The spectrum of patients with pelvic fractures ranges from patients with isolated, simple fractures to critically injured patients with multiple other life-threatening injuries. Critical care nurses care for patients with major pelvic fractures in many settings, including transport, trauma resuscitation bays, perioperative areas, and intensive care units. Accordingly, they need to understand the issues involved in providing that care. In this article, we survey the current information on pelvic fractures, including epidemiology, anatomy, assessment of patients, hemorrhage, management, and associated injuries.

Epidemiology

Motor vehicle crashes, including motor vehicles crashing into pedestrians, cause about 60% of pelvic fractures. Most of the remainder result from falls.14 Frequency of fracture is highest for occupants of subcompact or compact automobiles and for occupants of any vehicle struck on the side.7 Pelvic fracture generally contributes to traumatic death but is not the primary cause.2 For patients with pelvic fractures who die, hypotension at the time of admission is associated with increased mortality (42% vs 3.4% for patients with stable vital signs), as are head injuries requiring neurosurgery (50% mortality); abdominal injuries requiring laparotomy (52% mortality); and concomitant thoracic, urological, or skeletal injuries (22% mortality).5,7,10-13 Survival is worse for patients with open pelvic fractures and for pedestrians struck by cars.5,7,12,13 Pelvic fractures are less common and less lethal in children than in adults.11

Anatomy

The pelvis protects the viscera, transmits weight from the trunk to the lower limbs, and has attachment points for muscles. The abilities to stand and to bear weight require stability of the pelvic ring, made of the sacrum and aspects of the paired innominate bones. The innominate bones are formed bilaterally by the ilium, the ischium, and the pubis7,8 (Figures 1 and 2). These bones are inherently unstable and gain stability only with ligamentous support.
especially around the sacroiliac joint posteriorly. Figure 3 depicts the ligamentous network. The junction of the ilium, ischium, and pubis forms the acetabulum, the concave socket for the femoral head, and the anterior aspects of the innominate bones join with a cartilaginous disk to form the pubic symphysis. The pubic symphysis is important for pelvic support, but disruption of the symphysis by itself does not make the pelvis unstable.7,15,16

A stable pelvis can withstand normal vertical and rotational physiological forces, but either fractures or ligamentous injuries can disrupt pelvic stability. Disruption of the anterior pelvic ligaments creates rotational instability, whereas posterior ligamentous injury creates both rotational and vertical instability.17

Pelvic blood supply comes primarily from the iliac and hypogastric arteries, which run at the level of the sacroiliac joints. Those arteries are supplemented by a rich associated network, including the superior gluteal artery, which is susceptible to injury in posterior fractures, and the obturator and internal pudendal arteries, which can be injured in fractures of the rami8 (Figure 4).

Assessment for Fracture and Associated Injuries Physical Examination

Pelvic fractures can be accurately diagnosed through physical examination, but a high index of suspicion for a fracture based on the mechanism of injury is essential.18 Examination begins with inspection for abrasions and contusions, symmetry, isolated rotation of a lower extremity, and discrepancy in limb length. Discrepancy in limb length may be due to a hip injury, a femoral injury, or a vertically unstable pelvic injury.7 A rotated iliac crest indicates a serious fracture.4 Rotational stability is evaluated by palpating for tenderness and crepitus with inward and posterior compression of the iliac crests and with posterior compression of the pubic symphysis.17 Rocking the pelvis is inappropriate, and care must be taken to avoid displacing a fracture or disrupting a pelvic hematoma during the examination. If no fracture of a lower extremity has occurred, vertical stability is assessed by longitudinal manual traction on the lower extremities.7 Tenderness over the
trochanter indicates acetabular or femoral head injury. Any skin defect over the pelvis should be investigated as a possible open fracture.

Genitourinary injuries complicate up to one quarter of pelvic fractures, particularly those fractures with genitourinary injury at or near the pubic symphysis. Up to 6% of women and 11% of men who have pelvic fractures have urethral injuries; the frequency is lower in infants and children. Blood at the urinary meatus or a “high riding” prostate suggests a urethral injury and is a relative contraindication for placement of a Foley catheter.

If urethral injury is suspected, a retrograde urethrogram should be obtained before placement of a catheter in the bladder. For retrograde urethrograms, an abdominal plain radiograph is obtained, and then 60 mL of contrast material is injected directly into the urethra via a snugly placed syringe. Another radiograph is obtained during injection of the last 10 mL of contrast material. Extravasation of the contrast material indicates urethral injury.

Other genitourinary injury is also possible, so a urine sample should be collected. Microscopic hematuria is rarely associated with significant injury, but gross hematuria should prompt further evaluation. If urethral injury is excluded, gross hematuria suggests bladder or renal injury. Transmitted forces can rupture a full bladder, but only a bony fragment will injure an empty one. The bladder can be evaluated by using cystography; a Foley catheter is inserted, and radiographs are obtained when the bladder is filled with up to 400 mL of contrast material and again after the contrast material is drained. In patients with stable hemodynamic status, both the bladder and the kidneys can be evaluated by using computed tomography (CT).

Male sexual dysfunction is associated with pelvic trauma, and the frequency of impotence both with and without urethral rupture is significant. Gynecologic and vaginal injuries are rare with pelvic fracture, and most gynecologic injuries occur in women who are pregnant.

Gastrointestinal injury associated with pelvic fracture can occur either as a separate traumatic injury or as a laceration by the sharp edge of a fractured bone. Both rectal and vaginal examinations are necessary to rule out communication through a laceration. Especially in obtunded patients, it is important to keep from creating such a communication during the examination. Gastointestinal injury can be difficult to detect, because even guaiac testing for occult blood is not a completely reliable indicator.

The proximity of neurological structures to the sacrum and acetabulum creates the possibility for nerve injury. Spinal cord injury is most often associated with pelvic fracture when patients have vertical sacral fractures at or above the level of L5 or any transverse sacral fracture. Injuries at specific levels cause specific deficit patterns, so the dermatomes at and below L5 should be assessed carefully. Particular attention should be paid to plantar flexion and dorsiflexion of the great toe, sensation in the foot, and the Achilles deep tendon reflex.

Table 1 Nerve assessment in pelvic fractures

<table>
<thead>
<tr>
<th>Nerve level</th>
<th>Normal function</th>
</tr>
</thead>
<tbody>
<tr>
<td>L5</td>
<td>Dorsiflexion of the foot, sensation in dorsal part of foot and lateral part of calf</td>
</tr>
<tr>
<td>S1-S2</td>
<td>Hip extension, knee flexion, plantar flexion</td>
</tr>
<tr>
<td>S2-S5</td>
<td>Sensation in posterior part of leg, lateral part of foot, and genitalia, sensation in perineum, bowel and bladder function</td>
</tr>
</tbody>
</table>
Table 1 describes expected nerve function. The cauda equina syndrome, a saddle-shaped area of defect with leg weakness and plantar flexion weakness, also sometimes occurs.7,8

**Radiological Studies**

Advanced Trauma Life Support guidelines24 recommend an antero-posterior pelvic radiograph for all patients with multiple trauma. That radiograph alone is adequate for classification and management of most pelvic fractures, but it does not reveal some sacral fractures or sacroiliac injuries, and it does not reliably indicate the amount of bony displacement.8 Some patients with multiple trauma may not need routine anteroposterior pelvic radiographs. In patients who are awake and alert and have no clinical evidence of pelvic fracture, anteroposterior radiographs reveal unexpected injuries less than 1% of the time. The radiographs are essential for some patients, however, because physical examination by itself is inadequate in adults who are not alert and is only 69% to 90% sensitive for detection of pelvic fractures in infants and children.25-28

On radiographs, a normal pubic symphysis is less than 5 mm wide and has less than 3 mm of vertical offset. Overlap is abnormal. Generally, the pelvic structures should be symmetrical about the midline, and edges and curves should be generally smooth (Figure 2). Positioning and technique can cause pelvic rotation on plain radiographs, and the degree of rotation should be evaluated by looking at the size and shape of the iliac wings.7

Other radiological views can provide additional information. An inlet projection, in which the x-ray beam is angled from the head toward the feet, offers improved views of superiorly and posteriorly displaced posterior fractures, posteriorly displaced anterior arch injuries, and sacroiliac widening. The outlet view, with the x-ray beam angled toward the head, gives better views of sacral fractures and sacroiliac joint injuries.8 These views are less commonly used now, because CT scans and reconstructions are widely available. The greater detail and multiple views with CT scanning are especially useful for evaluating sacral, sacroiliac, posterior arch, and acetabular injuries, and CT scans also allow visualization of retroperitoneal hematomas.7,8

**Fracture Types and Classifications**

When injury is found, a number of classification systems to describe pelvic fractures are available. Two of the most prominent are the Tile classification10 and the Young and Burgess classification,29 which are based on the direction of the injury, pelvic stability, and forces involved (Table 2). Classification helps in identifying associated injuries, correlates with the degree of pelvic injury, and is useful in preparing for definitive orthopedic repair.10,29-31 Fracture classification, however, is not essential for developing early strategies for management of patients with pelvic fractures.

**Fractures of the Ramus and Acetabulum**

Patients with low-force injuries generally have stable fractures and stable vital signs. One third of all

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**Table 2 Classification schemes for pelvic fractures**

<table>
<thead>
<tr>
<th>Tile’s classification10</th>
<th>Young and Burgess classification29</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type A, Stable</strong></td>
<td>Lateral compression (LC)</td>
</tr>
<tr>
<td>A1, Without involvement of pelvic ring</td>
<td>I, Sacral compression on side of impact</td>
</tr>
<tr>
<td>A2, With involvement of pelvic ring</td>
<td>II, Iliac wing fracture on side of impact</td>
</tr>
<tr>
<td></td>
<td>III, LCI or LCII injury on side of impact with contralateral open-book injury</td>
</tr>
<tr>
<td><strong>Type B, Rotationally unstable</strong></td>
<td>Anterior posterior compression (APC)</td>
</tr>
<tr>
<td>B1, Open book</td>
<td>I, Slight widening of pubic symphysis or anterior part of sacroiliac joint with intact anterior and posterior sacroiliac ligaments</td>
</tr>
<tr>
<td>B2, Ipsilateral lateral compression</td>
<td>II, Widened anterior part of sacroiliac joint with disrupted anterior and intact posterior sacroiliac ligaments</td>
</tr>
<tr>
<td>B3, Contralateral lateral compression</td>
<td>III, Complete disruption of sacroiliac joint</td>
</tr>
<tr>
<td><strong>Type C, Rotationally and vertically unstable</strong></td>
<td>Vertical shear (VS)</td>
</tr>
<tr>
<td>C1, Rotationally and vertically unstable</td>
<td>Vertical displacement anteriorly and posteriorly</td>
</tr>
<tr>
<td>C2, Bilateral</td>
<td>Combination of other injury patterns</td>
</tr>
<tr>
<td>C3, With associated acetabular fracture</td>
<td></td>
</tr>
</tbody>
</table>
pelvic fractures are individual bone fractures without involvement of the pelvic ring. An isolated, nondisplaced fracture of the pubic ramus is the most common pelvic fracture; it often occurs in elderly patients who fall. It should be considered in the differential diagnosis of any patient with hip pain. Fractures of both the superior and inferior pubic rami on the same side are also common and are also typically stable.

A special type of ramus fracture is the straddle fracture, caused by direct injury of the pubic arch or by lateral compression forces. The injury produces either a fracture of all 4 rami or ipsilateral rami fractures with disruption of the pubic symphysis. Genitourinary injury is common with straddle fractures, and clinical manifestations often include anuria, hematuria, or perineal ecchymosis.

The acetabulum is involved in about 20% of pelvic fractures in adults and may involve injury of the femoral head or fracture of the pelvic ring. A complex classification scheme for acetabular injuries essentially describes the anatomical locations of fractures across or within the acetabulum, as well as fractures of the posterior hip. A posterior hip dislocation is common with a posterior fracture of the acetabular hip, and displacement of the femoral head is highly suggestive of some acetabular injury. Hip pain aggravated by percussion of the greater trochanter or the talus is also suggestive of acetabular injury. Injuries to the sciatic nerve complicate more than 10% of acetabular fractures.

**High-Energy and Pelvic Ring Fractures**

Higher energy injuries produce greater structural and hemodynamic damage to both the pelvis and other organs. Compared with patients with low-energy fractures, patients with high-energy fractures of the pelvic ring have higher transfusion requirements, between 3.6 and 14.8 units, and more than three quarters have associated head injury, hemothorax, pneumothorax, splenic laceration, or gastrointestinal or genitourinary injuries.

Because the pelvis has a ring shape and because the sacroiliac joints are relatively immobile, displacement of the pelvic ring requires a break in 2 places. Even if plain radiographs appear to show only an isolated displaced anterior fracture, bone scans and autopsy studies indicate that all patients who have anterior pelvic ring displacement have a posterior pelvic ring injury as well. Patients with double breaks in the pelvic ring are severely injured. These fractures, from either anteroposterior or lateral compression, always create rotational instability and may or may not be vertically unstable. If the compression force is sufficient to cause both rotational and vertical instability, the significant ligamentous and bony injuries are typically complicated by damage to both vascular and nerve structures. The direction of injury helps define common patterns of injury.

The so-called open-book fracture is caused by a severe anteroposterior compression force, such as a head-on motor vehicle crash, that causes disruption at the pubic symphysis (Figure 5). The sacroiliac joint remains supported by the posterior ligaments and opens like a hinge, creating a pelvis that is vertically stable but rotationally unstable. Associated injuries to the neurological and vascular structures in the posterior arch are common, and increased pelvic volume allows the collection of a large amount of blood. Patients with severe anteroposterior injuries have the highest crystalloid and blood requirements of all patients with pelvic fractures.

High-energy lateral forces such as a side-impact motor vehicle crash or a car striking a pedestrian cause inward rotation of the hemipelvis and rotational instability. Pelvic volume is decreased with these injuries, and although critically injured, these patients generally have much lower fluid resuscitation requirements than do other patients with pelvic injuries caused by high-energy forces.

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**Figure 5** Plain radiograph of open-book pelvic fracture. Note widening of the pubic symphysis and disruption at the right sacroiliac joint, creating a fracture with vertical and rotational instability.

Image courtesy of Adam Starr, MD, University of Texas Southwestern Medical Center, Dallas, Tex. Reprinted with permission.
High-energy vertical forces transmitted to the pelvis via extended femurs can produce unique injury patterns. Malgaigne fractures are anterior fractures through the rami and/or pubic symphysis coupled with posterior fracture of the ipsilateral ilium, sacrum, or sacroiliac joint.

About 90% of hemorrhaging associated with pelvic fractures is venous bleeding from fractured bone surfaces.

The combination of anterior and posterior injury creates both rotational and vertical instability, and mortality and morbidity in patients with Malgaigne fractures are high. The bucket-handle fracture is similar, with the posterior injury on the contralateral side. These injuries could be caused by motor vehicle crashes in which the force of a frontal impact is transmitted through extended legs or by a long fall with a foot-first landing.

Acute Injury and Management

Pelvic Bleeding

The most common cause of death in patients with lateral compression pelvic fractures is an associated closed-head injury; death in patients with anteroposterior pelvic injuries is related to pelvic bleeding and visceral injuries. Among patients in whom death is due solely to pelvic fracture, 65% die because of exsanguination.

About 90% of hemorrhaging associated with pelvic fractures is venous bleeding from fractured bone surfaces. The fracture site itself is the primary bleeding source in about 86% of injuries. An arterial source amenable to embolization occurs in only about 10% of patients. Large venous injury is even less common; it occurs in 1% or less of patients. Patients with injury to large vessels have very high mortality rates, up to 85%, and are typically hypotensive at the time of admission. Pedestrians struck by cars have the highest incidence of large vessel injury.

Blood from pelvic fractures typically goes into the retroperitoneum, which can hold up to 4 L. An intact peritoneum is important in controlling retroperitoneal bleeding, and movement during examination, resuscitation, or transport can prevent hemostasis. Similarly, the tamponade provided by the peritoneum makes abdominal surgery in patients with pelvic fractures particularly challenging, because simply opening the abdomen increases pelvic volume by 15%. Intrapelvic bleeding can also track into the thorax or abdomen, and retroperitoneal bleeding can dissect anteriorly through the peritoneum.

Fracture Stabilization and Bleeding Management

Several therapeutic options are available for the management of pelvic fracture and associated bleeding. Care usually begins with some form of pelvic stabilization, with some form of invasive management indicated by continued hemodynamic instability that persists after chest and intraperitoneal injury has been ruled out or by a blood requirement greater than 6 units in 24 hours.

Current trauma management guidelines recommend that early external pelvic stabilization be considered in hypotensive patients with unstable pelvic fractures and that external fixation precede laparotomy incision if that operation is to be performed. Anterior external fixation provides adequate rotational stability and reduces bleeding by reapproximating bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing bleeding bony surfaces and preventing ble
Another version of the external fixator is the C-clamp, developed to create greater compression of the posterior part of the pelvis at the point of greatest bleeding and to increase the speed of application.\textsuperscript{1,12} The clamp has 2 pins placed on the posterior part of the ilium, near the sacroiliac joints. The clamp allows continued access to the abdomen, pelvis, and lower extremities.\textsuperscript{7} In an evaluation\textsuperscript{1} of the use of clamps in patients with hypotension, the need for blood products was decreased and blood pressure was increased. The clamp can be placed in as few as 10 minutes.\textsuperscript{8}

Pneumatic antishock garments appear to be useful in pelvic fractures, presumably because the garments provide tamponade of injuries to small vessels and immobilize fractures. The garments may be particularly useful in a community hospital setting where patients must be transferred to trauma centers for definitive management. In a follow-up study of 92 patients with pelvic fractures who required more than 6 units of blood, Moreno et al\textsuperscript{44} found that pneumatic antishock garments alone controlled bleeding in 71\% of the patients. In another study, Flint et al\textsuperscript{45} found that mortality was reduced when the garments were used. Pneumatic antishock garments are easy to use, can be applied rapidly, and are noninvasive. However, they also block access to significant parts of patients, decrease vital capacity and diaphragmatic excursion, and can cause compartment syndromes.\textsuperscript{7} The garments have been used for up to 48 hours and have been used successfully in children.\textsuperscript{8,44-46} An inflation pressure of 40 mm Hg is recommended, and the bony prominences of the hips, thighs, knees, and ankles should be padded before the garments are inflated.\textsuperscript{8}

Other alternatives for temporary pelvic stability are available. Often acceptable intermediate support can be achieved by wrapping the pelvic girdle with a bed sheet and then securing the sheet tightly in place. The Trauma Pelvic Orthotic Device, a commercial stabilization corset, has been used with some success, as have the Dallas belt and a collapsible beanbag.\textsuperscript{36,47}

As mentioned earlier, arterial bleeding manageable by embolization is uncommon in patients with pelvic fractures.\textsuperscript{1,11,12,48} When such an injury does occur, however, embolization is definitive and reduces the mean blood requirement by about 85\%.\textsuperscript{49} The most likely injuries are ones to the superior gluteal artery or internal pudendal arteries.\textsuperscript{50} Although the indications vary from author to author, angiography is generally suggested when hemodynamic instability persists after nonpelvic sources of bleeding have been excluded, and many authors recommend external fixation before angiography. Injuries to the posterior arch are most often associated with severe bleeding, so earlier angiography may be appropriate for patients with such injuries. Certainly, the timing of angiography should be individualized for each patient and varies according to institutional capabilities and requirements.\textsuperscript{7,36,37,51} Adequate personnel and equipment to manage the potential deterioration in status of a critically injured patient should be available during angiography.\textsuperscript{8}

Surgery to control bleeding in pelvic fractures typically is reserved for injuries to large vessels.\textsuperscript{7} Attempts at surgical control of an expanding pelvic hematoma are rarely successful because of the loss of tamponade from opening the peritoneum and exploring the hematoma.\textsuperscript{55} Similarly, early internal fixation of pelvic fractures is rarely attempted.\textsuperscript{15}

External bleeding is possible as well. Open pelvic fractures involve marked pelvic visceral injury and are fatal for about half of patients. Profuse rectal or perineal bleeding often occurs, and heavy contamination from gastrointestinal and genitourinary disruption greatly complicates the recovery of patients who survive initial resuscitation.\textsuperscript{19}

**Pelvic Fracture in Multiple Trauma**

Management of patients with multiple trauma is complicated by the presence of pelvic fractures. When the pelvic fracture is discrete, management proceeds as described before. The force required to fracture the pelvis, however, makes associated injury common, and other injuries occur in more than 90\% of patients with disruption of the pelvic ring. Head injury is concomitant in 27\% of such patients and thoracic injury in 26\%.\textsuperscript{19} Compared with the general population of patients with blunt trauma, patients with anteroposterior pelvic injury have an 800\% increase in aortic rupture.\textsuperscript{52,53}

When pelvic fracture is accompanied by head, chest, or extremity injury, management follows trauma guidelines in a fairly straightforward manner, blending specific responses to the associated injuries with the specific management of the pelvic fracture.\textsuperscript{24} Because a single episode of hypotension or hypoxia dramatically decreases recovery from head
injury, the hemodynamic compromise possible with pelvic fracture can be particularly troublesome for patients with head injuries.\textsuperscript{54}

Up to 40% of patients with pelvic fractures also have abdominal injuries, and trauma patients with intra-abdominal blood and pelvic fractures present a diagnostic and management challenge for which no clear consensus on the preferred approach exists.\textsuperscript{7,16} Distinguishing abdominal from retroperitoneal bleeding in patients with pelvic fractures is difficult but important, because a laparotomy that provides no therapeutic benefit is clearly associated with a high mortality rate and should be avoided.\textsuperscript{7,16,18,39} Unfortunately, pelvic fractures limit the effectiveness of available diagnostic tools.

Both diagnostic peritoneal lavage and bedside sonography are useful but are complicated by the presence of pelvic fractures. Diagnostic peritoneal lavage has up to 98.9% overall accuracy for detecting peritoneal blood, but the false-positive rate is between 16% and 20% in patients with pelvic fractures.\textsuperscript{7,8,11} An early diagnostic peritoneal lavage done by using an open, supraumbilical technique helps minimize false-positives, especially those associated with a pelvic hematoma dissecting along the abdominal wall.\textsuperscript{36,35}

Bedside sonography can also be used to detect intra-abdominal bleeding, but information on the use of sonography in patients with pelvic fractures is limited.\textsuperscript{15} In one study,\textsuperscript{56} specificity for detecting abdominal bleeding was 100% (positive predictive value 1.0, negative predictive value 0.8), but the false-negative rate was high in patients with fractures of the pelvic ring, patients with the most serious injuries. The authors\textsuperscript{56} concluded that patients with fractures of the pelvic ring and normal findings on sonography should have appropriately timed CT scans to avoid missed detection of injury. The exact role of sonography in trauma decision making is still being clarified.

CT scanning accurately differentiates the location of bleeding, but the procedure can be time-consuming and in areas poorly staffed and equipped for resuscitation, is associated with a risk for deterioration in patients’ clinical status.\textsuperscript{7} Little published support exists for CT evaluation of patients with unstable hemodynamic status.\textsuperscript{36,37}

Current trauma management guidelines\textsuperscript{36,37} recommend that external pelvic fixation precede laparotomy if laparotomy is performed. However, support for early external fixation is not universal, and it may not be used by all trauma teams. Both early laparotomy and early angiographic repair are also advocated. The care plan should be developed collaboratively between staff in trauma surgery, orthopedic surgery, and interventional radiology and varies according to institutional capabilities.\textsuperscript{30,31,36}

Management in the Critical Care Unit

Whereas some patients with pelvic fractures arrive in the critical care unit in stable hemodynamic condition, others have profound shock and require aggressive resuscitation to restore perfusion. Management of patients both during and after resuscitation is complex and is fraught with risks for complications.

Resuscitation

A full discussion of massive resuscitation is beyond the scope of this article, but such resuscitation does require consideration of issues, including coagulopathy, hypothermia, and acid-base disorders. Coagulopathy in patients resuscitated with packed red blood cells and crystalloid fluids is due to dilution of clotting factors. Prothrombin and activated partial thromboplastin times begin to be prolonged after replacement of roughly half of a patient’s blood volume, and increases in clinically evident bleeding become manifest when the times are more than 1.5 times normal. A similar dilutional effect on platelets occurs and generally becomes critical after depletion of clotting factors. Administration of fresh-frozen plasma will help restore the clotting factors; platelet repletion will be needed for the thrombocytopenia. The use of both products should be guided by specific laboratory results. One recommendation\textsuperscript{57} is to evaluate prothrombin and activated partial thromboplastin times and levels of fibrinogen and platelets with every replacement of 5 units of packed red cells.

Coagulopathy is worsened by hypothermia, because of both slowed metabolism and temperature-related platelet dysfunction. Administration of each unit of packed red cells at storage temperatures (1°C-6°C) reduces core body temperature by about 0.25°C. Lowered body temperature also impairs tissue perfusion, increases oxygen consumption, and leads to the development of a metabolic acidosis. Hypothermia is associated with increased morbidity and mortality, so all fluids used in resuscitation should be warmed.\textsuperscript{57}
Two other traits of stored blood are also important. Banked blood is acidic, with a pH between 6.9 and 7.1. Whether administration of banked blood by itself leads to acidosis or the citrate preservative added to stored blood prevents it is unclear. Poorly perfused patients certainly have acidosis, and restoration of tissue perfusion is probably the best approach to resolving the acidosis. Transfusion is also complicated by a time-related degradation of the 2,3-diphosphoglycerate in banked blood. This decrease results in less efficient oxygen delivery from the transfused blood, despite an appropriate hemoglobin response.

Because hemodynamic stability may not reflect adequate resuscitation, base excess or lactate levels should be evaluated. The base deficit at the time of admission to the hospital correlates well with degree of shock, the need for transfusion, the likelihood of transfusion complications, and risk for death. Nurses should anticipate and prepare for transfusion when the base deficit exceeds 5 mmol/L. Failure to progressively clear lactate is also associated with complications and death. Lactate levels greater than 2.5 mmol/L 12 hours after admission correlate with the development of multiple organ dysfunction, and levels of 8 mmol/L at 24 hours are associated with nonsurvivable injuries. Accordingly, the base deficit or lactate levels should be evaluated at the time of admission and followed up throughout resuscitation. An elevated level of either, even with adequate vital signs, indicates cellular acidosis and should be corrected by increasing oxygen delivery via volume loading, transfusion, or pharmacological measures.

Orthopedic Repair

Permanent orthopedic repair can be accomplished with external or internal fixation and generally is done 24 to 72 hours after injury, when the patient is warm and resuscitated, and does not have acidosis or coagulopathy.

Nondisplaced, stable pelvic fractures do not require surgical intervention and can be managed with analgesics and early mobilization. Displaced anterior fractures, however, require some kind of invasive intervention. External fixation with either a frame or an Ilizarov system avoids the complications and risks of an operation and can sometimes be done without general anesthesia. However, the reduction must be precise. If a reduction to less than 1 cm of displacement is not maintained throughout healing, about 80% of patients require chronic analgesia, compared with essentially none of those in whom reduction is maintained. External fixators remain in place for 6 to 12 weeks and require meticulous care of the pin site to prevent infection. Twice daily cleaning with hydrogen peroxide swabs is usually adequate. The dressing should apply some compression to minimize pin motion. Loose or infected pins need replacement and debridement of the pin site.

Internal fixation works well, with little occurrence of chronic pain even with strenuous activity. This type of fixation is a complex operation generally performed through a long horizontal incision just above the pubis (the Pfannenstiel incision), and some combination of plates and screws is used.

Vertically unstable posterior injuries can also be fixed with either external or internal approaches. An external repair is not accomplished with a frame but through placement of percutaneous screws. This approach risks damage to neurological and vascular structures in and near the sacrum, but it is associated with good outcomes when used by surgeons with experience with the procedure. Adequate reduction is sometimes difficult to achieve with a closed approach, necessitating open reduction before placement of the screws. The alternative is to proceed directly to open reduction and internal fixation (Figure 6).

After invasive repair, patients generally are given antibiotics for 2
to 3 days and have suction drains in place for 2 days. Whatever repair is chosen, early mobilization is important in facilitating recovery and minimizing complications. Patients with anterior injuries can begin weight bearing when comfortable and can progress as tolerated. Patients with unilateral posterior injuries begin with a limit of 15 kg of weight bearing on the affected side and progress to “as tolerated” at 6 to 8 weeks. Patients with bilateral posterior injuries can do pivot transfers but no other weight bearing until after 6 to 8 weeks.

**Potential Complications**

Patients who have multiple trauma may have primary lung injury and are also at risk for the secondary complications of respiratory failure and respiratory distress syndromes. Careful attention to early diagnosis and relief of pneumothorax or hemothorax is important, as are early evaluation of ventilation and oxygenation and ongoing observation for decline in pulmonary function. Risk for primary lung injury is increased in patients with rib fractures, and the risk for complications increases when positive-pressure ventilation is required. Use of lung-protective ventilator strategies with smaller tidal volumes, lower pressures, and permissive hypercapnia may help reduce morbidity and mortality.

**Deep vein thrombosis occurs in up to 80% of patients with multiple trauma, and clinical pulmonary embolism develops in about 10% of those patients.**

Immobilization also increases the risk for ventilatory and infections complications, so positioning is important, and early mobilization or early use of a therapeutic bed should be considered. Thromboembolic disease is associated with pulmonary disorders and is a known complication of pelvic fracture because of venous stasis, immobility, endothelial damage, and direct venous injury. Deep vein thrombosis occurs in up to 80% of patients with multiple trauma, and clinical pulmonary embolism develops in about 10% of those patients. An equal number may have subclinical emboli. Mortality from pulmonary embolism in patients with pelvic fractures may be as high as 4%. Because of the high risk, patients with pelvic fractures need prophylaxis for deep vein thrombosis, probably with low molecular weight heparin unless contraindicated by uncontrolled bleeding or associated intracranial bleeding. Pneumatic compression devices are useful, unless massive orthopedic injury precludes their use, and the placement of a ven caval filter may be useful if other means of prevention are impossible or unsuccessful. Early mobilization out of bed is also helpful. Critical care nurses should maintain a high index of suspicion for pulmonary embolism in patients with a history of pelvic fracture in whom dyspnea, tachypnea, chest pain, wheezing, hypotension, or right ventricular electrocardiographic abnormalities develop. Pain management is important independently and also as an adjunct in preventing pulmonary and thromboembolic complications due to reduced mobility. Continuous infusion and patient-controlled administration of analgesics are both generally more effective than nurse-delivered intermittent bolus strategies. The Society of Critical Care Medicine standards for analgesia recommend morphine as the drug of choice, with fentanyl available for patients who are allergic to morphine or in whom hemodynamic instability makes the histamine release associated with use of morphine undesirable. Use of narcotic analgesics dramatically increases the risk for gastrointestinal complications, so an aggressive gastrointestinal protection strategy should be followed when these drugs are used.

Patients with pelvic fractures, like all other trauma patients, require prompt and effective nutritional support to optimize their potential for recovery. Enteral feeding is associated with fewer septic complications than is parenteral feeding, and total parenteral nutrition is recommended only if patients cannot meet more than 50% of their nutritional needs by hospital day 7. A specialist should evaluate nutritional needs, and feeding should begin within 24 hours after resuscitation is completed. Patients who have had a laparotomy should probably have small-bowel feedings via either a nasojejunal or a feeding jejunostomy tube. Patients who have not had a laparotomy may do well with gastric feedings, and a trial of gastric feeding is suggested.
Serial measurements of prealbumin levels appear to be the most useful way to monitor ongoing nutritional status.\(^6\)

Wound care is a concern for patients with pelvic fractures. The patients may have other external traumatic injuries and may have surgical sites from internal fixation of the pelvic fractures or repair of other injuries. As described earlier, external fixation requires careful skin care. Open fractures generally require debridement and irrigation in the operating room for at least 4 days and frequent dressing changes.\(^5,6,13\)

Colostomy is a common part of the management of visceral injury and is often, but not always, necessary for patients with open pelvic fractures. If the laceration is in the rectal, perineal, buttock, or midline areas, a colostomy is always indicated. As the location of the laceration moves laterally from those areas, the need for colostomy is progressively lower.\(^6,7)\) A colostomy is not without risks. As described earlier, opening the abdomen can disrupt retroperitoneal tamponade. Additionally, operating on the colon can introduce contamination that may not have previously existed and also necessitates subsequent procedures for repair. Careful attention must be paid to the health of the new ostomy site, to the nearby skin, and to preventing contamination of nearby wounds and incisions.\(^7)\)

Immobility increases the risk for iatrogenic skin breakdown, and inadequate nutrition impairs wound healing and the ability to maintain skin integrity. Early feeding, good pain management, adequate resuscitation, and mobility or use of therapeutic beds with repositioning of patients are all key tools in decreasing and preventing integumentary complications.\(^8)\)

Infection can come from surgical sites, open fractures, skin breakdown, pulmonary infection, invasive catheters, and a myriad of other sources. Infection may cause up to 50% of late deaths in patients with pelvic fractures.\(^7)\) Again, prevention with good nursing care, resuscitation, and feeding is preferred, and antibiotic therapy based on the results of microbial cultures is also important.\(^8)\)

Rehabilitation is also an essential part of the care of patients with pelvic fractures. The physical therapy department should be consulted early in the case and should follow up the patients closely. Critical care nurses have an important role as case managers in helping to ensure that these consultations are ordered and therapies are implemented. Early and expert involvement of physical therapy, occupational therapy, and rehabilitation services is one of the benefits of care at a verified trauma center.

**Conclusion**

Pelvic fractures can range from simple, stable injuries to a component of injury in severe multisystem trauma. Critical care nurses should have a high index of suspicion for pelvic injury, should conduct a careful examination for fractures and associated injuries, and should be prepared for diverse needs of patients and diverse interventions. Recovery from pelvic fracture is a long-term process and can include multisystem complications. Good basic, critical care, and trauma nursing skills and an understanding of the nature of pelvic injuries are important to critical care nursing practice.

**References**

Major Pelvic Fractures
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