



## **Emergency Management of Pelvic Fractures**

The identification and management of pelvic fractures are important parts of caring for the traumatized patient. The lecturer will review the skills necessary for detection of pelvic injuries and the appropriate emergency department management of pelvic fractures and associated injuries.

- Explain an approach to pelvic radiograph interpretation.
- Discuss the importance of early pelvic stabilization.
- Discuss an algorithm for the unstable patient with a pelvic fracture.
- Discuss important associated injuries.

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## **FACULTY**

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## **ED MANAGEMENT OF PELVIC FRACTURES**

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### **A. INTRODUCTION**

Pelvic fractures account for approximately 1 to 3 percent of all skeletal injuries. They occur in a bimodal distribution with a peak in the second to fourth decades and then in patients older than sixty-five years. Pelvic fractures range in severity from benign injuries to massive ring disruptions. When pelvic fractures are the result of high-energy forces, they are associated with a substantial risk of hemorrhage and soft tissue damage. Pelvic fractures are the third most common cause of death in motor-vehicle crashes, ranking behind traumatic brain injury and blunt aortic disruption. The overall mortality associated with pelvic fractures is approximately 10%. In the patient suffering multiple trauma, the detection of a pelvic fracture has several important implications:

- They are associated with other significant, and often occult injuries
- Their presence may alter the sequence of early diagnostic testing
- Co-existent injuries must be individually prioritized and managed

Rothenberger DA, et al: The mortality associated with pelvic fractures. *Surgery* 84:356, 1978.

Gilliland MD, et al: Factors affecting mortality in pelvic fractures. *J Trauma* 22:691, 1982.

Melton LJ III, et al: Epidemiologic features of pelvic fractures. *Clin Orthop* 155:43, 1981.

Morreno C, et al: Hemorrhage associated with major pelvic fractures: a multidisciplinary challenge. *J Trauma* 26:987, 1986.

McMurtry R, et al: Pelvic disruption in the polytraumatized patient: a management protocol. *Clin Orthop* 151:22, 1980.

### **B. ANATOMIC CONSIDERATIONS**

The pelvic ring is made up of three bones, the sacrum and two innominates. Each innominate is formed by the fusion of three separate centers of ossification, the ilium, the ischium, and the pubis. They meet at the triradiate cartilage, which fuses by age 16 years. The posterior pelvis, which must transmit the major weight bearing forces across the sacroiliac joint into the lower extremities is strengthened by the sacrospinous, sacroiliac, and sacrotuberous ligaments. Anteriorly the pubic symphysis acts as a strut, preventing collapse of the pelvis. The energy required to disrupt the pelvic ring is substantial. When high-energy forces are applied to the pelvis, reproducible fracture patterns involving the osseous and ligamentous components occur that correlate with the vectors of these forces.

## **C. MECHANISM OF INJURY**

Several different classification systems have been developed for pelvic ring injuries. A common objective of these schemes is to assess the degree of pelvic instability based on the admission AP radiography, using this to predict the risk of hemorrhage, and associated injury. The most widely accepted classification system is based on the mechanism of injury and the direction of the causative force vector. This concept was originally developed by Pennal et al, and several modifications of this system have since been published. Using this approach, the emergency physician can identify patients at risk for hemodynamic deterioration, formulate a comprehensive diagnostic plan, and communicate effectively with the consulting traumatologist and orthopedic surgeon during the early phase of patient resuscitation.

There are three types of force that may produce pelvic fractures. These include *lateral compression*, *AP compression*, and *vertical shear*. "Complex patterns" describe injuries that are the result of more than one force vector, although in most cases a dominant vector can be identified.

### **Lateral Compression**

In most series lateral compression fracture are the most common injury type, accounting for roughly half of all injuries. As the name suggests, the force is delivered to the pelvis from the side. These injuries most commonly occur in "T-bone" motor vehicle crashes or when a pedestrian is struck from the side. Lateral compression injuries are associated with a high incidence of traumatic brain injury, which in most series is the primary cause of mortality in these patients.

### **Anteroposterior Compression**

These account for 20-30% of pelvic ring fractures. Force are delivered in an anteroposterior, and less commonly in a posterioranterior direction. AP compression may occur following a head-on motor vehicle crashes, or when a pedestrian is struck head-on by an oncoming vehicle. Patients with AP compression injuries have a high incidence of thoracic, abdominal, and pelvic vascular injuries. Mortality is the result of the combined effect of pelvic bleeding, and other visceral injuries.

### **Vertical Shear**

Vertical shear injuries are relatively rare. They occur when a vertically oriented force is delivered to the pelvis via the extended femurs. This may occur following a fall from a height. Alternatively, a downward force delivered to the pelvis via the spine (as may occur when a heavy object falls on the back or shoulders) may cause the same injury pattern. Patients with vertical shear fractures have a similar pattern to patients with lateral compression injuries.

Pennal GF, et al: Pelvic disruption: assessment and classification. *Clin Orthop Rel Res* 151:12, 1980.

Young JWR, et al: Lateral compression fractures of the pelvis: The importance of plain radiography in the diagnosis and surgical management. *Skelet Radiol* 15:102, 1986.

Young JWR, et al: Pelvic fractures: Value of plain radiography in the early assessment and management. *Radiology* 160:445, 1986.

Bucholz R: The pathological anatomy of malgaigne fracture dislocations of the pelvis. *J Bone Joint Surg* 63A:500, 1981.

Dalal SA, et al: Pelvic fracture in multiple trauma: Classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma* 29:981:1988.

## D. ASSOCIATED INJURIES

Because of the magnitude of force required to disrupt the pelvis, associated injuries are common. These include injuries of the adjacent viscera, as well as organs distant to the pelvis. Eastridge *et al* reviewed 1014 cases of pelvic fractures and found associated neurologic injury in 27%, thoracic injury in 26%, and abdominal injury in 14%. There is also evidence that the fracture pattern on the admission pelvic radiography is predictive of these associated injuries. Dalal *et al* reviewed a series of patients with pelvic fractures, and noted that AP compression fractures were associated with severe injuries to the torso, whereas lateral compression fractures were associated with traumatic brain injury. In a blunt trauma patient, a pelvic fracture should be considered a "red flag" for multisystem injury, rather than just a "broken bone." Some of the specific associated injuries are discussed in more detail below:

### Traumatic Aortic Disruption

- Two-fold to five-fold increased risk when a pelvic fracture is present.
- Especially likely in patients with an AP compression fracture pattern (8x's).
- The presence of a wide mediastinum has implications when a treatment plan is made.

### Urologic Complications

#### Urethral Injury

- Pelvic fracture is present in 95% of patients with an injury to the posterior urethra.
- Urethral injury in 5-25% of patients with pelvic fractures.
- Firm attachment of the urethra to the pubis (puboprostatic ligament) increases the risk.
- Retrograde urethrogram should be performed *before* the insertion of a Foley:
  - Blood @ urethral meatus, penile or scrotal hematoma, abnormal prostate
  - Wide pubic diastasis/multiple pubic ramus fractures

#### Bladder Injury

- Bladder injury is usually the result of perforation by fracture spicules.
- 70% to 95% of patients with bladder injuries have associated pelvic fractures.
- Between 4 and 8% of patients with pelvic fractures have an associated bladder injury.
- Fracture types: pubic rami, symphyseal diastasis, displaced pelvic ring fractures.
- Retrograde cystogram *after* a urethral injury is ruled out:
  - Hematuria, suprapubic tenderness or ecchymosis

→Ensure adequate distension of the bladder (400 cc's of contrast in adults).

### Vaginal Injury

- A rare complication of pelvic fracture (3-5%).
- Results from penetration of a bone fragment through the vaginal wall.
- Shearing forces, or displacement of fracture segments may also cause vaginal tears.
- Complications: pelvic abscess, fistulas, strictures, dyspareunia, osteomyelitis.
- A careful speculum examination is mandatory in all female patients suffering pelvic trauma:
  - Bleeding the hallmark (may not be grossly apparent due to muscle spasm).
  - Hematuria, vaginal urine/stool, difficulty urinating or passing a Foley.

### Neurologic Injury

- Sciatic nerve and its roots (L4, 5 and S1, 2, 3) are particularly vulnerable.
- Incidence of neurologic injury complicating pelvic fractures as high as 10% to 21%.
- Pelvic ring fractures with posterior disruption carry a higher risk (40% to 50%).
- Clinically, most injuries affect the L5 or S1 nerve root...examine from L4 distally.
- Bowel and bladder dysfunction, and impotence are important complications.
- Sphincter tone and perianal sensation should be carefully evaluated.

Dalal SA, et al: Pelvic fracture in multiple trauma: Classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma* 29:981:1988.

Ochsner MG Jr., et al: Associated aortic rupture-pelvic fracture: An alert for orthopedic and general surgeons. *J Trauma* 33:429, 1993.

Fallon B, et al: Urologic injury and assessment in patients with fractured pelvis. *J Urol* 131:712, 1984.

Palmer JK, et al: Diagnosis and initial management of urologic injuries associated with 200 consecutive pelvic fractures. *J Urol* 130:712, 1983.

Niemi TA, et al: Vaginal injuries in patients with pelvic fractures. *J Trauma* 25:547, 1985.

Reilly MC, et al: Neurologic injuries in pelvic ring fractures. *Clin Orthop* 329:28, 1996.

## **E. PREDICTORS OF MORTALITY**

Mortality rates in patients with pelvic fractures range from 9% to 20%. Mortality has been reported to be as high as 42% to 50% in hemodynamically unstable patients. Hypotension on ED presentation is the strongest predictor of early mortality, and most hemorrhagic deaths occur within the first 24 hours. Other predictors of mortality include:

- The severity of the posterior pelvic injury
- The presence of a brain injury
- Hypotension + brain injury is especially deadly
- A low hemoglobin on presentation
- An increased need for blood products

There is also recent evidence that aggressive management (including rapid

hemodynamic stabilization, early pelvic fixation, and angiographic embolization of pelvic arterial injuries) is associated with improved survival in the unstable patient.

Gilliland MD, et al: Factors affecting mortality in pelvic fractures. *J Trauma* 22:691, 1982.

Moreno C, et al: Hemorrhage associated with major pelvic fracture: A multispecialty challenge. *J Trauma* 26:987, 1986.

## **F. OPEN PELVIC FRACTURES**

Open pelvic fractures are invariably associated with severe injuries of the pelvic visceral, and have traditionally been associated with mortality rates of up to 30%-50%. Brisk pelvic hemorrhage and associated torso and intracranial injury contribute to early mortality. In survivors of the early resuscitation phase, heavy contamination of perineal wounds resulting from damage of the rectum and genitourinary tract is a frequent cause of localized abscesses, sepsis, and multisystem organ failure.

A structured multidisciplinary approach to these devastating injuries, involving (1) aggressive hemodynamic stabilization, (2) internal pelvic ring stabilization, (3) primary repair of rectal injuries with diverting colostomy, and (4) primary repair of genitourinary injury and urinary diversion with a suprapubic catheter has improved outcome and reduced mortality into the single-digit range.

Birolini D, et al: Open pelvico-perineal trauma. *J Trauma* 30:492, 1990.

Davidson SB, et al: Pelvic fractures associated with open perineal wounds: A survivable injury. *J Trauma* 35:36, 1993.

Leenen LPH, et al: Internal fixation of open unstable pelvic fractures. *J Trauma* 35: 220, 1993.

## **G. DIAGNOSIS**

### **Pelvic Radiography**

During the initial resuscitation of the patient suffering blunt trauma, the radiographic identification of a pelvic fracture has several important implications:

- It reflects a major force-vector and risk for serious multisystem injury.
- It rapidly identifies a potential site of life-threatening hemorrhage.
- It provides clues to the likelihood of pelvic soft tissue and vascular injuries.
- It may alter the method and/or sequence of diagnostic testing.
- It helps the clinician develop a prioritized management plan.

### **Indications For Pelvic Radiography**

Traditional teaching recommends pelvic radiography in all patients suffering significant blunt trauma. While this approach is effective at excluding injury, it comes at the expense of a large number of negative radiographs. Pelvic radiography is mandatory in severely injured patients who are unstable, obtunded, or who has clinical evidence of

abdominopelvic injury.

Conversely, there is also data to suggest that a thorough physical examination can be used to identify the patient at low risk for pelvic injury. Several studies have shown that the stable, alert patient without clinical signs and symptoms of pelvic injury can be managed safely without pelvic radiography.

Civil *et al* prospectively evaluated 265 patients suffering blunt multisystem trauma. There were 26 pelvic fractures (10%), none occurring in the awake, alert, and asymptomatic group. Kouri *et al* studied 717 blunt trauma patients, and found no pelvic fractures in 125 patients who were hemodynamically stable, alert, and without pelvic pain or tenderness, gross hematuria, or presence of a femur fracture. Yugueros *et al* prospectively evaluated 608 blunt trauma patients, and found the negative predictive value of a negative physical examination to be 99%. Selective use of pelvic radiography has obvious financial implications, reduces unnecessary exposure to radiation, and avoids potential delays in trauma patient evaluation and treatment.

## **Radiographic Interpretation**

### Anteroposterior View

This AP radiograph is obtained with the patient supine, and the beam directed perpendicular to the midpelvis and radiographic plate. It should include the iliac crests, each hip joint, and the proximal portion of each femur. The anatomic landmarks visible on the AP radiograph include the pubic symphysis, superior and inferior rami, anterior superior, and anterior inferior iliac spines, sacroiliac joints, sacral ala, sacral foramen, and L5 transverse processes. When assessing the AP radiograph, look for:

- Anterior pelvic ring lesions:
  - Pubic rami fractures
  - Symphyseal disruption
  - Combined lesions
- Posterior pelvic ring lesions:
  - Sacral fractures
  - Sacroiliac joint disruptions
  - Iliac wing fractures
- Signs of vertical instability:
  - Disruption of the arcuate lines
  - Vertical hip joint asymmetry

The AP radiography will identify most pelvic fractures and help guide the clinician through the initial phase of resuscitation. It is important to remember, however, that in the supine position the pelvis lies 45° to 60° oblique to the long axis of the skeleton. Therefore, the AP radiograph of the pelvis is oblique to the pelvic brim. Radiographs at right angles to each other (*inlet and outlet views*) will provide a more accurate picture of pelvic displacement. Once cardiopulmonary stabilization has been initiated, the AP view can be supplemented by these views. This step must not delay or interrupt resuscitative efforts, and it may be bypassed in patients who must be taken immediately to either the

operating room or angiography suite, or in patients for whom there are clear indications for immediate interfacility transport.

### Inlet View

The inlet view is obtained with the patient supine, and the beam directed from the head to the midpelvis at an angle of approximately 60° from vertical. This projection is perpendicular to the pelvic brim and provides a true pelvic inlet view. It provides excellent visualization of the sacral promontory, sacroiliac joint, ala and body of the sacrum, iliopectineal line, and the geometry of the pubic symphysis, and ischial spines. The inlet view shows anterior and posterior displacement in the plane of the pelvis better than any other view, and is useful to displacement of the sacroiliac joint, iliac wings. The arcuate line should be carefully inspected for evidence of a sacral impaction fracture.

### Outlet View

The outlet view is obtained with the patient supine, and the beam directed cephalad from the foot to the symphysis at an angle of approximately 45° from vertical. This provides the best view to assess superior displacement and vertical migration of the anterior hemipelvis. It provides a true AP view of the sacral body and foramina, and is the best view to demonstrate fractures in this region. The inferior pubic ramus is also brought into full view.

Civil ID, et al: Routine pelvic radiography in severe blunt trauma: Is it necessary? *Ann Emerg Med* 17:488, 1988.

Koury HI, et al: Selective use of pelvic roentgenograms in blunt trauma patients. *J Trauma* 34:236, 1993.

Yugueros P, et al: Unnecessary use of pelvic X-ray in blunt trauma. *J Trauma* 39:722, 1995.

## **Diagnostic Peritoneal Lavage**

During the resuscitation of the hemodynamically unstable patient with a pelvic fracture, it is critical to rapidly identify the predominant site of hemorrhage. Should pelvic bleeding pose the primary life-threat, skeletal stabilization and angiographic embolization is indicated. Conversely, if hypotension is the result of associated intraabdominal bleeding, immediate laparotomy should be performed. It is obvious that if the *incorrect triage decision* is made, the patient may succumb from pelvic hemorrhage during a non-therapeutic laparotomy, or die from intraabdominal hemorrhage in the angiography suite. The diagnostic peritoneal lavage (DPL) can be a valuable tool to triage the unstable patient down the appropriate arm of the algorithm.

While the results of the DPL cell count are notoriously inaccurate in this setting, several studies have shown that the DPL aspirate result can be used to help guide decision



making. Moreno *et al* study the DPL results in 72 unstable patients with pelvic fracture. Twenty two patients had negative DPL results, while the DPL was positive in 51 patients. 84% of patients with a positive DPL aspirate had active intraperitoneal hemorrhage at laparotomy, while all 19 patients with only a positive cell count had minor intraabdominal bleeding. Evers *et al* examined the DPL results in 83 patients. Results were negative in 37 patients, positive in 46. Again, a negative DPL aspirate accurately excluded significant intraperitoneal hemorrhage in 100% of cases. So, a positive peritoneal tap should trigger laparotomy, while a negative tap should be followed by immediate angiography and application of an external fixator. When performing the DPL, the open supraumbilical method should always be used. This avoids the risk of entering an anterior abdominal wall hematoma dissecting cephalad from the pelvis and obtaining a false-positive aspirate.

Hubbard SG, et al. Diagnostic errors with peritoneal lavage in patients with pelvic fractures. *Arch Surg* 114:844, 1979.

Moreno C, et al: Hemorrhage associated with major pelvic fracture: A multispecialty challenge. *J Trauma* 26:987, 1986.

Evers BM, et al: Pelvic fracture hemorrhage: Priorities in management. *Arch Surg* 124:422, 1989.

Rothenberger D, et al. The mortality associated with pelvic fractures. *Surgery* 84:356, 1978.

## H. MANAGEMENT

The initial evaluation and treatment should follow the fundamental principles germane to blunt trauma care. This includes a rapid primary and secondary survey, aggressive airway management and hemodynamic stabilization, and development of a well thought out and prioritized management plan. Remember, injuries that pose an immediate life-threat should be addressed first. Once ABC stabilization has been initiated, a detailed physical examination of the pelvis can be performed.

### ABC Issues

#### Airway

- Airway management strategies will generally not be altered.
- If anything you should be *more* aggressive, since patients will often become unstable.
- Co-exist brain injury common, protect the head (formal RSI preferable).
- Remember, hypotension is a significant risk...be careful with sedatives!

#### Breathing

- Associated torso injury (pulmonary contusion, pneumothorax) common

#### Circulation

- Anticipate hemodynamic decompensation
- Aggressive resuscitation:
  - Adequate IV access
  - Avoid femoral lines if possible (pelvic venous injury?)
  - Use warm fluids, transfuse early
- Monitor urine output, tissue perfusion

- Anticipate hypothermia....core temperature monitoring a good idea
- Anticipate coagulopathy in the unstable patient

## **Injury-Specific Clinical Assessment**

During the secondary survey, examination of the pelvis should focus on:

- Clinical evidence of instability
- Evidence of soft tissue injury (roll the patient!)
- Signs of urologic injury (blood @ meatus, penile/scrotal hematoma...)
- Speculum examination in the female patient
- Rectal examination
- Detailed lower extremity neurologic examination

## **Pelvic Stabilization**

In patients with displaced pelvic ring fractures, venous and arterial injury is significant. Hemorrhage is the number one killer in these patients. Early stabilization of the pelvis has been shown to improve survival. Pelvic stabilization works by reducing pelvic volume (and thus decreasing the potential space for hemorrhage), stabilizing displaced fracture segments, and by providing a tamponade effect on venous bleeding.

This can be accomplished by several measures, from simple to complex:

- Internally rotating the lower extremities (if pelvis disrupted anteriorly)
- Wrapping a sheet tightly around the pelvis
- Bringing a shortened ipsilateral extremity to length
- Applying MAST
- Applying a vacuum splint
- Using an external fixator
- Using a pelvic C-clamp

## **MAST**

Although there are no controlled studies assessing the efficacy of MAST in pelvic fractures, they provide theoretical benefit by reducing pelvic volume, stabilizing displaced fracture segments, and by providing a tamponade effect on venous bleeding. The use of MAST is recommended in the prehospital setting for patients with closed pelvic fractures and obvious clinical instability, and as a temporizing measure in the hemodynamically unstable emergency department patient. The MAST should not be used when external pelvic or lower extremity bleeding is present, as hemorrhage may continue and remain unrecognized under the trousers. When patients are brought to altitude during helicopter transport, the MAST should be monitored for expansion and deflated as needed. Because prolonged use has been reported to cause lower extremity compartment syndrome, the MAST should be considered a temporary intervention.

Clarke G, et al Use of MAST to control massive bleeding from pelvic injuries. *Injury* 24:628, 1993.

Sanders AB, et al: Effect of altitude change on MAST suit pressure. *Ann Emerg Med* 12:140, 1983.

Aprahamian C, et al: MAST-associated compartment syndrome (MACS): A review. *J Trauma* 29:549, 1989.

Kunkel JM: Thigh and leg compartment syndrome in the absence of lower extremity trauma following MAST application. *Am J Emerg Med* 5:118, 1987.

## Angiography

The majority of pelvic bleeding is venous. Decreasing pelvic volume, and stabilizing fracture segments will arrest bleeding in the majority of cases. However, injury of named arteries in the pelvis can result in brisk hemorrhage that does not respond to pelvic stabilization. Standardized protocols using early angiographic evaluation in patients with complicated pelvic fractures and hemodynamic instability may significantly decrease mortality.

Different indications have been used based on:

- Persistent hypotension on presentation
- Transfusion requirements
- Negative DPL in the unstable patient
- A large retroperitoneal hematoma discovered @ laparotomy

If you anticipate that angiography may be needed, be sure to involve the appropriate personnel early. You can follow the algorithm covered in the section on DPL.

Panetta T, et al: Percutaneous transcatheter embolization for massive bleeding from pelvic fractures. *J Trauma* 25:1021, 1985.

Margolies MN, et al: Arteriography in the management of hemorrhage from pelvic fractures. *N Engl J Med* 287:317, 1972.

O'Neill PA, et al: Angiographic findings in pelvic fractures. *Clin Orthop* 329:60, 1996.

## Transfer Issues

There is definite evidence that the patient with a complex pelvic fracture benefits from trauma center care. A multidisciplinary team is essential in the care of these patients, and rapid availability of an OR and/or angiography suite will save lives. Again, some fundamental principles apply:

- Anticipate the need for transfer
- Effective communication
- Avoid delays, inertia
- Secure the airway, initiate resuscitation
- Pelvic stabilization (MAST)
- Keep the patient warm
- Have blood available for the transport team