Hemodynamically Unstable Pelvic Fracture Management by Advanced Trauma Life Support Guidelines Results in High Mortality

ZHIYONG HOU, MD; WADE R. SMITH, MD; KENT A. STROHECKER, MS; THOMAS R. BOWEN, MD; KAAN IRGİT, MD; SUSAN M. BARO, DO; STEVEN J. MORGAN, MD

abstract

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The purpose of this study was to examine the acute outcomes and mortality rates of an Advanced Trauma Life Support guideline approach for managing hemodynamically unstable pelvic ring injuries.

We retrospectively reviewed the acute outcomes of 48 consecutive patients with hemodynamically unstable pelvic fractures. Patients underwent treatment via the advanced trauma life support protocol, with primary angiography based on trauma surgeon preference. Mean patient age was 51.2 years, with a mean injury severity score of 43.2±14.3. Mean systolic blood pressure was 74.8±16.1 mm Hg at presentation. Patients received an average of 7.0±6.6 units of red blood cells and 4.2±2.3 units of fresh frozen plasma in the first 6 hours. Fourteen patients underwent emergent angiography, and 12 patients were treated with embolization. Mean time to angiography was 3 hours and 55 minutes (range, 2-19 hours). Twenty patients died during hospitalization, with an overall mortality rate of 41.7%; 13 (27.1%) of them died within 24 hours.

Advanced Trauma Life Support guidelines with angiography are not adequate for the management of hemodynamically unstable pelvic ring injuries and result in unacceptably high mortality rates compared with more specific approaches using transfusion protocols and interventions, such as pelvic packing.

Dr Hou is from the Department of Orthopaedics, Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, China; Drs Smith and Morgan are from the Department of Orthopaedics, Mountain Orthopaedic Trauma Surgeons at Swedish, Englewood, Colorado; and Drs Strohecker, Bowen, Irği, and Baro are from the Department of Orthopaedics, Geisinger Medical Center, Danville, Pennsylvania. Drs Hou, Smith, Strohecker, Bowen, Irği, Baro, and Morgan have no relevant financial relationships to disclose.

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Correspondence should be addressed to: Zhiyong Hou, MD, Third Hospital of Hebei Medical University, Shijiazhuang, Hebei, China 050041 (drzyhou@gmail.com).

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Patients with hemodynamically unstable pelvic fractures are a diagnostic and therapeutic challenge for the trauma team. These injuries often occur in conjunction with other life-threatening injuries, and no universal agreement exists regarding clinical management strategies. Current management algorithms incorporate variable time frames for bony stabilization, fixation, and hemorrhage control by angioembolization. Direct retroperitoneal pelvic packing has been described as an additional hemostatic maneuver in the resuscitation protocol to reduce mortality; however, the indications and use are evolving. Massive transfusion protocols and graded resuscitation with matching of blood products have also positively affected outcome, yet no specific requirements exist for trauma centers to use these strategies. Despite advances in management during the past decade, patient mortality remains significantly high. Overall, the mortality rate of patients with pelvic fractures has been reported to be 5% to 10%.\(^5,6\) Hemodynamically unstable pelvic fractures have a mortality rate of 20% to 60%\(^,\)** and the mortality rate in patients with open pelvic fractures is as high as 70%\(^,9,10\).

A common theme in the orthopedic and trauma literature is that management by protocol of hemodynamically unstable pelvic fractures provides better outcomes than management with no specific protocols. However, the treatment of hemodynamically unstable pelvic fractures at many Level I trauma centers historically followed Advanced Trauma Life Support clinical guidelines with no specific pelvic protocol. Clinical guidelines function as suggested practices, with no adherence to set steps, facilitating enhanced real-time clinical decision making. Critical steps may be missed due to the level of training and experience of the on-call team. At our Level I trauma center, we hypothesized that an approach to pelvic fracture care based on Advanced Trauma Life Support guidelines and early angiography resulted in worse outcomes and a higher mortality rate than those achieved with published protocols using massive transfusion protocols and pelvic packing. We also hypothesized, based on clinical impression, that the efficacy of early angiography would not be substantiated.

**Materials and Methods**

All patients with hemodynamically unstable pelvic fractures admitted to our Level I academic trauma center between June 2004 and June 2009 were evaluated. We evaluated all patients aged 14 years and older presenting with pelvic ring injuries and a persistent systolic blood pressure of <90 mm Hg despite the transfusion of ≥1 unit of red blood cells. Management approaches followed general trauma guidelines but were not formalized in regard to blood product ratios, indications for mechanical stabilization, laparotomy, or angiography. All patients underwent Advanced Trauma Life Support protocol with a primary resuscitation survey, and the trauma surgeon determined whether to use angiography or external fixation. Patient demographics, admission hemodynamics, physiologic indices, transfusion requirements, pelvic angiography results, intensive care unit/hospital course, complications, and mortality were recorded. All data were cross-referenced and confirmed by retrospective chart review. Statistical analysis was performed using Student’s t-test and reported as the mean±standard error of measurement (SEM). This study was approved by the Institutional Review Board.

During the study period, 724 trauma patients with pelvic fractures were admitted with pelvic fractures, acetabular fractures, or both. Of these, 48 patients with pelvic fractures met the inclusion criteria. Thirty-six (75%) patients with hemodynamic instability were men, with a mean age of 51.2±21.5 years. The most common mechanisms were motor vehicle collisions (n=22), automobile–pedestrian collisions (n=10), falls (n=8), motorcycle collisions (n=4), farm tractor accidents (n=3), and crush injuries (n=1).

Pelvic fractures were classified according to Burgess et al\(^5\) as lateral compression I (n=10), lateral compression II (n=6), lateral compression III (n=2), anteroposterior compression I (n=14), anteroposterior compression II (n=11), anteroposterior compression III (n=3), and vertical shear (n=2). Three patients had open pelvic fractures. Patients were multiply injured, with a mean injury severity score of 43.2±14.3. In addition to pelvic fractures, 23 (47.9%) patients had associated brain injuries, 32 (66.7%) had thoracic injuries, 23 (47.9%) had abdominal injuries, 7 (14.6%) had bladder injuries, 28 (58.3%) had extremity injuries, and 21 (43.8%) had spine injuries.

For initial pelvis stabilization, 10 patients underwent pelvic binder or sheet wrapping, 7 patients underwent ipsilateral skeletal traction, and 4 patients underwent external pelvic fixation. Twenty-seven patients had no bony stabilization. Twelve of the 14 patients transferred to angiography underwent embolization for active bleeding: 3 had splenic artery injuries, 2 had superior gluteal artery injuries, 1 had obturator and internal pudendal artery injuries, 1 had a hypogastric artery injury, and 5 had injuries involving small branches of the internal iliac artery. Mean time to emergent angiography was 3 hours and 55 minutes (range, 2-19 hours). No patient underwent angiography <2 hours after admission. An inferior vena cava filter was placed to prevent pulmonary embolism in a prophylactic basis in 24 patients. Twelve patients underwent exploratory laparotomy (5 of 12 receiving intra-abdominal packing but not pelvic packing for ongoing hemodynamic instability), 1 patient underwent resection of the small bowel for mesenteric artery injury, 1 patient underwent splenectomy, and 2 patients underwent suture ligation of mesenteric artery injury and splenectomy. Large retroperitoneal hematomas with no active intra-abdominal hemorrhage were found in 8 patients (3 had bladder rupture). One patient underwent exploratory thoracotomy, 1 patient underwent cranietomy for...
subdural hematoma, 2 patients underwent external fixation for long bone fractures, and 4 patients underwent debridement of open wounds/fasciotomy.

**RESULTS**

Mean systolic blood pressure was 74.8±16.1 mm Hg in the emergency room, mean respiratory rate was 16.5±7.5 breaths per minute, and mean heart rate was 102.2±29.0 beats per minute. Patients received an average of 4.2±2.3 units of fresh frozen plasma and 7.0±6.6 units of red blood cells in the emergency room. Patients remained in the surgical intensive care unit for a mean of 10.6±14.2 days and received mechanical ventilation for a mean of 7.7±11.1 days. Mean time to emergent angiography was 3 hours and 55 minutes (range, 2-19 hours). No patient underwent angiography <2 hours after admission. Average hospital length of stay was 18.2±17.9 days. Complications included pneumonia (n=7), atelectasia (n=5), acute respiratory distress syndrome (n=5), genitourinary tract infection (n=8), deep venous thrombosis (n=8), wound infection (n=9), sepsis (n=5), acute renal failure (n=4), gastrointestinal bleeding (n=3), and pleural effusion (n=7).

The overall mortality rate was 41.7%, with 20 deaths. Thirteen (27.1%) patients died within 24 hours of admission as a result of pelvic exsanguination (n=9), closed head injury (n=3), and pulmonary injury (n=1); 7 (14.6%) patients died >24 hours after admission as a result of multiple organ failure (n=4), acute respiratory distress syndrome (n=1), and exsanguination (n=2) (Table 1). Of the 14 patients transferred to angiography for embolization, 4 died and 10 survived. Nine of the 12 patients who underwent exploratory laparotomy died (Table 2). No differences existed between those who lived vs those who died in presenting systolic blood pressure, respiratory rate, injury severity score, or transfusion requirements. However, mean patient age and mean heart rate were significantly different between the 2 groups (Table 3).

**DISCUSSION**

The mortality for patients with hemodynamic instability treated by Advanced
Trauma Life Support guidelines and primary angiography in our trauma center was high and comparable with previous literature reports of angiography protocols with no pelvic packing. The majority of our patients who died did so within 24 hours from admission. Angiography was not adequate as a main pelvic intervention for the management of patients with hemodynamically unstable pelvic fractures and appeared to have little effect on decreasing mortality.

Although the global implementation of Advanced Trauma Life Support guidelines has contributed to improved overall trauma outcomes,11,12 many of the recommendations are nonspecific. The guidelines are not adequate for hemorrhage control in patients with hemodynamically unstable pelvic fractures.13-15 Pelvic hemorrhage is a major cause of mortality in patients with hemodynamic instability when combined with associated sources of bleeding.16 Combined decision making by the attending trauma surgeon and the orthopedic trauma surgeon has positively affected the course of resuscitation.1,17 Eastridge et al8 reported a mortality rate of 40% in patients with hemodynamically unstable pelvic fractures who followed a generic trauma activation guideline. They also suggested that control of pelvic hemorrhage often requires a multidisciplinary approach, including a trauma surgeon, an orthopedic surgeon, and an interventional radiologist. Heetveld et al18 treated 30 patients with hemodynamic instability without following the multidisciplinary team clinical practice guidelines. Eleven (37%) of their 30 patients died. The authors thought an opportunity existed to improve the rates of initial assessment of the abdomen, pelvic stabilization, and early angiography.18

Our overall mortality rate (41.7%) with treatment based on Advanced Trauma Life Support guidelines was comparable with previous reported high mortality rates, despite our use of angiography. The major cause of mortality in our series was exsanguination (55%) due to pelvic hemorrhage. Nine (65%) of 20 patients died within 24 hours of admission.

Early angiography and embolization have been useful in controlling pelvic hemorrhage and are recommended by multiple authors to improve outcomes.19,20 However, correct and timely use of pelvic angiography and embolization remains challenging and controversial. Angiography can be time consuming, delaying simultaneous treatment of other associated injuries. Early identification of the hemorrhage site and rapid intervention are vital to decreasing mortality. Meighan et al21 reported that major trauma centers should be able to apply standard treatment methods to control life-threatening hemorrhaging within the golden hour (<1 hour). According to Clarke et al,22 every 3 minutes of delay in the resuscitation room leads to a 1% mortality increase in a patient with hemodynamic instability and blunt abdominal trauma during the first 90 minutes of treatment at a Level I trauma center. Preoperative time for angiography has been reported to range from 50 minutes to 5.5 hours and 19 minutes23-25 and may not be tolerated by patients with hemodynamic instability. Moreover, 85% of bleeding as a result of pelvic fractures is venous or bony in origin and cannot be addressed by angiography.23 In some cases, small arterial bleeding can end spontaneously with no embolization.3,26-28 The overall prevalence of patients with pelvic fractures who need embolization is <15%.3,8,19,23,28 With an effective protocol guideline for the management of patients with hemodynamic instability, unnecessary angiography procedures should be avoided because they waste time and may contribute to patient death. In our series, 12 of the 14 patients transferred to angiography were treated with embolization, with a mean time to emergent angiography of 3 hours and 55 minutes. Although angioembolization was performed effectively based on imaging results, 4 of the 14 patients died as a result of prolonged shock. Despite a readily available team, the angiography procedure always occurred 2 hours after admission. This reflects the reality at many trauma centers and represents insufficient resuscitation with no effective hemorrhage control during the preangiography period.

The efficacy of multidisciplinary protocols in decreasing mortality in patients with hemodynamic instability and pelvic fractures is well documented. The most common protocol is resuscitation using blood products, external stabilization, and emergent pelvic angioembolization.26,29-32 Smith et al33 showed improved results by direct packing via a retroperitoneal approach combined with an overall protocol emphasizing 1:1 resuscitation, rapid mechanical stabilization, and selective angiography. If a patient was persistently unstable despite blood transfusion, the combined procedures (external fixation followed by retroperitoneal packing) were performed in <30 minutes. If the patient demonstrated hemodynamic instability after packing, the patient underwent angiography and selective embolization if necessary. This procedure was reported to be quick and easy to perform and eliminated the decision between the operating room and interventional radiology suite.1,7,13,16,33,34 Their overall mortality rates decreased from 42% to 25%, and no patients died from acute blood loss when direct packing was used. Retroperitoneal packing quickly controls hemorrhaging and reduces the need for emergent angiography. Four (16.7%) of 24 nonresponders required subsequent embolization.7 Tötterman et al15 reported similar results and concluded that retroperitoneal pelvic packing reduced the need for and increased the efficacy of angiography. Improved survival depends on the evolution of early hemorrhage control and resuscitative strategies in patients with hemodynamic instability. A predetermined protocol allows definitive, immediate decisions to be made early and make the resuscitative technique more effective. Table 4 summarizes recent literature regarding outcomes of various pelvic protocols.

Our study was limited due to the relatively small number of patients who met the inclusion criteria. Also, different surgical teams with different levels of expe-
perience at our institution during the study may have contributed to potential variations in outcome. However, these variations are an accurate reflection of normal day-to-day reality at most Level I trauma centers. Because of our accurate electronic medical record, we were able to ensure that all patients included in the current study met uniform inclusion criteria and had significant hemodynamic instability.

**CONCLUSION**

Advanced Trauma Life Support guidelines with angiography are not adequate for the management of patients with hemodynamic instability and pelvic ring injuries. These guidelines result in an unacceptably high mortality rate compared with more specific approaches using transfusion protocols and interventions, such as pelvic packing. Comparative studies should be used to determine best recommended practices for trauma centers. Due to the significant differences in outcomes between published protocols, trauma centers should be held accountable for a best-practice approach based on evidence. We have used these data at our institution to initiate a prospective protocol using pelvic packing and specific transfusion triggers, with the intent of improving care and outcomes.

**REFERENCES**


23. Cook RE, Keating JF, Gillespie I. The role of angiography in the management**Table 4**

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<tr>
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