Name of Study: Pre-hospital Advanced Therapies for Control of Hemorrhage (PATCH) - Pelvis
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Background and Significance

Pelvic fractures represent a small percent of all skeletal injuries but are associated with significant morbidity and mortality. They commonly result from high-energy trauma, particularly blunt trauma, as a significant force (an average of more than 3,000 N) must be imparted to disrupt the pelvic ring (Grimm 1989). Pelvic fractures are frequently associated with significant head, thoracic, abdominal, and extremity injuries as well as hemodynamic instability due to bleeding from cancellous bone surfaces and disrupted pelvic vasculature. Patients hypotensive at the scene and upon arrival at the definitive treatment facility have increased mortality relative to normotensive patients (Gabbe 2011, Sathy 2009). Stabilization of the pelvic ring reduces pelvic volume, decreases bleeding from bony surfaces, and stabilizes early hematoma (Grimm 1989).

Multiple techniques of pelvic reduction and stabilization have been described in the literature. These include spica casts, pneumatic antishock garments (e.g. MAST), anterior or posterior C-clamps, circumferential pelvic antishock sheeting (CPAS), commercially available external compression devices (i.e. pelvic binders), external fixation, closed reduction and percutaneous fixation, and open reduction and internal fixation. Today, CPAS and external compression with commercial pelvic binders are the most common prehospital techniques for supporting patients with hemodyamic instability and suspected pelvic fractures. Temporary pelvic splinting with these devices is now recommended in the initial management of hemodynamically unstable patients (Cuillinane 2011; White 2009; American College of Surgeons 2008). Not only are they relatively easy to apply in the prehospital setting and Emergency Department, these devices are relatively inexpensive; do not preclude physical exam, inguinal vascular access, splinting, or skeletal traction; and can be left in place for a limited period of time until the patient is hemodynamically stable.

The goal of external pelvic compression is stabilization of early clot. Historically, this has been attributed to reduction in pelvic volume; however, some studies suggest that splintage may actually be the mechanism (Ghaemmaghami 2007, Grimm 1989). Cadaveric and biomechanical studies suggest that these devices reduce both pelvic volume and motion in multiple planes (Bottlang JBJS 2002, Bottlang JOT 2002, Prasarn 2013). What is not known, however, is whether these biomechanical characteristics actually improve clinical outcomes. In one retrospective review of patients with pelvic fractures and other risk factors for hemorrhage (unstable pattern, age > 55, or hypotension), institution of an in-hospital pelvic binder protocol did not alter the need for massive transfusion, angioembolization, or exploratory laparotomy; the 24-hour transfusion requirement; or in-hospital mortality relative to those who received no binder or, rarely, CPAS (Ghaemmaghami 2007). In a retrospective review of patients at a different institution with severe pelvic fractures, patients who received a commercial pelvic binder had significantly diminished 24- and 48-hour transfusion requirements and shorter hospital stays than those who received early anterior external fixation (Croce 2007). Additionally, there was a trend toward decreased mortality in patients who received a pelvic binder, though this was not statistically significant.

Data on the safety of circumferential pelvic compression devices, whether from CPAS or commercially available binders, is mainly limited to cadaver studies and case reports. There is a known risk of skin breakdown secondary to strain at the skin-strap interface. The force measured at the interface between the skin and the binder varies between studies and in some studies has been measured above levels thought to cause tissue damage (Knops 2010, Jowett 2007, Bottlang JOT 2002, Hendrick-

Thompson 1992). Furthermore, there have been reports of patients sustaining significant injuries secondary to prolonged circumferential binding with pelvic sheets (Schaller 2005). This risk can be extrapolated to the use of commercial pelvic binders but can likely be minimized by removal of the binder as soon as pelvic injury has been ruled out or the patient is hemodynamically stable. The use of backboards in the prehospital environment also increases the risk of skin compromise related to binder use. Cadaveric studies suggest that centering the pelvic binder around the greater trochanters may reduce the potential for skin breakdown since adequate reduction of the pelvis requires the least amount of force at this location (Bottlang JOT 2002).

Over-reduction of the pelvis could potentially injure pelvic viscera or exiting sacral nerve roots in patients with lateral compression type fractures or fractures through the sacral neuroforamina (Tile 1980). In patients with unstable acetabular fractures or hip dislocations, application of a binder could cause additional displacement or damage to the articular surface. Thus, these injuries are generally considered contraindications to pelvic binder use. However, a cadaveric study of binder application to unstable lateral compression fractures failed to demonstrate a significant change in pelvic volume or degree of internal rotation of the hemipelvis compared to the amount of maximal displacement created by the fracture itself (Bottlang JBJS 2002). Other cadaver studies have failed to demonstrate clinically significant over-compression of commercially available devices (Knops 2011). Some manufacturers have designed their binders with a self-regulating compression device that controls the maximal amount of tension applied, theoretically preventing over- reduction, though data on the efficacy of this design is mixed (SAM Pelvic Sling, Knops 2011).

What is not known is whether prehospital use of pelvic compression devices would alter clinical outcomes for patients with pelvic fractures. It seems logical that stabilization of the pelvis even before arrival at a treatment facility may help mitigate the hemodynamic consequences of pelvic fracture and improve both morbidity and mortality. In the prehospital environment, however, these devices would be placed without the use of diagnostic or confirmatory radiography. It is likely that these binders will thus be inappropriately used in some percentage of patients who will later be found to have a relative contraindication to binder use (e.g. lateral compression pelvic fracture) or a different diagnosis altogether (e.g. acetabular, hip, or femur fracture). There is also the risk of skin compromise and the small though not insignificant chance that such an event could preclude operative fixation or otherwise alter patient management.

Purpose of the Study

The goal of our study is to determine whether prehospital use of a commercial pelvic binder will improve morbidity and mortality in patients with pelvic fractures. We hypothesize that prehospital placement of pelvic binders will reduce hemorrhage and need for resuscitation and will improve overall mortality in patients with pelvic fractures. Our primary outcomes will be indicators of hemorrhage (including vital signs, lactate, base excess, volume of blood products required for resuscitation, need for angioembolization or surgical control of bleeding, and length of ICU stay) and 30-day mortality. We will also measure safety events related to binder use. Additionally, we hypothesize that pelvic splinting via external compression will improve patients' pain regardless of whether they have a pelvic, acetabular, or proximal femur fracture. Pain control in the prehospital environment will be addressed as a secondary outcome in this study.

Study Design

Type of Study: prospective, randomized clinical trial
Study Population: adult patients with a traumatic mechanism of injury who are evaluated at the scene by Medic and have injuries concerning for pelvic fracture and/or hemodyamic instability.

Inclusion Criteria:

(1) Age 18 years or older, *and*

(2) Traumatic injury other than ground-level fall (e.g. MVC, MCC, fall from height ≥ 20 feet, etc.), *and*
(3) Complaint of pelvic, groin, or hip pain, *or*
(4) Pelvic or hip deformity, ecchymosis, or crepitus in an obtunded patient, *or*
(5) Hemodynamic instability:
    a. Systolic blood pressure ≤ 90 mmHg
    b. Heart rate >100 BPM

Exclusion Criteria:

(1) Ground level fall.
(2) Penetrating pelvis injury without frank evidence of fracture.
(3) Obviously pregnant patients
(4) Patients who are too small (<32in) or too big (>50in) for the binder
(5) Priority 2 or 3 Trauma

Representativeness of the Sample: Our study should capture a large portion of the patients who present to the hospital with pelvic trauma. We chose to exclude patients who sustained a ground level fall. These are low-energy mechanisms of injury less likely to be improved by external pelvic compression, and more likely to have skin compromise.

Definition of Variables:

Primary Outcome Variables: These variables will be abstracted from the medical record by research staff.

(1) Initial heart rate and blood pressure at the scene (pre-hospital)
(2) Initial heart rate and blood pressure upon arrival at the Emergency Department
(3) Time of injury, EMS arrival, binder application (if done), ED arrival
(4) Initial labs upon arrival at the Emergency Department: lactate, base deficit, PT/INR, hemoglobin
(5) 24-hour transfusion requirements
(6) 48-hour transfusion requirements
(7) Need for angioembolization
(8) Need for surgical control of bleeding
(9) Length of intensive care unit stay
(10) Length of hospital stay
(11) Need for readmission
(12) 30-day mortality
(13) Location of pelvic binder upon presentation to the hospital
(14) Time the binder removed
(15) Skin compromise attributable to binder use (location and time since binder placement)
(16) Other complications of binder use (description and time since binder placement)

Secondary Outcome Variables: These variables will be reported by non-obtunded patients using a Visual Analog Score in the pre-hospital environment.

(1) Pain score at presentation
(2) Pain score at the conclusion of ambulance transfer (upon arrival to the Emergency Department)

Potential Confounding Variables

The following variables will be abstracted from the medical record by research staff:

(1) Age
(2) Gender
(3) Body mass index
(4) Comorbidities (history of diabetes or cardiac disease)
(5) Anticoagulant use

The following variables will be determined by an orthopaedic surgeon based on data abstracted from the medical record:

(6) Injury severity score
(7) Fracture severity: defined by the Young and Burgess and AO/OTA classification of pelvic fractures

Methodology

Application of inclusion and exclusion criteria: Awake patients will be asked at the scene for their age (inclusion criteria 1), mechanism of injury (inclusion criteria 2), and presence of pelvic, hip, or groin pain (inclusion criteria 3). Patients who state they sustained a ground level fall will be excluded (exclusion criteria 1). The age of obtunded patients will be determined using personal identification (e.g. driver's license) if available but will otherwise be estimated by EMS personnel. EMS personnel will evaluate patients for signs of pelvic injury (inclusion criteria 4) and hemodynamic instability (inclusion criteria 5). Based on the location of the scene and severity of the injuries, EMS personnel and their dispatcher will determine whether participating hospital or a different facility will receive the patient (exclusion criteria 2).

Randomization: Prior to each shift, each ambulance will be randomly assigned an opaque box containing either a commercial pelvic binder or a weight-equivalent object and patient ID tag When an ambulance arrives at the scene, EMS personnel will apply inclusion and exclusion criteria to determine if the patient is appropriate for this study. If so, EMS personnel will open the opaque box. If the box contains a pelvic binder, the patient will have a pelvic binder placed. If the opaque box contains the weight-equivalent object, the patient ID tag will be clipped to the patient, and the patient will be managed without a binder under the current standard of care. At the receiving facility, EMS personnel will page the research team and fill out the label on the box with information identifying the run number, unit number, and time of dispatch. The box will be placed in a box in the emergency department for research staff to pick up. The removal of pelvic binder on patient will be determined by the appropriate physician team. Pelvic binder should be removed within 72 hours of admission.

Collection of prehospital outcome data: At the time of initial assessment by EMS personnel, awake patients will be asked to rate their pain using a visual analog scale (VAS). At the conclusion of ambulance transport, awake patients will again be asked to rate their pain using a VAS. The patient's initial heart rate and blood pressure will also be recorded in the prehospital environment.

Collection of data in the hospital environment: Patients enrolled in the study will be identified using the information collected by EMS personnel on the box, the page to research staff, and/or the presence of a pelvic binder or patient ID tag on the patient. Primary outcome data will be abstracted from the medical record. The patient's initial heart rate and blood pressure will be recorded upon presentation to the Emergency Department (ED). Other laboratory data, including lactate, base deficit, hemoglobin, and PT/INR, will be collected upon presentation to the ED. Pelvic radiographs will be obtained as appropriate per standard of care. Both placement and location of the pelvic binder upon arrival will be determined from pelvic radiographs. Whether or

not the pelvic binder is removed in the ED is based on clinical data (clinical evidence of hemodynamic stability, imaging failing to demonstrate a pelvic fracture) and is at the discretion of the treating physician (generally an emergency medicine physician or trauma surgeon) in the ED. Patients with evidence of hemodynamic instability or concern for ongoing hemorrhage will undergo angioembolization or surgical intervention according to our institution's protocol. Twenty-four and 48-hour transfusion requirements (including packed red blood cells, fresh frozen plasma, platelets, and cryoprecipitate); need for endovascular or surgical intervention for control of hemorrhage; and length of intensive care unit and hospital stay will be determined from the medical record. Thirty days after the injury, the need for readmission and all-cause mortality within this period will be recorded. Demographic and medical variables (BMI, history of cardiac disease, anticoagulant use, initial PT/INR) will also be abstracted from the medical record.

Complications of binder use, including skin compromise, will also be identified, as will the length of time between binder placement and each event. Should such an event occur a formal incident report will be filed with the appropriate hospital agency as well.

The fracture classification will be assigned by a fellowship-trained orthopaedic traumatologist. The type and timing of operative fixation of the patient's pelvic injury, if necessary, will be at the discretion of the treating orthopaedic surgeon.

Data analysis: Data analysis will be carried out when all patients have been assigned to either the experimental or control group. In order to determine whether the randomization process produced comparable groups, we will use t-tests and cross-tabulations to compare patients randomized to the pelvic binder group with those randomized to the control group. The following variables will be considered: age, gender, BMI, history of cardiac disease, anticoagulant use, PT/INR at presentation, injury severity score, and Young and Burgess pelvic fracture class. An intention to treat analysis will also be performed.

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