

The Pelvic Fracture

Stabilization in the Field

By Michael Bottlang, PhD, & James C. Krieg, MD

Fractures of the pelvis, which often cause life-threatening internal blood loss, are among the most devastating musculoskeletal injuries. Similar to a fracture of the cervical spine, pelvic fractures require emergent stabilization before patient transport, if possible. Recently, the U.S. Office of Naval research sponsored a study to develop a pelvic sling for reliable, safe and effective stabilization of pelvic fractures. Paramedics and first responders will soon be able to apply the Pelvic Sling on scene.

Engineering a Solution

Four years ago, a trauma surgeon and a biomechanical engineer teamed up to develop a better way to stabilize pelvic ring fractures at the scene. At that time, the standard of care was to wrap a sheet around the pelvis. While this simple intervention can save lives, surprisingly little information is available on how best to apply a sheet. In May 2003, Dr. Ramsey et al. published, for the first time, a guideline on how to wrap a fractured pelvis in a sheet.¹ However, even their guideline states that it is not known how tight to apply a sheet to be effective, or how dangerous it may be if a sheet is applied too tightly.

To answer these essential questions, we used biomechanical studies to explore how

effective and safe this procedure can be and how it should be best applied. Based on the results of these studies, we subsequently developed a Pelvic Sling, which provides EMS with a simple tool to optimally stabilize pelvic fractures at the scene. This article provides a brief review of pelvic fractures, describes research that led to the new device, and explains how the Pelvic Sling can be used by EMS providers.

Diagnosing Pelvic Ring Fractures

Fracture of the pelvic ring can occur in falls from a height, crush-type injuries, or by forceful blows sustained in motor vehicle accidents. In general, the pelvic ring either collapses (lateral compression fracture) or expands ("open-book" fracture), as shown in *Figure 1*. In both scenarios, the pelvic ring typically breaks in the front through the pubic bone or symphysis, and in the back at the sacroiliac joint. In the unconscious patient, it can be difficult to recognize a pelvic ring fracture at the accident site. Although there may be no visible blood loss, massive internal bleeding from the venous plexus is often present. Internal hemorrhage is the leading cause of death in patients with pelvic ring fractures.

Diagnosing pelvic fractures can be difficult as the pelvic ring often "recoils" after injury toward its normal position. A fracture can be diagnosed by examining the stability

of the pelvic ring. Assess for instability by pelvic compression with diffuse hand pressure against the upper anterior pelvis, or by directly grasping the anterior or superior iliac spine between the thumb and index finger of each hand. If an unstable fracture is detected, no further stability exams should be made to prevent dislodgement of blood clots, which may be tamponading pelvic bleeding.¹

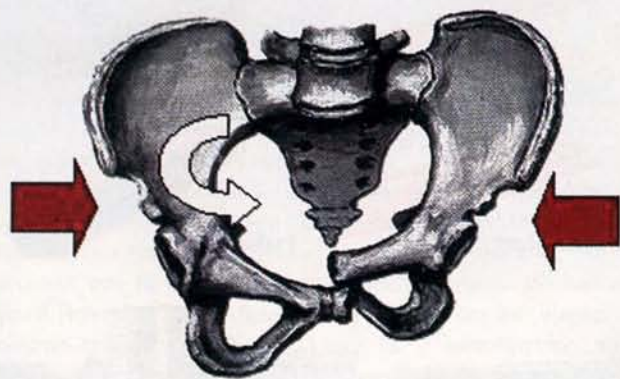
Pelvic Stabilization Can Save Lives

Stabilizing pelvic fractures in the field within the "golden hour" is most effective to control pelvic hemorrhage. Pelvic stabilization is especially important during patient rescue and transport. Any motion between the torso and lower limbs can cause severe shifting of the fractured pelvis, which will jeopardize coagulation and blood clot formation.

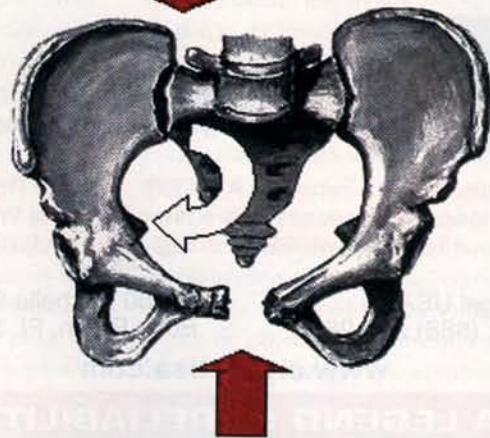
Military Antishock Trousers (MAST) have been used to stabilize a fractured pelvis before patient transport, but have recently been contraindicated due to complications and uncertain efficacy. Therefore, in their Advanced Trauma Life Support (ATLS) guidelines, the American College of Surgeons recommends wrapping a sheet around the broken pelvis for emergent stabilization. While this is a simple and readily available intervention, it is not exactly clear how to apply a sheet. In fact, within our Level I trauma center, recommendations for sheet application ranged from "loose" to "very tight."

Figure 1: Common Types of Pelvic Ring Fractures

Lateral compression fracture: pelvic ring collapse



Open-book fracture: pelvic ring expansion



Research as the Basis for a New Intervention

Since there were no clear instructions on sheet application, and no data that document the benefits of applying a sheet to a broken pelvis, the U.S. Office of Naval Research supported a study at the Legacy Biomechanics Laboratory in Portland, OR, to develop a pelvic sling for controlled and safe stabilization of pelvic fractures. The Pelvic Sling should provide the proper amount of tension at the right place to best stabilize a broken pelvis, as well as shield the broken pelvis from excessive forces that could be harmful. To develop the Pelvic Sling, we conducted laboratory studies on human cadavers to answer four key questions:

- 1) How should a pelvic sling be applied to best reduce and stabilize the pelvis?
- 2) How tightly should a pelvic sling be applied?
- 3) How effectively can a pelvic sling stabilize a fractured pelvis?
- 4) How safe is this intervention if applied to a variety of pelvic fracture types?

Results of this two-year research effort defined the proper force required to reduce and stabilize a pelvic ring fracture.^{2,3} Most interestingly, results showed that applying the Pelvic Sling around the hip (around the greater trochanters and symphysis pubis) was more effective than at the waist (around the iliac crest). Applying the Pelvic Sling with proper tension around the hip reliably reduced "open-book"-type pelvic fractures (see Figure 2) and dramatically improved the mechanical stability of the pelvis. In fact, the Pelvic Sling delivered as much stabilization as an invasive pelvic C-clamp, which can only be applied in the hospital after patient transport.

Regarding safety of the Pelvic Sling, the main concern arises from the fact that the type of pelvic fracture is difficult to assess at the scene. In a "worst-case" scenario, the Pelvic Sling could be applied to a highly unstable lateral compression fracture, which is susceptible to over-compression. However, research results demonstrated that even in this instance, Pelvic Sling application with proper tension remained safe and did not significantly over-compress the pelvis.

Hospital Testing

After two years of laboratory investigations, we developed an advanced Pelvic Sling, which automatically limits the applied tension to the proper and safe level. Over the past year, this Pelvic Sling has been routinely applied at two Level I trauma centers in a prospective clinical trial. This clinical study

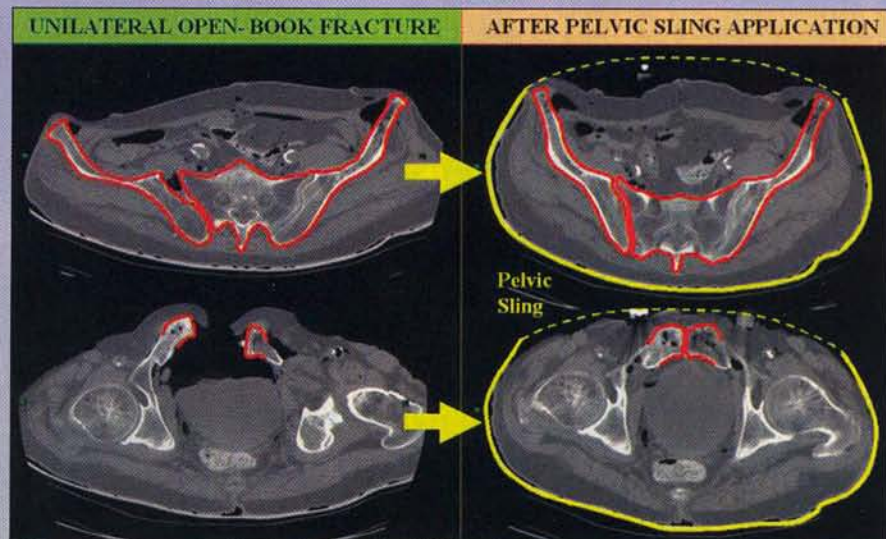


Figure 2: Computer tomography of a fractured pelvis before and after stabilization with the Pelvic Sling.

allowed us to observe how effectively and safely the Pelvic Sling can be used in a real-world environment. The clinical trial demonstrated not only efficacy and safety, but also showed that the Pelvic Sling was well tolerated and did not cause ischemia or skin breakdown, even if applied for as long as five days. Details of this clinical trial and the advanced Pelvic Sling can be found at www.pelvic sling.com.

Albeit this Pelvic Sling has been tested in a hospital environment at Level I trauma centers, it was explicitly designed for use by first responders at accident scenes, not for in-hospital use. As such, it was designed to be applied as simply as a sheet or rolled blanket, but in less time and with greater consistency. If a patient at the accident scene has to be transferred to a stretcher, the Pelvic Sling should ideally be placed on the stretcher before the patient to reduce the amount of physical manipulation. At the hospital, the Pelvic Sling may be left on the patient to preserve stabilization as long as possible and well-tolerated, or until definitive stabilization by external or internal fixation can be achieved.

How Does the Pelvic Sling Work?

The Pelvic Sling is a noninvasive device that wraps around the patient's hip (see Figure 3a). The back and side portions of the sling are comfortably wide, soft and allow for passage of air, but do not stretch. It is narrower at the front to allow better access to critical areas of the polytraumatized patient, namely the perineum and abdomen. Both ends of the sling are guided through a buckle, which is placed approximately over the pubis symphysis. Pulling on both ends of the sling in a lateral direction gradually and symmetrically increases sling tension and reduces the pelvis. It provides equally distributed compression to the soft tissue envelope surrounding the hip, which in turn stabilizes the pelvic ring. Application around the soft tissue envelope of the hip effectively prevents direct compression of prominent bony structures, which otherwise could affect the quality of reduction.

Most important, the Pelvic Sling buckle has a mechanism that automatically limits the force applied to the pelvis to the proper level (Figure 3b). When the proper sling tension is reached, a mechanical stop, accompanied by

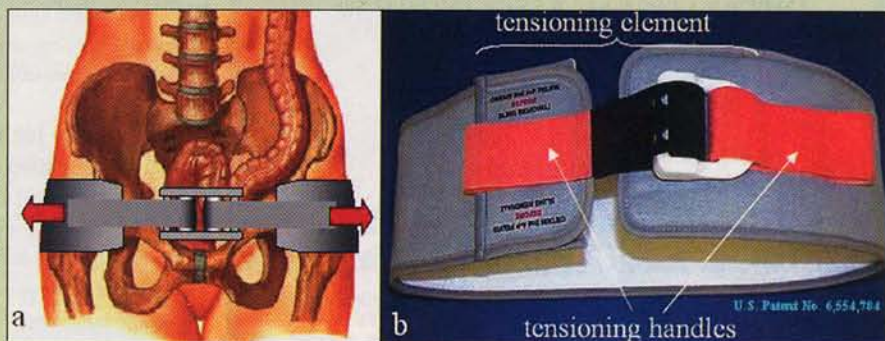


Figure 3: Pelvic Sling concept and device.

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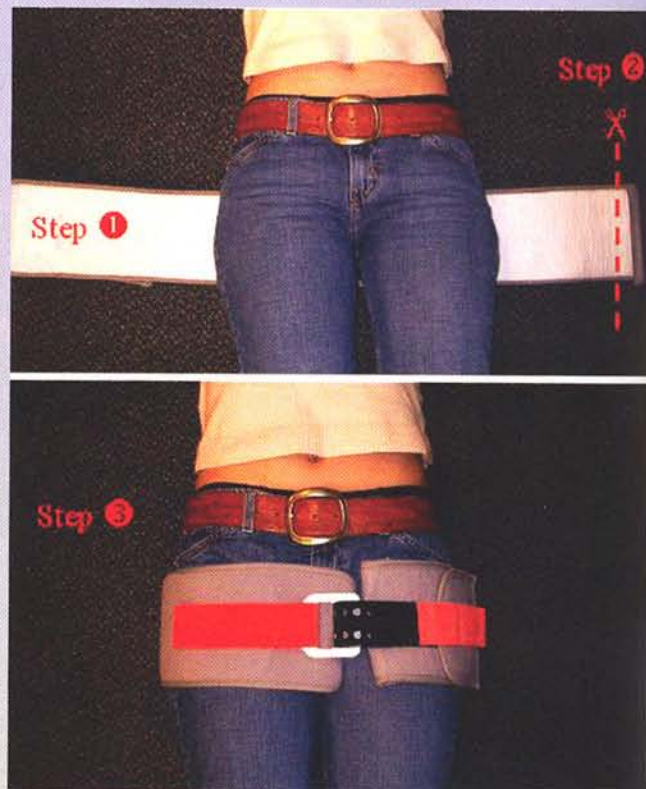


Figure 4: Pelvic Sling 3-step application procedure.

a "clicking" sound, indicates that the pelvis is properly stabilized. This ensures reduction of pelvic ring fractures in a consistent and safe manner, regardless of the amount of tension applied by the first responder. Proper sling tension is maintained by simply pressing the tensioning handles onto the lateral sections of the Pelvic Sling, where they are held in place by Velcro. If required, the sling can be released and re-tensioned within seconds.

Applying the Pelvic Sling

The Pelvic Sling is applied in three simple steps. With the patient lying flat on his back (Figure 4), place the Pelvic Sling around the hip at the level of the greater trochanters and the symphysis pubis. This can be achieved by either lifting the patient or sliding the sling upward from underneath the legs. Next, cut the sling ends to size or fold inward to avoid overlapping the ends anteriorly. Finally, attach the tensioning unit that contains the tensioning handles and sling buckle. The Pelvic Sling can be tensioned by a single person, or more conveniently by two persons. Typically, it can be applied in less than five minutes and can remain applied for several days, until definitive surgical stabilization of the pelvic ring can be provided. However, in case of prolonged application, skin condition should be monitored. While the Pelvic Sling can easily be released and re-tensioned, this should be avoided, if possible, to promote and preserve blood clot formation.

Indications for the Pelvic Sling

The Pelvic Sling should be applied by first responders or rescue personnel in the field to stabilize the pelvis *before* patient transport. It serves as an emergent, temporary intervention to reduce the risk of exsanguination from diffuse pelvic hemorrhage before definite pelvic stabilization can be provided. Early pelvic stabilization is a potentially life-saving intervention; therefore, a Pelvic Sling should be applied if a pelvic ring fracture is suspected. Open-book pelvic fractures are likely to benefit the most from this intervention. The risk for adverse effects



U.S. Patent No. 6,554,784

Figure 5: The Pelvic Sling is lightweight, compliant and compact.

in case of alternative fracture patterns is minimal due to the provision of circumferential compression at a proper and safe level. Once the patient arrives at a hospital, the Pelvic Sling can also facilitate application of an anterior external fixator for definitive pelvic stabilization by maintaining pelvic reduction during fixator frame application.

Considerations for Deployment in EMS

The Pelvic Sling is lightweight, radiolucent and almost invisible on x-ray, with the exception of two stainless-steel compression springs (Figure 5). It can remain on the patient for CT and MRI procedures and is designed to function through the extreme ranges of normal ambient temperatures. It is waterproof and noncorrosive, but not fireproof. Its simple and intuitive functionality allows for application by a single person with minimal training. The Pelvic Sling design allows for low-cost mass production of a commercial, disposable device. The Pelvic Sling is a "one-size-fits-all" design, which conveniently can be cut to size. The device has not been tested for adolescent use, but pelvic ring fractures in the adolescent population are rare.

A commercial version of the Pelvic Sling will soon be available from The Seaberg Company (800/818-4726, seaberg@sam.splint.com), inventor of the SAM Splint. The Legacy Clinical Research & Technology Center selected The Seaberg Company based on its history regarding the development and distribution of technology for emergent stabilization of fractures. The commercial version of the Pelvic Sling will allow, for the first time, safe in-field stabilization of pelvic fractures by EMS to greatly increase the chance of survival of patients with suspected pelvic ring fractures. ■

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