ELSEVIER SAUNDERS

Crit Care Clin 20 (2004) 159–170

CRITICAL CARE CLINICS

Initial management of pelvic and femoral fractures in the multiply injured patient

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Fractures of the shaft of the femur are the result of high-energy trauma such as motor vehicle collisions, pedestrian accidents, gunshot injuries, and falls from heights. High-energy injuries caused by direct force often are associated with other injuries and open wounds. These injuries, therefore, can be life threatening and result in long-term disability. Patients with femur fractures on average lose up to two or three units of blood as a result of the injury. Up to 50% of all patients require blood transfusion [1,2].

As with most traumatic orthopedic injuries, fractures of the femoral shaft occur in a bimodal distribution with regard to age. These injuries occur more frequently in patients younger than 25 years of age and older than 65 years of age [1]. Femur fractures occur at a rate of one fracture per 10,000 patients per year. There is an increasing incidence of these injuries in patients over the age of 65 as a result of population aging.

Before routine surgical stabilization, femur fractures were associated with a high incidence of morbidity. Nonsurgical treatment options include skeletal traction followed by cast–brace application. Surgical treatments include external fixation, plate fixation, and intramedullary nail placement. Anterograde reamed intramedullary nail placement is the treatment of choice for most femoral shaft fractures. The goals of treatment are to stabilize the fracture to allow early patient mobilization, restore alignment to the extremity, and maintain normal hip and knee range of motion.

Evaluation

Femoral shaft fractures are diagnosed easily with physical examination. There is obvious deformity and tenderness of the affected limb. Associated injuries

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doi:10.1016/S0749-0704(03)00096-4

should be ruled out. Important factors to consider when evaluating a patient with a femur fracture are whether the fracture is open or closed, if it is an isolated injury or if there are multiple injuries, the patient's age, fracture pattern, and associated injuries.

A complete neurologic and vascular examination of the affected limb should be performed. Vascular injuries rarely occur in conjunction with femur fractures, with a reported incidence of 0.1% to 2% [3]. Absent or asymmetric pulses in the feet require further evaluation. Pulses should be re-evaluated after gentle stabilization of the fracture with longitudinal traction. Ankle–brachial indices (ABIs) should be obtained. If the ABI is less than 0.9, arteriography and vascular surgery consultation should be considered.

The injured limb should be examined circumferentially for soft tissue injury. In their classic article, Winquist et al found that 16.5% of 500 femoral wounds were open [4]. Open wounds should be irrigated and covered with sterile dressings. Open fractures indicate an orthopedic emergency and require early formal irrigation and debridement in the operating room. Severe open fractures frequently require multiple operative debridements. Antibiotic choice depends on the severity of soft tissue injury and the contaminating agents. Open fractures pose an increased risk of infection and nonunion because of disruption of cortical blood supply and cortical necrosis [5]. First-generation cephalosporins are recommended for less severe open fractures. Aminoglycoside coverage is added (gentamicin or tobramycin) in injuries with greater soft tissue destruction. Penicillin G is added for fractures associated with an extensive crush component or farm contaminants. Antibiotic coverage traditionally is provided for 3 to 5 days after each operative debridement [6]. Frequently, more severe open fractures are stabilized provincially with external fixators. Definitive fixation is delayed until the soft tissue injuries have been adequately debrided.

Initial radiographs should include full-length anterior–posterior (AP) and lateral views of the femur, pelvis, and knee. Femoral shaft fractures commonly are associated with other skeletal injuries. The ipsilateral femoral neck should be scrutinized for a hip fracture. Ipsilateral femoral neck fractures may not be seen in up to 30% of patients [7]. Initial radiographs should be reviewed to rule out hip dislocations, pelvic ring injuries, acetabular fractures, and ipsilateral tibial fractures. Associated ipsilateral tibia fractures (floating knee syndrome) also should be ruled out.

Femoral shaft fractures also can be associated with ligamentous knee injuries. In one case series, Swiontkowski et al [7] reported a 15% to 55% incidence of concomitant knee injuries with femoral shaft fractures. In their case series, Vangsness et al [8] reported 55% (N = 40) of patients with ligamentous knee injuries associated with femoral shaft fractures. Among these injuries, 48% were found to have partial anterior cruciate (ACL) tears, with an additional 5% having complete ACL ruptures. In the same series, 30% of patients were found to have some type of meniscal injury. It is difficult to assess for ligamentous knee injuries with unstable femur fractures. The ipsilateral knee should be examined carefully and stress assessed after fracture stabilization.

Timing of fracture fixation

Earlier reports advocated delayed stabilization of isolated femoral shaft fractures 3 to 7 days after injury [9–11]. Patients were observed initially for complications such as adult respiratory distress syndrome (ARDS) or fat emboli syndrome (FES). More recent studies have established the beneficial effects of early fixation of femoral shaft fractures. In polytrauma patients with multiple injuries (injury severity score greater than 18), several studies have shown decreased morbidity with immediate stabilization within the initial 24 hours [12–15]. A retrospective review by Johnson et al [14] indicated that more severely injured patients had greater benefits for early fracture stabilization within the initial 24 hours after injury. Patients with severe trauma and ISS scores greater than 40 had a five times higher incidence of ARDS, if fracture stabilization was delayed, compared with the immediate stabilization cohort. Bone and Johnson [12] subsequently compared the results of early versus delayed stabilization of femur fractures in 178 patients in a prospective randomized trial. Patients were randomized to early stabilization (less than 24 hours) versus late stabilization (after 48 hours). The authors noted that in patients with multiple injuries, early stabilization of femoral shaft fractures resulted in a statistically significant decrease in the incidence of pulmonary complications, including ARDS, fat embolism, and pneumonia. Patients randomized to the late fixation group stayed longer in the intensive care setting and had longer overall hospital stays.

In 1994, Charash et al [16] reviewed early versus delayed femoral shaft fracture stabilization with reamed intramedullary nailing in polytrauma patients with thoracic injuries. The overall incidence of pulmonary complications (ARDS, pneumonia, fat embolism, or pulmonary embolism) was 56% in the delayed fixation group compared with 16% in the early fixation group. The authors noted that 48% of patients in the delayed fixation cohort (N = 25) went on to develop pneumonia compared with 14% in the early fixation cohort (N = 56).

Early fracture stabilization allows for patient mobilization, improvement in pulmonary status, decreased incidence of deep venous thrombosis and pressure ulcers, and ease of nursing care. Femoral fractures can be stabilized provisionally with external fixation or definitively with internal fixation (intramedullary nails or plates). During the resuscitation phase, the fracture should be stabilized provisionally with a spanning external fixator. The fixator can be applied quickly with minimal blood loss, and it provides many of the benefits of intramedullary nailing. The goal in the early resuscitative phase is to maximize the benefits of skeletal stabilization while minimizing the surgical insult to the patient. Definitive treatment with internal fixation is delayed until the patient's hypotension, hypothermia, coagulopathy, and acidosis are corrected [12].

Associated head injury

Treatment of femur fractures in patients with head injuries remains controversial. Patients with multiple injuries associated with significant closed head injuries

(Glasgow Coma Scale [GCS] less than 8) are vulnerable to the second hit phenomenon resulting from hypoxemia and hypotension. Several studies have confirmed the close association between hypotension in head injury patients and increased morbidity and mortality [17]. Chestnut et al noted an increase in mortality from 27% to 75% in head injury patients associated with hypotension. The authors concluded that early or late shock is the most significant predictor of mortality in head injury patients. Secondary insults may be associated with early operative intervention, prolonged operative times, and general anesthesia. Such second hits may exacerbate the underlying brain trauma and result in neurologic deterioration [18–21].

In their retrospective review in 1998, Starr et al [22] reviewed the outcomes of patients with head injuries associated with femoral shaft fractures. Thirty-two patients were identified. Fourteen underwent early fracture fixation (within 24 hours), and 14 underwent late fracture fixation. Four patients did not have their fractures fixed. Early fracture stabilization did not increase the prevalence of central nervous system (CNS) complications. Patients in the delayed fixation group, however, were 45 times more likely to have pulmonary complications.

Poole et al [23,24] reviewed the cases of 114 patients with head injuries and associated lower extremity fractures. Forty-six patients underwent early fracture fixation (EFF) within 24 hours of injury; 26 patients had delayed fixation more than 24 hours after injury, and 42 had no fixation. The authors concluded that early skeletal fixation did not predispose patients with traumatic brain injuries to a greater risk for adverse outcomes. They noted that patients with head injuries are at greater risk for pulmonary complications as a direct result of their head injury. The authors concluded that early skeletal fixation could proceed safely if hypotension and hypoxia were avoided.

Optimal timing for fixing femur fractures in patients with head injuries remains unknown. Unfortunately, no prospective randomized trials have been performed to help answer this question. No conclusive evidence exists in the literature that early fixation of femoral fractures has a long-term negative outcome in head injury patients. Prevention is the best method for avoiding secondary brain insult. Patients require adequate resuscitation and maintenance of blood pressure and volume to optimize oxygenation. Hypotension (systolic blood pressure less than 90) and hypoxemia (oxygen saturation less than 90%) should be avoided. Intracranial pressure monitoring may be useful by allowing assessment of cerebral perfusion pressures, which should be maintained at greater than 70 mm Hg. Definitive early skeletal stabilization (intramedullary nailing) should be attempted in patients who have been resuscitated adequately and who have stable intracranial pressure/mean arterial pressure parameters. In patients at risk for secondary brain insult, less invasive fixation such as external fixators or skeletal traction should be considered to temporize femur fractures [25]. Scalea et al introduced the idea of damage control orthopedics. External fixation was used for initial stabilization of femoral shaft fractures as a bridge to delayed definitive fixation with reamed intramedullary nailing. The authors suggested that external fixation should be considered in patients who cannot tolerate further blood loss, have head injuries, or are not fully resuscitated. External fixation allows a less invasive means for stabilization of long bone fractures.

Fat emboli syndrome

Fat embolism syndrome (FES) is a multi-system disorder that results from fat pulmonary embolization in polytrauma patients. Clinically, this presents as pulmonary or CNS dysfunction, fever, and rash [26]. Almost all blunt trauma patients likely sustain some degree of pulmonary fat embolization as a result of soft tissue injury. The severity of FES covers a broad spectrum ranging from subclinical symptoms to ARDS. Patients with long bone fractures are particularly at risk for developing FES. Pulmonary failure requiring ventilatory support occurs in l% to 36% of patients with unilateral tibial or femoral shaft fractures and in 5% to 36% of patients with multiple long bone fractures [27–29].

The etiology of FES remains uncertain. Pulmonary fat embolization apparently alters pulmonary hemodynamics and increases pulmonary vascular permeability. Hypoxemia is the most consistent laboratory finding. The clinical onset of FES ranges from 12 to 72 hours after injury. Nearly 90% of patients with FES develop symptoms within 24 hours of injury [27]. The presentation of FES may occur immediately or be delayed as long as 1 week [30].

The best treatment for FES remains prevention. Numerous studies have shown the benefits of early femur fracture stabilization in multiply injured patients. Reamed intramedullary nailing is the treatment of choice for femoral shaft fractures in adults. It is controversial, however, whether fat embolization during reaming increases the risk for pulmonary complications in trauma patients. Pulmonary fat embolization occurs during this procedure and may be clinically significant. Studies indicate that this does not pose a problem in adequately resuscitated polytrauma patients without chest or head injuries [31]. Immediate definitive femoral shaft fracture fixation in patients who are hemodynamically unstable or not fully resuscitated should be delayed. Alternate less invasive procedures for skeletal stabilization should be considered.

Pelvic ring injuries

Pelvic fractures account for l% to 3% of all skeletal fractures seen in the emergency room [32]. They range in severity from low-energy stable fractures to high-energy unstable patterns. Management of these injuries is dictated by assessment of stability. Extremely large forces are needed to cause unstable injuries. This force is distributed to other organ systems and frequently results in significant associated injuries [33,34]. In trauma centers, 13% to 18% of all pelvic fracture patients have an unstable injury pattern [35,36]. Early identification of unstable pelvic injuries and the mechanism of injury are useful in isolating other associated injuries [34]. Evaluation and management of unstable pelvic fractures requires a multi-disciplinary team approach including trauma-trained general surgeons, orthopedists, neurosurgeons, urologists, and interventional radiologists [37].

The reported mortality for pelvic fractures ranges from 14% to 50% [35,36, 38,39]. Mortality is usually caused by associated injuries [32,40–42]. Certain factors such as hypotension and open injuries are associated with higher mortality rates. Patients with pelvic fractures associated with hypotension on admission have a mortality rate of 38% to 42%, compared with 3% for patients who were normotensive [42,43]. Other studies report a 30% to 50% mortality rate for open pelvic fractures [36,38,40,44,45].

Evaluation

Initial evaluation and management of polytrauma patients focus on proper diagnosis of all injuries in accordance with advanced trauma life support (ATLS) protocols. Resuscitation occurs simultaneously with the primary evaluation [46]. Accident information is obtained from the patient, witnesses, and paramedics. Injury mechanism should be determined to help assess the energy of the accident and possible associated injuries. Most pelvic fractures occur with lateral impact (85%) rather than frontal impact (15%) [47,48]. Lateral compression pelvic injuries are associated more frequently with head injuries, whereas AP compression injuries or frontal impact injuries are associated commonly with intra-abdominal injuries [34]. Up to 40% of patients with pelvic fractures may have associated abdominal injuries [40].

Early identification of the unstable pelvis, especially for the patient who is hemodynamically unstable, is a treatment priority. Acute management of trauma patients with pelvic ring injuries entails determining pelvic stability, identifying associated injuries, and determining hemodynamic status. Patients must be kept warm; volume replacement must be rapid, and sterile dressings must be applied to all open wounds. All sources for bleeding must be identified and addressed [46].

The general physical examination of trauma patients should follow the guidelines of the American College of Surgeons and ATLS protocols. The lower extremities should be scrutinized for possible long bone fractures. In the absence of lower extremity fractures, rotational or limb shortening deformities suggest a pelvic injury [49]. Open wounds in the pelvic area should be assessed carefully to rule out an open fracture. The genitourinary system also should be examined. Blood at the tip of the penis in men or from the urethra or vagina in women may indicate an open pelvic fracture and associated urethral injury. All patients also should have a rectal exam performed. Gross blood or guaiac-positive stool could represent a possible open pelvic injury. A thorough neurovascular exam of the lower extremities should be performed. Injury to the lumbosacral plexus occurs in up to 50% of patients with rotationally and vertically unstable pelvic fractures [49]. Physical exam findings associated with significant pelvic ring injuries include scrotal or labial swelling, flank ecchymosis, open lacerations/abrasions, leg length discrepancy, and blood at the urethral meatus [37].

Pelvic stability usually can be determined by the initial AP pelvic radiograph. If necessary, the anterior superior iliac spine test or the iliac wing compression test (pelvic rock test) can be used to see if the pelvis moves as one unit. Preliminary pelvic stabilization should be performed only by an orthopedic surgeon. After a mechanically unstable pelvis is determined, further provocative examination for pelvic stability should not be performed [37].

Maintaining hemodynamic stability is the primary goal during the initial evaluation of trauma patients with pelvic fractures. Hypovolemic shock caused by pelvic injury occurs in patients with mechanically unstable fractures. Initially, all other sources for potential bleeding must be ruled out, including intrathoracic bleeding, intraperitoneal bleeding, open wounds, closed extremity fractures, and retroperitoneal bleeding. Many trauma patients arrive in the emergency room hypothermic, hypocalcemic, and acidotic. All of these factors can contribute to a coagulopathic state resulting in further blood loss and subsequent hypotension. Correcting these derangements is essential during the initial evaluation and resuscitative effort. Prolonged hypotension results in a low-flow state, which can exacerbate existing head, pulmonary, and visceral injuries [50].

Pelvic stability is assessed through physical exam findings and analysis of radiographs. The AP pelvis is part of the initial trauma series of radiographs obtained in most patients with blunt trauma. This view allows assessment of pelvic symmetry and vertical translation of each hemipelvis. Pelvic inlet (40° cephalad tilt radiograph beam) and outlet (40° caudal tilt radiograph beam) allow assessment for rotational and sacral deformities, respectively. Pelvic computed tomography (CT) scan with 3-mm cuts allows for further assessment of pelvic stability. CT scans are particularly useful for identifying sacral injuries and sacroiliac (SI) joint disruptions. In urgent cases, a formal pelvis CT scan may not be possible. An abdominal CT scan, however, can provide valuable information regarding pelvic ring injuries also.

Classification

Multiple classification systems exist for pelvic fractures. Injuries can be characterized by anatomic location [51], mechanism of injury [34], or pelvic stability [52]. Tile's classification for pelvic ring injuries categorizes fractures based on stability. Type A fractures represent stable injury patterns. Type B fractures represent rotational instability, but they retain vertical stability. Type C injuries signify rotational and vertical instability. Both types B and C injury patterns signify mechanically unstable injuries.

Associated urologic injuries

Injuries to the lower genitourinary tract may occur with blunt lower abdominal trauma. These injuries commonly are associated with pelvic fractures. The presence of gross hematuria, bloody urethral discharge, or inability to pass a Foley catheter suggests a urologic injury. Clark and Prudencio [53] reviewed the cases of 2419 pelvic fractures and reported an overall incidence of 14.5% of lower urinary tract injuries. Isolated bladder ruptures occurred in 7% of cases and in 54% of patients with lower urinary tract injuries. Urethral injuries occurred in 5% of pelvic fracture cases [54]. In cases with suspected lower genitourinary tract injuries or in patients with significantly displaced pelvic fractures, retrograde cystourethrography or retrograde urethrogram should be performed. A cystogram can help identify bladder ruptures.

Management of hemodynamically unstable patients

High-energy pelvic ring injuries can be accompanied by life-threatening hemorrhage. Bleeding from osseous, vascular, and visceral structures may result in hypovolemic shock. It is of utmost importance to identify and control sources of ongoing blood loss. Intra-abdominal bleeding must be ruled out using ultrasound, supraumbilical peritoneal lavage, or CT scan. Head and chest injuries are the most common causes of mortality in patients with pelvic fractures and need to be ruled out as well.

Initially, hypotensive patients need to be fluid resuscitated, because normotensive patients with pelvic fractures have a reported 3% mortality, compared with 38% to 42% mortality for hypotensive patients [42,43]. Three liters of a balanced salt solution should be given upon arrival, followed by appropriate blood products (packed red cells, platelets, and fresh frozen plasma). As previously mentioned, many trauma patients arrive cold, acidotic, and hypocalcemic, resulting in a coagulopathic state. Hypotensive patients need to be warmed, and their coagulopathies need to be corrected. Appropriate monitoring, including core body temperature is essential [50].

When intraperitoneal, intrathoracic, and intracerebral sources for bleeding have been excluded, attention should be directed to stabilizing pelvic bleeding. Pelvic hemorrhage infrequently contributes to patient mortality. Less than 2% of patients with pelvic fractures die directly from their pelvic injury [34,55]. Pelvic bleeding, however, may play a significant contributing role in patient mortality. Provisional stabilization of an unstable pelvis is an integral part of patient resuscitation and should begin in the field. Most pelvic bleeding is venous, resulting from disruption of the large retroperitoneal venous plexus and bleeding at the fracture site. In a small percentage of cases, pelvic hemorrhage may result from arterial injury. Most commonly, the superior gluteal, internal pudendal, or obturator arteries are disrupted. Arterial sources for hemorrhage require embolization.

Temporary stabilization of the pelvis can be achieved through use sheet and towel clamp, pelvic sling, or external fixator. Provisional stabilization of unstable pelvic fractures should be performed simultaneously as hemodynamically unstable patients are resuscitated. Hemodynamic stabilization initially was thought to occur by decreasing the volume of the pelvis, thereby increasing the tamponade effect. Recent studies, however, have suggested that immobilization of the pelvis allows bleeding sources to clot, which in turn helps control pelvic hemorrhage [56–58].

Circumferential wrapping of the patient with a sheet is indicated in the acute resuscitation of hemodynamically unstable patients with a pelvic ring injury [59]. The sheet is wrapped around the pelvis between the iliac crests and the greater trochanter of the femur. The advantages of this technique are that it can be applied quickly without specialized training; it allows continued access to the patient during resuscitation, and it can be left in place during transfer to a trauma facility.

Pelvic external fixation is effective for stabilizing unstable pelvic fractures. In most institutions, however, they must be placed in the operating room. Therefore, circumferential pelvic wrapping is the primary modality used in the acute resuscitation phase in the emergency room. Timing for external fixator placement remains controversial. Many orthopedists recommend fixator placement before emergency laparotomy when possible. Fixator placement may prevent subsequent hemodynamic destabilization during abdominal cavity release [57]. Frame constructs should allow abdominal access during exploratory laparotomy. In a retrospective review, Riemer et al reported a significant decrease in mortality with the use of external fixators. The authors reviewed a consecutive series of cases of pelvic fracture patients with similar injury severity scores. They reported a decrease in mortality from 26% to 6% with the use of an external fixator [60]. Contraindications for fixator use include surgeon inexperience, stable fracture patterns, and hemodynamically stable patients with mechanically unstable pelvis fractures. In some instances, particularly posterior pelvic ring disruptions, anterior fixator placement alone may worsen posterior ring reduction.

Most pelvic bleeding occurs in the low-flow venous system (greater than 90%). Infrequently, however, an arterial injury may be the source of pelvic hemorrhage. Arterial injury is more common in frontal impact injury patterns. In their series, Burgess et al reported that 20% of patients with AP compression and vertical shear injury patterns required embolization, whereas only 1.7% of lateral compression injury patterns required embolization [34]. In such instances, embolization is necessary to control bleeding. The timing of arteriography and embolization remains controversial [40]. Typically, angiography is reserved for patients with continued unexplained blood loss and hypotension after all potential sites for bleeding have been excluded, and provisional pelvic stabilization has taken place. Panetta et al reviewed the cases of pelvic fracture patients with associated hemorrhage in which no external fixators were used. They recommended that angiography be performed in patients with greater than four units of blood loss within the first 24 hours, six units of loss within 48 hours, persistent hypotension with negative diagnostic peritoneal lavage, or expanding retroperitoneal hematoma noted at time of laparotomy [61]. Current consensus is that before angiography, aggressive resuscitation needs to be initiated; other sources of bleeding (chest/abdominal) need to be ruled out, and provisional pelvic stabilization with either a sheet or external fixator should be performed. If the patient remains hypotensive, angiography is indicated [33].

Summary

The management of polytrauma patients is clinically challenging and requires a multi-disciplinary team approach. The immediate and definitive operative care of fractures represents the optimal treatment for polytrauma patients with orthopedic injuries. Early orthopedic intervention in long bone fractures and pelvic ring injuries has been shown to decrease pulmonary complications, improve hemodynamic stability, reduce ventilator time, and facilitate early patient mobilization. These factors decrease mortality and improve outcomes for patients with multiple injuries.

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