



Traumatic pelvic fractures in children and adolescents



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ARTICLE INFO

Keywords:

Pelvic fractures
Pediatric trauma
Triradiate cartilage
Acetabular fracture
Pelvic trauma

ABSTRACT

Although traumatic pelvic fractures in children are relatively rare, these injuries are identified in about 5% of children admitted to level 1 trauma centers after blunt trauma.^{1–4} Such injuries differ from adult pelvic fractures in important ways and require distinct strategies for management. While the associated mortality rate for children with pelvic fractures is much lower than that for adults, the patient may require urgent surgical intervention for associated life-threatening injuries such as head trauma and abdominal injury. Unstable pelvic ring fractures should be acutely managed using an initial approach similar to that used in adult orthopedic traumatology. Although very few pediatric pelvic fractures will ultimately need surgical treatment, patients with these injuries must be followed over time to confirm proper healing, ensure normal pelvic growth, and address any potential complications. The trauma team suspecting a pelvic fracture in a child must understand the implication of such a finding, identify fracture patterns that increase suspicion of associated injuries, and involve pediatric or adult orthopedic specialists as appropriate during the management of the patient.

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Introduction

Background

Pelvic fractures are extremely uncommon traumatic injuries in pediatrics, occurring with an estimated incidence of 1 per 100,000 children per year.^{5,6} Despite their rarity, such injuries are identified in 2.4–7.5% of the pediatric trauma patient population.^{1–3,7–9} It is therefore important for traumatology, emergency medicine, critical care, and orthopedic providers to understand how patterns of pelvic and acetabular fractures affect management and prognosis.

Pelvic fractures in children differ significantly from those in adults because of differences in physiology and mechanism of injury. The pediatric pelvis is particularly resistant to fracture due to its intrinsic flexibility. Accordingly, the incidence of pelvic fractures in the pediatric trauma population is approximately half the rate seen in adults.^{1,2} Because of the inherent resiliency of the immature pelvis, a non-avulsion pelvic fracture in a child should be considered a marker of high-energy trauma and alert providers to the likelihood of concomitant injuries that may represent a significant threat to survival.

The majority of traumatic pelvic fractures in children occur as the result of pedestrian versus motor vehicle accidents. This

mechanism accounts for 39–78% of cases.^{2,8–15} Motor vehicle accidents (passenger injuries) are the major cause of adult pelvic fractures and the second most common cause of pediatric pelvic fractures, causing 10–30% of cases.^{2,8–15} The anterior–posterior compression experienced by passengers during rapid vehicle deceleration is more likely to cause pelvic enlargement, sacroiliac (SI) joint disruption, and pelvic vessel laceration.¹⁶ Thus, adults are naturally at a higher risk for fracture-related vascular injury and exsanguination.

Other common mechanisms for pediatric pelvic fractures include falls, bicycle and motor bike accidents, and high-energy sports injuries.

Anatomic and physiologic considerations in the pediatric orthopedic trauma patient

Flexible bone and thick, strong periosteum help to account for the pediatric pelvic ring's resilience. Additionally, when compared to adults, the sacroiliac and symphyseal joints of children are more elastic and the symphysis pubis is thicker. The immature pelvis is therefore able to dissipate a relatively large amount of energy before failing. As a result, multifocal ring fractures and pelvic ligament disruptions are quite rare in children. While the adult pelvis has been likened to a hard pretzel—impossible to break in one place without causing a second fracture¹⁷—this analogy does not extend to pediatric patients. In children, unifocal ring injuries are not unusual. A more appropriate analogy for the disruption of the immature pelvis may be the breaking of a soft pretzel—a break

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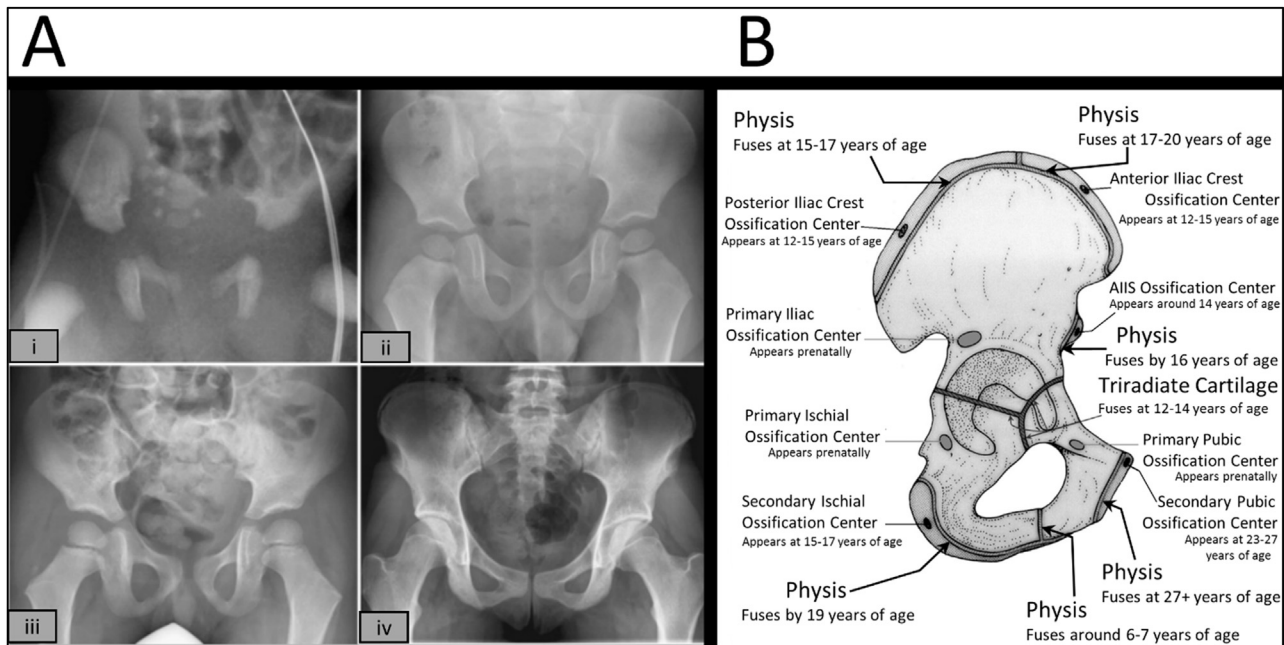


Fig. 1. (A) Normal pelvic bone anatomy and development shown on radiographs at birth (i), 2 years of age (ii), 5 years of age (iii), and 15 years of age (iv). (Adapted with permission from Donnelly.²¹) (B) The location of ossification centers in the pelvic bone, noting when they appear and when physes fuse. Note the Y-shaped triradiate cartilage at the acetabulum. (Adapted with permission from Scheuer and Black²² using information from McCarthy et al.⁴)

in one location does not necessitate a second one. Unstable, segmental ring fractures are thus much less common in children than adults.

While children have durable pelvic rings, they also have more effective hemostatic responses. When compared to the sclerotic vessels of adults, children's blood vessels are smaller in caliber and more reliably vasoconstrict in the event of hemorrhage. The thick, adherent periosteum of pediatric bones also limits fracture displacement and tamponades bleeding from raw bony surfaces. Due to these physiologic factors, traumatic pelvic fractures almost never lead to life-threatening arterial hemorrhage in children, while they do so in 10–20% of adult traumatic pelvic fracture cases.^{18–20}

The immature pelvic bone is marked by the presence of growth plates (physes) and cartilage undergoing endochondral ossification. Three primary ossification centers in each pelvic bone represent the developing ilium, ischium, and pubis. Several secondary ossification centers arise as development continues. Practitioners must be aware of these structures in order to appropriately interpret radiologic studies of the pediatric pelvis (Figure 1). The physeal junction of the ilium, ischium, and pubis occurs at the immature acetabulum, comprising the Y-shaped triradiate cartilage. The closure of this structure, which occurs at 12–14 years of age,⁴ has been shown to be one of the best radiographic indicators of skeletal maturity in a patient.⁸ In patients with fused triradiate cartilage, acetabular injury patterns are more like those seen in adults. In these patients, adult orthopedic trauma specialists should be consulted.⁸ Injury to an open triradiate cartilage, which may be isolated or part of a larger pelvic ring fracture, must be identified, as it greatly affects treatment and can result in long-term growth arrest of the acetabulum (see section on [Acetabular dysplasia](#)).

Practitioners should be aware of when other ossification centers appear and close (Figure 1B). For example, the pubis and ischium fuse at the inferior pubic ramus at age 6–7, the main iliac crest ossification center appears at age 13–15 and fuses at age 15–17, and the secondary ischial ossification center appears at age 15–17 and typically fuses by age 19. The anterior–inferior iliac spine (AIIS) ossification center appears around age 14 and

disappears by age 16. Three secondary ossification centers also appear in the acetabulum around adolescence.⁴ As these normal structures and variants can easily be confused for fractures, it is recommended that an experienced pediatric orthopedist or radiologist assist in analyzing any radiologic studies.

Avulsion fractures

Many secondary ossification centers represent muscle origins, which are separated from main ossification centers by cartilaginous apophyses. Avulsion fractures, which are some of the most common pediatric pelvic fractures, are low-energy injuries that occur when traction from an attached muscle pulls a developing muscle origin from its normal anatomic site. These apophyseal injuries—which include ischial tuberosity, anterior–superior iliac spine (ASIS), and AIIS avulsions as well as iliac apophysitis—are typically seen in the context of sports injuries. Avulsions are low-energy fractures that are managed on an outpatient basis and tend to heal with protected weight-bearing and temporary activity restriction. Accordingly, they are not the focus of this article.

Diagnosis of traumatic pelvic fractures in children

The approach to the pediatric trauma patient must be systematic and multidisciplinary. Although evaluation and management is typically led by a surgical traumatologist or emergency medicine physician, it is important to include orthopedic specialists and others throughout the patient's course. With potentially complicated polytrauma patients entering the trauma bay, it is vital that the team follow a standardized, validated care approach.

Primary survey

As in all pediatric trauma evaluations, initial management should follow the principles of Advanced Trauma Life Support (ATLS), identifying those injuries that pose the greatest threat to life. It should be recognized that severe pelvic fractures

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