Seminars in ROENTGENOLOGY

Imaging of Pelvic Ring and Acetabular Trauma

Claire K. Sandstrom, MD, Joel A. Gross, MD, and Ken F. Linnau, MD, MS

Introduction

Blunt trauma to the pelvis can cause fractures and ligamentous injuries to the pelvic ring and can fracture the acetabulum. Pelvic and acetabular fractures often occur with high-energy blunt trauma, including motor vehicle and motorcycle crashes, car vs pedestrian accidents, and falls.[1-3] Low-energy falls can also cause pelvic and acetabular fractures in elderly osteoporotic patients.[1,2,4-6] Potentially life-threatening pelvic hemorrhage, urethral and bladder injuries, and additional intra-abdominal injuries may accompany pelvic trauma, affecting emergent management decisions in patients with blunt pelvic trauma.[3,6-9]

Pelvic Ring Injuries

The presence of pelvic ring injuries affects clinical decision-making in several ways. Unstable patients with pelvic injuries may benefit from emergent angiography or retroperitoneal pelvic packing[10] rather than laparotomy for control of pelvic hemorrhage. Unstable pelvic ring injuries would ultimately require internal fixation. Bladder and urethral injuries, though not common, may require surgical repair and require dedicated imaging for prompt diagnosis.

Pelvic Hemorrhage

Pelvic fractures commonly cause pelvic bleeding. Most bleeding is self-limited, arising from venous structures or bone edges. However, 5%-20% of patients with pelvic fractures have potentially life-threatening arterial hemorrhage that may be amenable to angioembolization.[11] Clinical predictors of major hemorrhage related to pelvic fractures, based on initial pelvic radiograph (Fig. 1), blood work, and vital signs, are shown in Table 1.[11] Likelihood of pelvic hemorrhage ranges from less than 2% for those with no predictors to more than 60% for those with 3 or 4 predictors of major hemorrhage.[11] Thus, angiography should be prioritized for those patients with a higher probability of major pelvic hemorrhage. Patients older than 60 years with major pelvic fractures and those with active arterial contrast extravasation detected on computed tomography (CT) (Fig. 2) may benefit from pelvic angiography and angioembolization regardless of hemodynamic status.[12,13] External pelvic stabilization decreases pelvic volume, although the degree to which this helps to tamponade bleeding from venous structures and bone edges not amenable to angioembolization remains uncertain.[12] Although the usage of contrast-enhanced CT for detection of active arterial hemorrhage in patients with hemodynamically stable blunt trauma is well documented,[14-18] the role of arterial-phase CT of the pelvis remains uncertain.[19]

Bladder and Urethral Injuries

Bladder injuries complicate less than 10% of blunt pelvic fractures.[20] Injuries are categorized as extraperitoneal, intraperitoneal, or combined. Independent multivariate predictors of bladder rupture include pubic symphyseal diastasis >1 cm (relative risk = 9.8) and obturator ring fractures displaced >1 cm (relative risk = 3.2) (Fig. 3).[20] All patients with bladder rupture have hematuria, with at least 3+ hematuria on dipstick urinalysis or greater than 30 red blood cells per high-powered field on microscopic urinalysis.[20,21] Thus, detection of anterior pelvic ring injuries should prompt urinalysis, and CT cystogram should be performed when the hematuria threshold is exceeded.[22] Although most bladder ruptures are associated with pelvic fractures, a smaller percentage, usually involving intraperitoneal bladder rupture, occur in the absence of osseous pelvic injury.[21,23,24] Patients with bladder rupture often have other intra-abdominal injuries, including hollow visceral, splenic, and hepatic injuries.[24]

Urethral injuries are also rare, but are more likely in male patients with anterior pelvic ring disruption. Predictors of urethral injury include diastasis (≥ 1 cm) of the pubic symphysis (odds ratio = 11.8) or of inferomedial pubic bone fractures (odds ratio = 6.4).[25] The probability of urethral injury

Department of Radiology, Harborview Medical Center, University of Washington, Seattle, WA.

Address reprint requests to Claire K. Sandstrom, MD, Department of Radiology, Harborview Medical Center, University of Washington, 325 Ninth Ave, Box 359728, Seattle, WA 98104. E-mail: Cks13@uw.edu

 http://dx.doi.org/10.1053/j.ro.2016.03.002

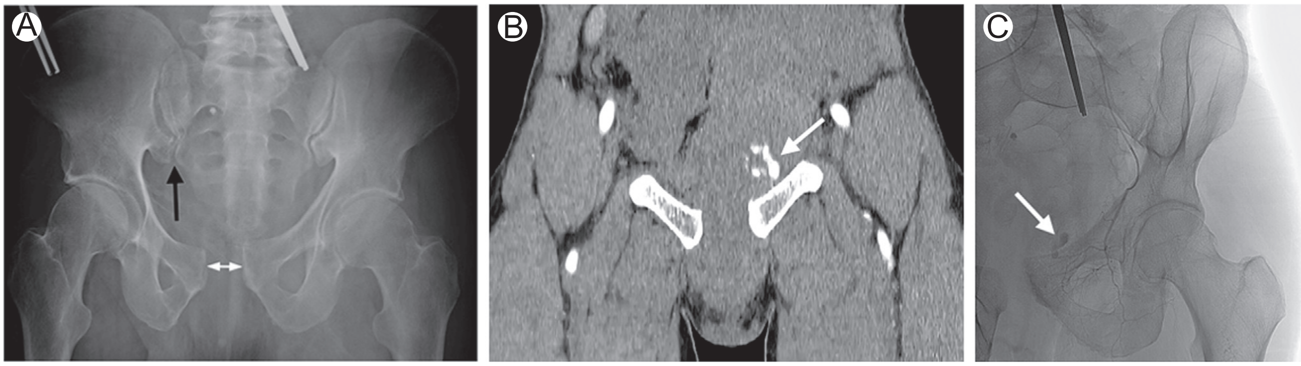

Figure 1 Arterial hemorrhage in pelvic ring injury in a 64-year-old man who was thrown from a horse. (A) The initial anteroposterior pelvic radiograph demonstrates distraction of the symphysis pubis (double-headed arrow) to 2.7 cm and mild right sacroiliac joint widening (black arrow). (B) Coronal CT image confirms widening of the symphysis pubis and demonstrates active arterial extravasation adjacent to the left superior pubic ramus (white arrow). (C) Subsequent pelvic angiography demonstrates active extravasation from the left obturator artery (white arrow), which was controlled with coil embolization.

Table 1 Clinical Predictors of Major Hemorrhage Related to Pelvic Fractures

Predictor	Odds Ratio for Major Hemorrhage
Displaced obturator ring fracture ($\geq$1 cm)	3.8
Pubic symphyseal diastasis ($\geq$1 cm)	3.9
Hematocrit $\leq$30%	6.6
Pulse $\geq$130 beats/min	3.3

increases approximately 10% with each millimeter increase in displacement of pubic components.[25] Diagnosis and characterization of male urethral injuries are performed by retrograde urethrogram,[26] although this might be difficult to perform in hemodynamically unstable patients or in those with spine injuries.[27]

Pelvic Ring Stability

The adult osseous pelvis is formed by the sacrum posteriorly and the bilateral innominate bones (formed by fusion of the ilium, ischium, and pubic bones) (Fig. 4). The osseous structures have no inherent stability, relying instead on the integrity of the sacroiliac (SI) ligaments (anterior, short interosseous, and posterior).[28] The pubic symphyseal fibrocartilage and pubic ligaments of the anterior pelvic ring reinforce the SI joints against rotation.[28,29] Supplemental support is provided by the iliolumbar, lateral lumbosacral, sacrotuberous, and sacrospinous ligaments, which primarily resist rotation of the innominate bone relative to the sacrum.[28]

A total of 2 types of stability, rotational and vertical, are considered (Fig. 5). Most commonly, rotational stability

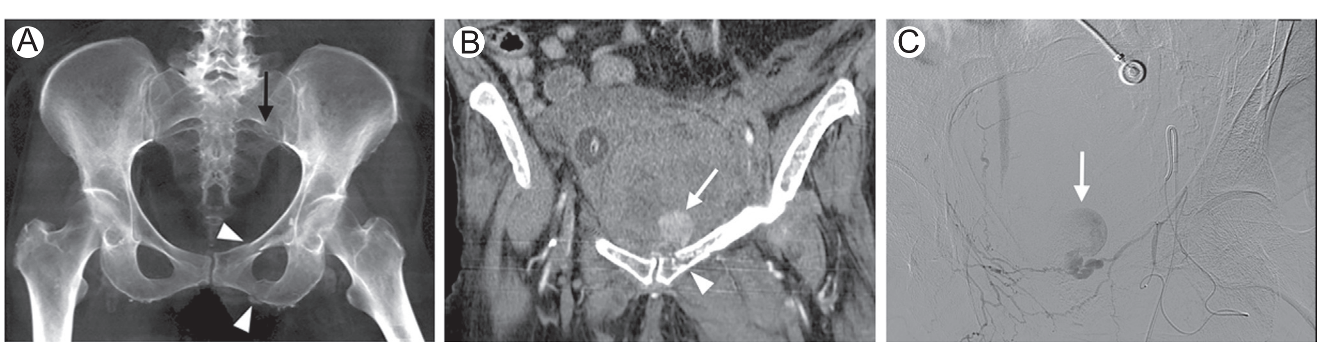

Figure 2 Arterial hemorrhage detected on CT image in a 75-year-old woman following ground-level fall. The patient was taking warfarin. (A) Semitransparent shaded surface display from CT of the pelvis demonstrates a lateral compression fracture, with left superior and inferior obturator ring fractures (white arrowheads), and left sacral impaction fracture (black arrow). (B) Coronal image from contrast-enhanced CT demonstrates active vascular extravasation (white arrow) near the left superior pubic ramus fracture (white arrowhead). Large pelvic hematoma displaces the bladder and Foley catheter toward the right. (C) Digital subtraction catheter angiogram demonstrates arterial extravasation (white arrow) from the left pudendal artery in this patient with multiple occluded pelvic arteries and extensive collateral vessels.