ELSEVIER
SAUNDERS

Orthop Clin N Am 35 (2004) 451 – 456

ORTHOPEDIC
CLINICS
OF NORTH AMERICA

Soft tissue injuries associated with pelvic fractures

Cory Collinge, MD[a], Paul Tornetta III, MD[b,*]

[a]*Orthopaedic Specialty Associates, 1325 Pennsylvania Avenue, Suite 890, Fort Worth, TX 76104, USA*
[b]*Department of Orthopaedic Surgery, Boston University Medical Center, 850 Harrison Avenue, Dowling 2, North Boston, MA 02118, USA*

The bony and ligamentous pelvic ring includes some of the strongest tissues in the human body; thus, significant injuries to the pelvic ring reflect high energy injury to the patient. Historically, high rates of mortality and morbidity have been seen in these patients. Recognition and care of the soft tissue component of complex pelvic injuries can be critical in optimizing the acute treatment and long-term outcomes for these patients.

A variety of injuries may occur to the pelvic ring, including crush injury, shear injury, or combined forms [1]. Soft tissue injuries vary also [2–4]. These may occur as direct soft tissue contusion or abrasion, closed or open degloving shear injuries, open fractures, or combinations of these injuries. The condition of the soft tissues has implications to treatment and ultimate patient outcome [2,4]. The rich anastomotic vascular plexi of the pelvis make hemorrhage a common problem when treating patients with these injuries. The soft tissues surrounding the pelvis provide a tamponade effect that may limit ongoing bleeding after injury. Traumatic loss of the soft tissue envelope around the pelvis can lead to severe hemorrhage or even exsanguination. Severe pelvic injuries also may violate the genitourinary or gastrointestinal systems, and contaminated wounds may complicate treatment.

Some areas of the pelvis, such as the iliac crests and sacrum, are subcutaneous and are afforded little protection by the overlying soft tissues, whereas in other areas of the pelvis thick cuffs of muscle provide protection and a rich vascular supply. Thin soft tissues lying over the posterior pelvis and along the iliac crests may be placed at risk by the injury itself, by surgery, or even by periods of recumbency.

Although the significance of soft tissue injuries in extremity fractures has been widely recognized [5,6], less attention has been directed to the soft tissues in evaluating and treating trauma around the hips and pelvis. High energy traumatic injuries are well known to have increased risk for complications such as infection and wound healing problems [5–7]. Traumatic injuries cause direct tissue injury and relative hypoxia. This leads to increased vascular permeability, soft tissue edema, and swelling. These factors result in further hypoxia and a vicious cycle may be created. In conjunction with the typical catabolic state of the polytrauma patient, these factors may lead to damaging consequences.

Closed soft tissue injuries around the pelvis

In the 1800s Morel-Lavallée described closed traumatic lesions in which the skin was detached from the underlying tissues [8]. This injury occurs by a shearing mechanism. Subsequently Letournel and Judet [3] referred to degloving injuries around the hip and acetabulum as “the Morel-Lavallée lesion.” They described a “local loss of sensation, abrasion, bruising, and hematoma formation” and noted its incidence to be 8.3% (23 of 275) of cases in which fracture of the acetabulum was caused by a blow to the greater trochanter. When the skin and subcutaneous tissues are traumatically separated from the underlying muscle fascia, fatty and soft tissue ne-

* Corresponding author.
E-mail address: ptornetta@pol.net (P. Tornetta III).

0030-5898/04/$ – see front matter
doi:10.1016/j.ocl.2004.05.003

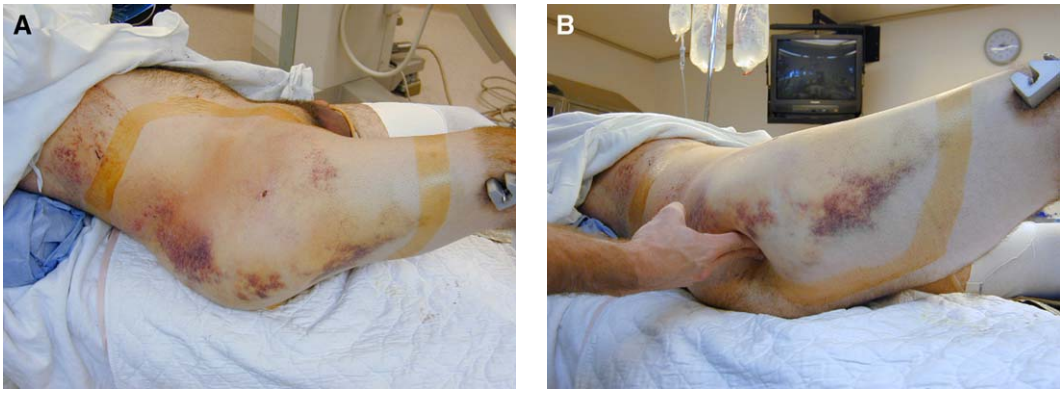

Fig. 1. Clinical appearance of a Morel-Lavallee lesion on postinjury day two. (*A,B*) Note the fluctuant area adjacent to the trochanter.

crosis may occur and a sizable fluid collection may form in the closed space. A soft fluctuant area represents the hallmark physical finding (Fig. 1). Cormack and Lamberty [9] demonstrated that blood supply to the subcutaneous and dermal tissues of the thigh is supplied largely from perforating musculocutaneous and fasciocutaneous vessels. If these perforators are disrupted, a less organized peripheral dermal plexus remains as the only vascular source to the superficial tissues. Cases of skin necrosis over the area of degloving have been reported [10].

These soft tissue injuries are not always initially apparent. In one series of high energy pelvic fractures the degloving injury was missed initially in more than a third of 16 cases [11]. Some cases may show little evidence of soft tissue trauma in the first days after injury, with only subtle signs, such as skin hypermobility, ecchymosis, or abrasion initially present. The characteristic soft fluctuant area may not be apparent until several days after injury. Clearly a high level of awareness is the key to identifying and treating this problem. The lesion is sometimes apparent on the preoperative CT scan (Fig. 2).

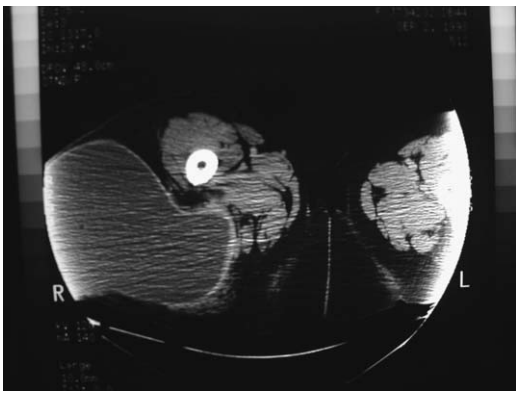

Fig. 2. CT scan demonstrating a large Morel-Lavallee lesion. (Courtesy of Michael McKee, MD, Toronto, Canada).

Treatment recommendations

Letournel and Judet concluded that occurrence of the Morel-Lavallée lesion predisposes the patient to infection and wound problems. Hudson et al [11] reported early infection in 9 of 16 (56%) cases in which the degloving injury was not treated aggressively. Hak et al [12] subsequently found that these wounds cultured positive in 46% (11 of 24) of cases at the time of surgery; however, these typically were found after the first 5 days. Current treatment recommendations include thorough debridement of all necrotic material. Because the goal of treatment is to avoid infection, recent investigators have demonstrated success with percutaneous techniques of debridement and irrigation. Tornetta et al recently reported on 19 patients with Morel-Lavallée soft tissue degloving injuries. All were treated within the first 3 days of presentation by percutaneous debridement using a plastic brush and thorough irrigation until the irrigation was clear (Fig. 3). The small incisions then were closed over high suction drainage until the drainage was less than 30 ml over a 24-hour period. Antibiotics were continued during the interval that the drain was in place. This demonstrated that a pelvic procedure could be performed at the same time as the irrigation and debridement of the Morel-Lavallée lesion and that open treatment of the pelvic and acetabular fractures were done on a delayed basis once the drainage had stopped and the wound looked healthy [13]. If, however, the lesions are diagnosed after the first 3 days, most surgeons recommend thorough open debridement and healing by secondary

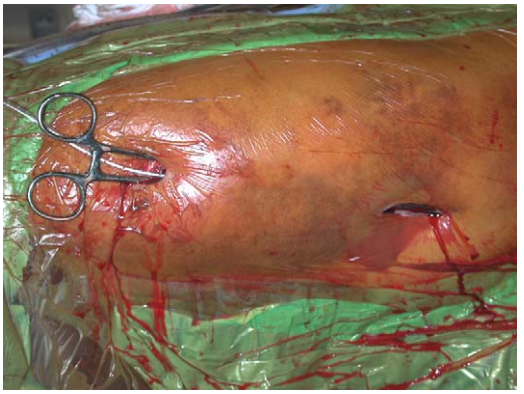

Fig. 3. Appearance of the leg after percutaneous irrigation and debridement.

intention or by dead space closure after serial débridements [12,14,15]. Recent advances in wound care such as vacuum-assisted devices also may prove useful for these situations in the future. Incisions for debridement should be planned carefully to allow for fracture reduction and fixation. Débridements may be performed before or during operative repair of the accompanying fracture [3,12,14]. If debridement is performed late and there is a large amount of dead space, Carlson et al have demonstrated the safety of primary closure of these wounds after the debridement as long as the dead space is handled and closed carefully [16].

Kellam et al [2] reported a 25% "significant" wound infection rate using an open posterior approach for unstable pelvic ring injuries. Although the investigators noted that many of these complications occurred in patients that had severe soft tissue injuries, these results tempered enthusiasm for the open treatment of posterior pelvic ring injuries. Subsequently alternative methods have been advocated. Some groups have advocated closed reduction maneuvers followed by percutaneous posterior fixation in an effort to avoid these complications [17]. Other investigators have demonstrated more satisfactory risks for infection or wound complications using open approaches in carefully selected patients without severe soft tissue injuries at the operative site [18,19]. Moon and Merkle [18,19] described their experience in 42 posterior approaches to the sacroiliac joint. Only one patient developed a deep wound infection and none had wound necrosis or skin slough. A reasonable approach may be to select treatment methods on a case by case basis depending on the bony and soft tissue injuries, timing of surgery, patient factors, and the surgeon's experience.

Open pelvic injuries

Although only 5% or less of pelvic fractures are open, these injuries carry a considerable risk for morbidity and mortality [20–22]. The vast majority of these patients have associated injuries that also may be life threatening. Historically, 25%–50% of patients died as a result of their injuries [4,20,21,23,24]. Open pelvic injuries typically occur when high energy forces applied to the pelvis result in considerable bone and soft tissue disruption. The addition of bacterial inoculation places these patients at high risk for complications [4,5,20,23].

Jones et al [23] proposed a classification system of open pelvic fractures based on results of a multicenter study. Class 1 fractures were those with an intact pelvic ring and no rectal or perineal wounds. Class 2 fractures were those with rotational or vertical pelvic ring instability and no rectal or perineal wounds. Class 3 fractures were those with rotational or vertical pelvic ring instability and associated rectal or perineal wounds with the potential for fecal contamination. Despite aggressive treatment, they found that 44% of patients with potential for fecal contamination of their pelvis fracture died and 77% developed systemic septicemia. Of those with open pelvic ring with mechanical instability and no perineal wounds only 11% experienced systemic sepsis.

Mechanically stable pelvic injuries

Open pelvic fractures may occur with or without disruption of the pelvic ring. Open iliac wing fractures are the most common example of open injuries of the pelvis in which the structure of the ring remains intact. These injuries are usually the result of a direct blow to the subcutaneous iliac wing. Although there may be associated injuries and significant bleeding, these patients are at lower risk for complications and death compared with patients with unstable pelvis injuries [1]. Complex wounds may occur with these injuries and several treatment recommendations have been proposed [15,25]. Current recommendations include appropriate resuscitation, intravenous antibiotics, and urgent and thorough debridement and irrigation of the wounds. Wound packing, closure over drains, and use of a vacuum system then may be considered [17]. Fracture fixation in this setting remains controversial if the pelvis ring remains intact. There are advocates for treating open iliac wing injuries with and without internal fixation [17]. These decisions may best be made on a case by case basis. Considerations for the internal fixation of these injuries include fragment size, involvement of the

acetabulum or sacroiliac joint, incarceration of bowel, and level of pain. If fixation will aid in the stability of the soft tissues, then it is generally recommended.

Mechanically unstable pelvic ring injuries

Open pelvic fractures are much more likely to have rotationally or vertically unstable fracture patterns as compared with closed pelvic fractures [20,21,23]. These unstable open pelvis injuries possess greatly increased risk for complications and death compared with those retaining mechanical stability. Raffa and Christensen [4] reported no deaths in 8 patients with mechanically stable open pelvic injuries, whereas 8 of the 16 patients with mechanically unstable open pelvis injuries died. In a series of 36 patients treated for open fractures of the pelvis, all 10 deaths and nearly all major complications were seen in the 27 patients with unstable pelvic ring injuries [23].

Hemorrhage

Although the risk of massive hemorrhage in mechanically unstable pelvic ring injuries are well known, patients with unstable open pelvic fractures are at even higher risk for massive blood loss. Half or more of the early deaths in these patients have been attributed directly to hemorrhage [20,23]. Raffa and Christensen [4] reported that the mean transfusion requirement in their series of open pelvic fractures was an impressive 33.6 units. Brenneman et al [20] found that the transfusional requirement was four times higher (16 units versus 4 units) for open pelvic fractures compared with a similar group of high energy closed pelvic fractures. The loss of the tamponade effect by disruption of the pelvic soft tissues and the energy imparted likely plays a central role in this potentially life-threatening situation.

Perineal and rectal wounds

The presence of a perineal or rectal wound as part of an open pelvic injury creates a potential portal of entry for virulent bacteria and also may demonstrate the destructive nature of that patient's injury. Occult injuries should be sought by digital rectal examination in all patients and by digital vaginal and speculum examination in female patients. Contamination of these highly traumatized tissues may result in high rates of sepsis and death. Jones et al reported nine patients with a mechanically unstable open pelvic ring injury and perineal or rectal wounds. Seven (77%) of these patients developed sepsis and four (44%) died. Of those unstable open pelvic injuries without perineal wounds only 11% experienced systemic sepsis and none died. A delay in performing a fecal diverting colostomy also correlated with mortality. Of the five patients whose diverting colostomy was performed at less than 48 hours only one died, whereas three of four patients who were treated with a diverting colostomy at greater than 48 hours died. Similarly, Richardson et al [24] found in their series of 37 open pelvic fractures that three patients with rectal or perineal wounds treated with diverting colostomy at greater than 72 hours developed an infection. The authors strongly recommend performing a diverting colostomy early in patients with open fracture with contaminated perineal or rectal injuries.

Clearly perineal wounds and vaginal or rectal tears require special attention if infection and sepsis are to be avoided. Open fractures in these areas may be missed if due diligence is not afforded. A rectal examination must be performed on all trauma patients and a vaginal examination should be included for all women. Blood or other signs of trauma from either orifice mandate a speculum or proctoscopic evaluation. In patients in whom perineal, rectal, or vaginal wounds communicate with the pelvic injury, the need for a thorough debridement and irrigation followed by a diverting colostomy is recommended. The debridement and irrigation should be performed as soon as possible. Diverting colostomy and distal washout are necessary and typically are performed at the time of irrigation and debridement.

Internal fixation

Adding mechanical stability to an unstable pelvic injury may benefit the patient by preventing additional trauma, allowing more mobility, and providing pain relief [17,26,27]. Options include anterior external fixation or internal fixation alone or in combination with posterior fixation, or posterior fixation alone applied open or in a percutaneous fashion. Many investigators advocate use of early external fixation in the acute setting that may be exchanged later for a more definitive method of fixation [27,28]. Other investigators advocate resuscitation and early definitive fixation [17]. Leenan et al [29] reported a small series of unstable open pelvic ring injuries treated with immediate open reduction and internal fixation. Half of their 14 patients developed infections, although there was a high proportion (64%) of patients with associated perineal or rectal injuries in their series. Despite early infections, the investigators reported good functional results at intermediate follow-up. Decisions on the optimal timing and method of definitive fixation are probably best made on a case by case basis.

Outcomes

Death has been reported as 5%–50% of patients with open pelvic ring injuries [4,20,23,24], although over the last 10–20 years survivability and outcomes have improved as more standardized approaches have been adopted, the most important of which is to divert the fecal stream in patients with perineal wounds. Early mortality typically occurs from pelvic hemorrhage, because the tamponade effect of the pelvic soft tissues may be lost, or from other associated injuries. Delayed mortality usually occurs from sepsis or multisystem organ failure. Concomitant injuries are common and certainly play a role in long-term outcomes [20,21].

Brenneman et al [20] found that open fractures of the pelvis often result in long-term pain and functional disability also. They noted that at a mean of more than 4 years, 14 of 27 patients had chronic sequelae from their pelvic injury, including sexual dysfunction (5), fecal (3) and urinary (2) incontinence, and unhealed fractures (3). There were significantly diminished physical function and role limitations in patients with open pelvic fractures on SF-36 assessment as compared with similar trauma patients with high energy closed fractures. No significant differences in emotional or general health categories were found when compared with closed fractures. Long-term problems also were reported by Ferrera and Hill [21], who reported that 7 of the 15 patients in their series of open pelvic fractures required assistance with activities of daily living or ambulated with an assist device, although several of these had additional injuries limiting their function.

Treatment principles of open pelvic fractures

Early recognition and aggressive resuscitation are the first critical steps for optimizing survival and outcomes for patients with open pelvic injuries. Hemorrhage control and reducing the risk for infection should be the next treatment priorities. Intravenous antibiotics and tetanus should be administered early, as for other open fractures, and wound packing with sterile gauze may be used if wounds are large enough. Operative débridements of the open pelvic wounds must follow until the wounds are clean. Serial débridements are especially important if gross contamination has occurred. Fecal diversion is required if perineal or rectal injury has occurred and wounds at high risk for fecal contamination are present. Delays in performing a diverting colostomy may have disastrous consequences and fecal diversion should be performed early (ie, within 48 hours) if necessary [23,24]. Ostomies should be placed with forethought as to the type of pelvic ring reconstruction that may be necessary. Finally, providing for pelvic stability should follow as determined by the bony and soft tissue injury, patient factors, and surgeon's experience. Patient transfer to a tertiary care center should be considered if the considerable resources required to treat these complex injuries and patients are not available.

Summary

High energy injuries to the pelvis and hip area, as in other regions of the body, include a significant soft tissue component that often is given little consideration. When unrecognized, soft tissue injuries around the pelvis may affect outcomes adversely. Even when appropriately recognized, these injuries require special consideration that may alter acute and more definitive treatment decisions. Basic principles of treatment are (1) urgent resuscitation of these trauma patients, (2) understanding of the soft tissue injuries (including open fractures) and their implications, and (3) a treatment plan based on the totality of the patient's pelvic injury (including soft tissue components) and condition.

References

[1] Bucholz R. The pathoanatomy of Malgaine fracture-dislocations of the pelvis. J Bone Joint Surg [Am] 1981; 63A:400–4.
[2] Kellam J, McMurtry R, Paley D, Tile M. The unstable pelvic fracture. Orthop Clin N Am 1987;18:25–41.
[3] Letournel E. Operative treatment of specific types of fracture: posterior wall fractures. In: Letournel E, Judet R, editors. Elson, RA (translating editor). Fractures of the acetabulum. 2nd edition. Berlin: Springer-Verlag; 1993. p. 417–521.
[4] Raffa J, Christensen N. Compound fractures of the pelvis. Am J Surg 1976;132(2):282–6.
[5] Gustilo R, Anderson J. Prevention of infection in the treatment of one thousand and twenty-five fractures of long bones: retrospective and prospective analysis. J Bone Joint Surg [Am] 1976;58:453–61.
[6] Tscherne H, Gotzen L. Fractures with soft tissue injuries. Berlin: Springer-Verlag; 1984.
[7] Gregory P, Sanders R. The management of severe fractures of the lower extremities. Clin Orthop Rel Res 1995;318:95–105.
[8] Morel-Lavallée. Archives generales de medecine. 1863.
[9] Cormack G, Lamberty B. The blood supply of the thigh skin. Plast Reconstr Surg 1985;75:342–54.
[10] Mir y Mir L, Novell A. Repair of necrotic cutaneous

lesions secondary to tangential trauma over detachable zones. Plast Reconstr Surg 1950;6:264–74.
[11] Hudson D, Knottenbelt J, Krige J. Closed degloving injuries: results following conservative surgery. Plast Reconstr Surg 1992;89:853–5.
[12] Hak D, Olson S, Matta J. Diagnosis and management of closed internal degloving injuries associated with pelvic and acetabular fractures: the Morel-Lavallée lesion. J Trauma 1997;42(6):1046–51.
[13] Tornetta III P, Normand A. Percutaneous management of Morel-Lavallee lesions. Orthopaedic Trauma Association Annual Meeting, Toronto, Ontario, Canada, October 10–12, 2002.
[14] Helfet D, Schmeling G. Management of complex acetabular fractures through single non-extensile exposures. Clin Orthop 1994;305:58–68.
[15] Kottmeier S, Wilson S, Born C, Hanks G, Iannacone W, DeLong W. Surgical management of soft tissue lesions associated with pelvic ring injury. Clin Orthop Rel Res 1996;329:46–53.
[16] Carlson D, Simmons J, Sando W, Weber T. Morel-Lavallee lesions treated with debridement and dead space closure. Orthopaedic Trauma Association Annual Meeting, Toronto, Ontario, Canada, October 10–12, 2002.
[17] Routt M, Kregor P, Simonian P, Mayo K. Early results of percutaneous iliosacral screws placed with the patient in the supine position. J Orthop Trauma 1995;9(3):207–14.
[18] Matta J, Saucedo T. Internal fixation of pelvic ring fractures. Clin Orthop Rel Res 1989;242:83–9.
[19] Moon C, Merkle P. A level one trauma center's experience with the posterior approach to the pelvis. Orthopedics 2002;25(2):159–62.
[20] Brenneman F, Katyal D, Boulanger B, Tile M, Redelmeier D. Long-term outcomes in open pelvic fractures. J Trauma 1997;42(5):773–7.
[21] Ferrera P, Hill D. Good outcomes of open pelvic fractures. Injury 1999;30:187–90.
[22] Rothenberger D, Velasco R, Strate R, Fishcer R, Percy J. Open pelvic fracture: a lethal injury. J Trauma 1978;18(3):184–7.
[23] Jones A, Powell J, Kellam J, McCormack R, Dust W, Wimmer P. Open pelvic fractures: a multicenter retrospective analysis. Orthop Clin N Am 1997;28(3):345–50.
[24] Richardson J, Harty J, Amin M, Flint L. Open pelvic fractures. J Trauma 1982;22(7):533–8.
[25] Switzer J, Nork S, Routt M. Comminuted fractures of the iliac wing. J Orthop Trauma 2000;14(4):270–6.
[26] Goldstein A, Phillips T, Sclafani S, Scalea T, Duncan A, Goldstein J, et al. Early open reduction and internal fixation of the disrupted pelvic ring. J Trauma 1986;26:325–9.
[27] Gylling S, Ward R, Holcroft J, Bray T, Chapman M. Immediate external fixation of unstable pelvic fractures. Am J Surg 1985;150(6):721–4.
[28] Browner B, Cole J, Graham J. Delayed posterior internal fixation of unstable pelvic fractures. J Trauma 1987;27:998–1006.
[29] Leenen L, van der Werken C, Schoots F, Goris R. Internal fixation of open unstable pelvic fractures. J Trauma 1993;35(2):220–5.