Stabilization of Pelvic Ring Disruptions with a Circumferential Sheet

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Pelvic ring disruptions in the polytraumatized patient are associated with a mortality rate of up to 25%.[1] Acute uncontrolled hemorrhage and its complications are the leading causes of death in these patients.[2] Treatment algorithms for resuscitation and control of hemorrhage are aimed at reducing morbidity and mortality. Although variations exist among these algorithms, essentially all include the goal of pelvic reduction and stabilization.[3,4]

Various means of pelvic reduction and stabilization exist. Each has is own advantages and limitations. Invasive measures include anterior external fixation, open reduction and internal fixation (ORIF), and posterior pelvic clamps.[5] Although each of these interventions can be utilized early in the resuscitation phase, none can be applied acutely outside the hospital setting. The desire to provide early stabilization, at the accident scene or during patient transport, has led to the development of noninvasive measures, such as vacuum bean-bags or pneumatic antishock garments (PASGs). However, each of these methods is limited either by its ability to effect controlled reduction, or by its potential for severe complications.[6]

Most recently, wrapping of the pelvic region with a sheet has been advocated. In fact, the American College of Surgeons' Advanced Trauma Life Support (ATLS) course now includes a protocol for emergent management of pelvic ring disruptions, advising circumferential application of a pelvic sheet.[7] Sheets can be readily applied at the accident scene and may provide better reduction and stabilization of open-book type pelvic fractures when compared with bean-bags or PASGs. Anecdotal accounts of sheet application at time of hospital admission are numerous. However, case reports documenting application and performance of such pelvic sheets are virtually nonexistent. In this report, we present two exemplary cases of open-book type pelvic fractures (OTA classification 61-B/C) temporarily managed with a pelvic sheet. Furthermore, we provide an analysis of the amount of reduction achieved by circumferential pelvic compression.

CASE 1

A 34-year-old male was involved in a high-speed motorcycle crash. Upon arrival at the hospital he was hypotensive, with a blood pressure of 72/23, and a pulse of 122 beats/min. He had a hematocrit of 21. A massive transfusion protocol was initiated soon after arrival. During his resuscitation, radiographs were obtained that revealed an open-book type pelvic injury (Fig. 1*a*). A circumferential pelvic sheet was applied, resulting in near-anatomic reduction of the pubic symphysis diastasis and left sacroiliac (SI) joint dislocation (Fig. 1*b*). With the sheet left in place, the patient was then transferred to the CT scanner for head, abdominal, and pelvic CT scans (Fig. 2). The patient remained in shock. An angiogram was obtained. It was negative for arterial injury in the pelvis. The patient was taken to the operating room urgently for completion amputation of the right upper extremity. An external fixator was applied to the pelvis within 2 hours of arrival. The patient received 17 units of packed red blood cells, 22 units of fresh frozen plasma, 6 units of cryoprecipitate, and 4 units of platelets within the first 24 hours of admission.

CASE 2

A 43-year-old male was admitted to a regional Level I trauma center after being involved in a motor vehicle crash as an unrestrained driver. Vital signs on admission included a blood pressure of 94/56, pulse of 84 beats/min, and a Glasgow Coma Scale score of 12. He was diagnosed with closed cervical trauma, pelvic ring disruption with symphysis diastasis and widening of both SI joints, and intra-abdominal injuries (Fig. 3*a*). The patient was fluid resuscitated in the emergency department. A sheet was tightly wrapped circumferentially around the pelvis for stabilization. A subsequent anteroposterior radiograph (Fig. 3*b*) and CT scan (Fig. 4) revealed partial reduction of the open-book pelvic fracture. Angiography was performed and did not reveal any obvious source of intrapelvic arterial bleeding. The patient underwent emergent laparotomy. Findings included laceration of the sigmoid artery and injuries to the sigmoid colon. Repair of the artery and low anterior resection of the sigmoid colon were performed. A traction pin was placed in the right femur at this time for additional pelvic stabilization. Hemodynamic

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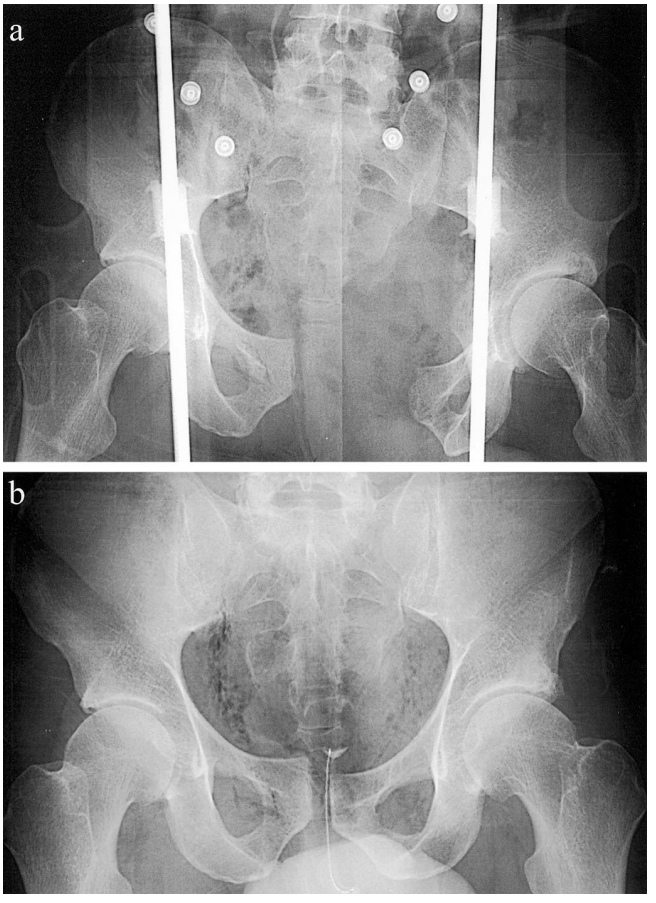

Fig. 1. *Anteroposterior radiograph of the open-book pelvic fracture of case 1, demonstrating significant disruption of the left sacroiliac joint. (*a*) Before intervention. (*b*) After emergent application of a tightly wrapped sheet around the pelvis, demonstrating near-anatomic reduction of the pubic symphysis and the SI joint.*

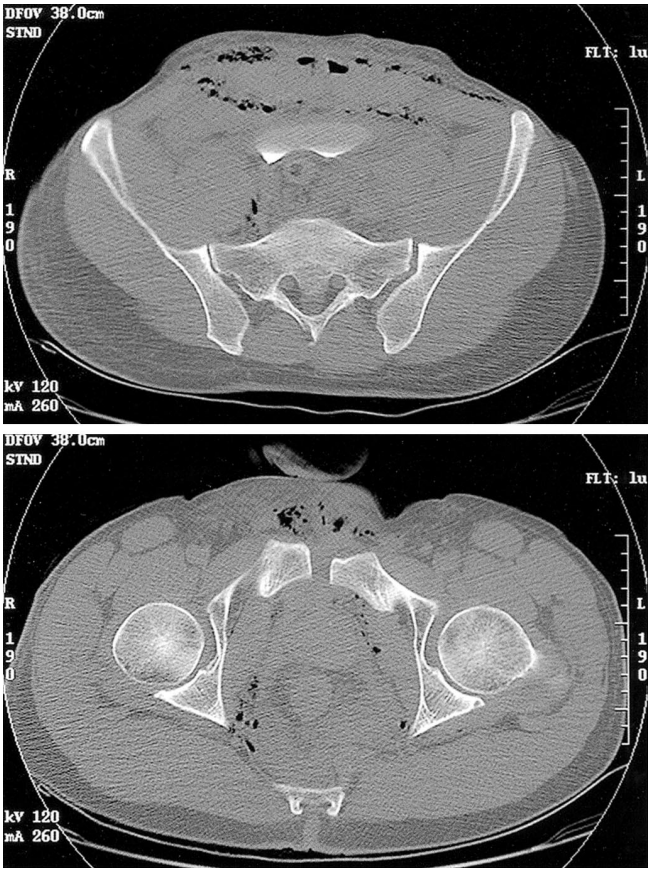

Fig. 2. *Case 1: Cross-section CT scan of the pelvis after temporary reduction of the open-book pelvic fracture with a large circumferential sheet.*

stability was achieved following repair of the sigmoid artery. The patient received 16 units of packed red blood cells, 22 units of fresh frozen plasma, 6 units of cryoprecipitate, and 6 units of platelets during the first 24 hours. On hospital day 2, an external fixator was placed on the pelvis and a percutaneous right SI screw was placed. Definitive treatment was delayed after development of intra-abdominal infection.

DISCUSSION

Early control of life-threatening hemorrhage is the primary goal in the emergent management of pelvic ring disruptions. Direct blood loss from pelvic injuries occurs from several sources. The major source is believed to be from injury to the sacral venous plexus. Less commonly, injury to the main or small trunks of the hypogastric artery can contribute significantly to pelvic bleeding, with an incidence from 7–15% in reported series.[8] Other common sources of blood loss include fracture surfaces and surrounding soft tissue injury.[2] Reduction and stabilization of the unstable pelvis are reported to be effective means of controlling hemorrhage.[5,9] Several theoretical mechanisms that contribute to the observed decrease in hemorrhage after reduction and stabilization of the pelvis have been hypothesized.[10] Reduction of the injured pelvis may result in a decrease in pelvic volume, which in turn reduces potential space for bleeding. Bony bleeding may be reduced by apposition of fracture surfaces. Furthermore, stabilization of the pelvic ring may aid in blood clot formation and protection.

Multiple algorithms exist for management of exsanguinating pelvic ring injuries. There is no consensus regarding the optimal sequence of timing of interventions. However, general agreement exists that early, effective reduction and stabilization of the pelvis contributes to overall patient management.[1,3,8] ORIF constitutes the "gold standard" for definitive management of the hemodynamically stable patient in an operating room setting. However, its use is limited in the resuscitation phase of the acutely unstable patient. Anterior external fixation can theoretically be applied in the emergency room by a skilled orthopedic surgeon.[11] However, concerns over patient comfort and sterility often demand an operating room environment. In addition, control of the se-

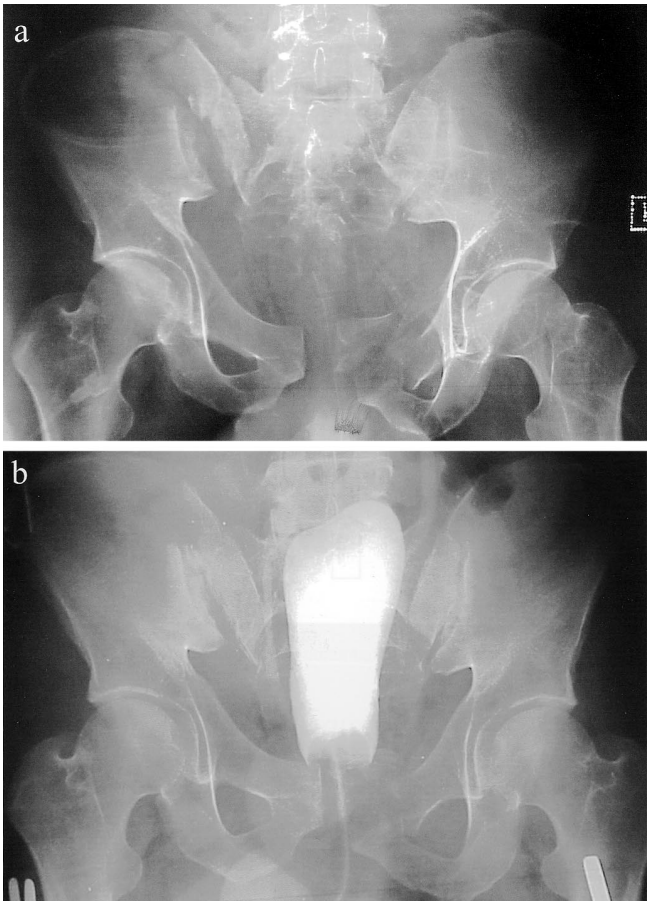

Fig. 3. *Anteroposterior radiograph of the open-book pelvic fracture of case 2. (*a*) Before intervention. (*b*) After emergent application of a pelvic sheet.*

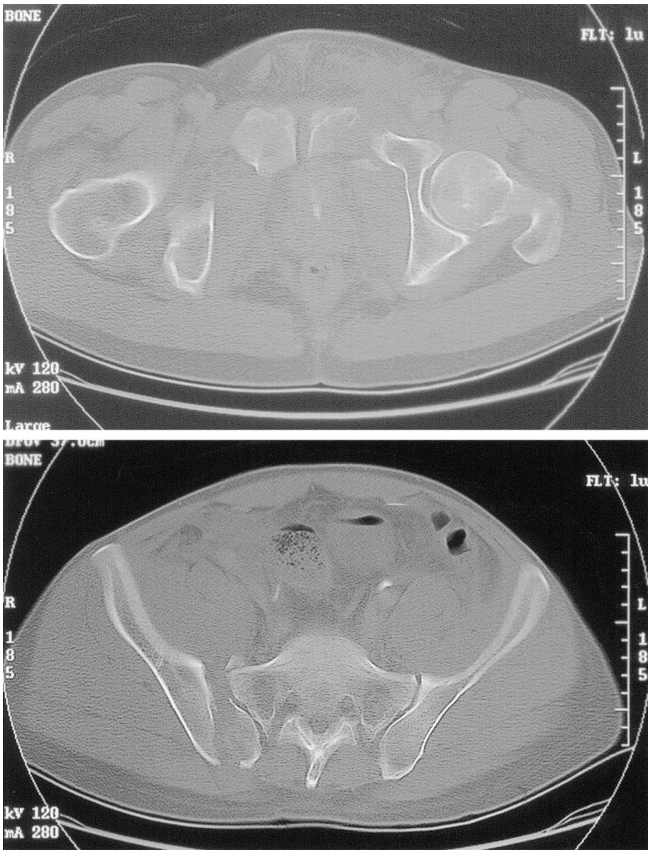

Fig. 4. *Cross-section CT scan of the pelvis after temporary reduction of the open-book pelvic fracture of case 2.*

verely disrupted posterior pelvis is marginal. Posterior pelvic clamps do not require insertion of fixation pins, allowing for even faster pelvic stabilization compared with external fixation.[5] Furthermore, they provide excellent stabilization of posterior pelvic ring injuries. However, pelvic clamps have caused injury to intra-abdominal and neurovascular structures and should only be applied after comprehensive training, thus limiting their use in acute resuscitation.[12] Vacuum bean-bags and PASGs are suited for emergent management of hemodynamically unstable patients with apparent pelvic fractures. They can be applied by paramedical personnel at the accident scene. However, they may restrict access to the abdomen and perineum and do not allow for controlled pelvic reduction.[13] In addition, more recent prospective studies conclude that complications associated with PASGs, caused by compression of the lower extremities and abdomen, outweigh any potential benefits of their use.[6]

Pelvic sheets provide a readily available, noninvasive alternative to reduce open-book type pelvic fractures at the accident scene. However, little published information on the use of circumferential pelvic compression exists. Vermeulen et al.[14] reported the application of a pelvic strap to 19 patients in Switzerland. Their antishock strap was applied at the accident scene by paramedics upon suspicion of unstable pelvic lesions. Two of their patients showed no abnormalities on initial pelvic films obtained with the strap in place. However, a 4-cm opening of the symphysis pubis appeared after strap removal, and associated sacral fractures were present in both cases. They report a strap application time of approximately 30 seconds, and stress significant time savings compared with the use of pneumatic garments. Routt et al.[9] encircled the pelvic region of one hemodynamically unstable patient with bilateral pubic rami fractures and sacroiliac joint disruptions in a snugly clamped sheet and noted improvement in blood pressure and heart rate.

In the presented cases, a large circumferential sheet was pulled tight around the pelvis. The sheet remained in place until further stabilization could be achieved with an external fixator. In both cases, the application of the sheet achieved reduction and stabilization in a safe and time-effective manner and did not interfere with resuscitation efforts. The amount of temporary reduction achieved by application of the pelvic sheet was quantified by computer-aided three-dimensional reconstruction of the pelvic geometry from CT data. Custom software code (PV Wave, Visual Numerics, Houston,

Table 1 **Symphysis Diastasis and Pelvic Inlet Area at Presentation and after Reduction**

Treatment	Symphysis Diastasis		Pelvic Inlet Area	
	Case 1	Case 2	Case 1	Case 2
Unreduced (mm)	67	29	128	114
Pelvic sheet (mm)	9	18	91	104
Reduction achieved (%)	87	38	29	9

TX) was utilized to extract cross-sectional images in a pelvic inlet view plane, and to quantify the pelvic inlet area after manual digitization of the pelvic brim. Since CT scans were obtained after application of a pelvic sheet, the preintervention pelvic inlet area was retrieved by transforming the CT data set to reflect geometric relations apparent on radiographs, obtained before application of a pelvic sheet. Reduction achieved by the sheet is listed in Table 1 in terms of absolute values and percentile change. While it is desirable to test the hypothesis of reduction-induced decrease in pelvic hemorrhage, this would require a large-scale prospective study to reduce confounding effects caused by nonassociated hemorrhage in the patient with multiple injuries.

These cases demonstrate the use of circumferential pelvic compression for temporary reduction of open-book type pelvic fractures before definitive fixation. While the use of a bed sheet provides a rather simple means to achieve pelvic stabilization, further research should investigate a method for well-controlled and reproducible circumferential pelvic compression.

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