patients underwent pelvic angiography. Bleeding pelvic vessels were identified in 4 patients, 2 of whom underwent successful embolization.

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