IMAGING OF PELVIC FRACTURES AND ASSOCIATED INJURIES

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Introduction

Pelvic fractures occur in approximately 113,000 persons in the United States each year [1], and have a major impact on the person's functional status and well-being [2-4]. There are four general categories of pelvic fractures. 1) Avulsion fractures occur from the multiple ligamentous and tendinous insertions and tend to be relatively minor. 2) Insufficiency fractures generally occur in the osteoporotic and elderly, and usually involve only the obturator ring. 3) Acetabular fractures occur from higher energy trauma, but are limited to the anterior pelvis. 4) Finally, pelvic ring disruptions are high energy injuries involving the anterior and posterior pelvis. Pelvic ring disruptions are associated with high morbidity and mortality and will form the focus of this presentation.

Because of its strength and inherent stability, great force is required to disrupt the normally ossified pelvis. Pelvic ring disruptions occur most commonly from high-energy trauma, including motor vehicle crashes (37-64 %), pedestrians struck by motor vehicles (16-32%), or falls (usually from great height) (5-11%) [5-10]. Pelvic ring disruptions are associated with a 5-20% mortality, although the most common cause of death in these usually severely injured patients is head injury rather then the pelvic fracture itself [6, 11-15].

Imaging Approach

The initial identification of pelvic ring disruption generally comes from AP radiography that is performed in the initial resuscitation of the trauma patient. With faster CT technology, more patients are now initially imaged with CT. However, radiography remains the initial imaging approach in subjects with hemodynamic instability. Visualization of injury to the anterior pelvic ring, inclusive of the acetabulum and obturator ring is not generally a challenge on AP radiography. However injuries to the posterior structures, and therefore discrimination of pelvic ring disruptions, with the associated implications for immediate care, from injuries limited to the acetabulum or obturator ring can be a challenge. Identification of pelvic ring disruptions requires a high index of suspicion for posterior injury when anterior injury is identified, and careful scrutiny of both the sacral arcuate lines and the anterior and posterior sacroiliac joints. Identification and classification of pelvic ring disruptions is easier after complete imaging with CT and/or oblique radiography. At our institution, we perform CT on all pelvic ring disruptions, and are using 3D CT reformations to replace inlet/outlet and Judet oblique pelvic radiography.

Classification

There have been a number of efforts in the past to classify pelvic ring disruptions into differing levels of severity. These classification methods are designed to guide eventual definitive orthopedic repair of the pelvis. The Young classification scheme, later revised by Burgess, is based on direction of force, either anterior-posterior (AP) compression, lateral compression, or vertical shear type. There are three subsets within AP compression and three subsets within lateral compression, along with a single category for vertical shear, and a combined mechanism category for injuries that do not readily fit within the above framework. Classification within the Young-Burgess system is based on five radiographic views of the pelvis, the AP, inlet, outlet, and left and right Judet views [16], although classification based on the AP view only may be accurate in the majority of cases [17]. CT scan is also used an adjunct for classification [16]. Based on a retrospective review by a team of pelvic injury experts, 90% of pelvic ring disruptions fit into one of these main categories, with only 10% in the combined mechanism group [7]. Higher grades in the Young-Burgess classification tend to be more unstable injuries [16].

Stability is a key, but confusing concept in pelvic ring disruptions. The strong ligamentous attachments between the pelvic bones provide stability for weight bearing. As these structures are disrupted, and as fractures occur, the pelvic loses its mechanical integrity, and ability to tamponade hemorrhage. In general disruption (through ligamentous injury or fracture) of the anterior pelvis (pubic symphysis and obturator rings) and the anterior sacroiliac ligaments leads to rotational instability. The rotational unstable pelvis can rotate externally and sometimes internally, but cannot translate in the vertical plane. Vertical instability requires disruption of the anterior pelvis and all of the osseous or ligamentous elements of the posterior pelvis, including the extremely strong posterior sacroiliac ligaments. Unfortunately, vertical instability can only be confirmed on imaging by identification of vertical displacement. The key landmark for identification of vertical displacement is the inferior margin of the sacroiliac joint. 3D CT reformations can also provide critical information in determining vertical instability.

Associated Injuries

All pelvic ring disruptions result in some hemorrhage, due to the rich network of both arteries and veins that course in close association with the pelvic ring. In most pelvic ring disruption patients, bleeding is relatively minor, and stops spontaneously. However, a minority of patients with pelvic fracture will sustain major hemorrhage that leads to hemodynamic compromise, and potential exsanguination. The source of this major hemorrhage is variable, and may include arterial, venous, and osseous bleeding from the fracture margins. In fractures leading to osseous instability, the ability of the pelvis to tamponade is lost, and large volumes pelvic hemorrhage is facilitated.

A common critical decision point in the early management of major trauma patients is determination of the source of hemorrhage in patients with hemodynamic compromise. Because subjects with pelvic ring disruption generally have multiple injuries, the pelvic fracture may not be the most important cause of hemorrhage. Accordingly, radiologists must be able to assess the likelihood of arterial injury from pelvic fractures.

Arterial blush on CT has been identified as an important predictor of arterial hemorrhage. Although data is limited, the published series suggest that in the presence of blush, the yield on arteriography is high [12, 18, 19]. In patients with hemodynamic instability, contrast extravasation should prompt arteriography. In addition, the volume and location of pelvic hematoma can aid identification of subjects at high risk for arterial injury. Subjects with high volumes of pelvic hemorrhage on CT (>600ml) have an 80% probability of major pelvic hemorrhage, while low volumes (<100ml) carry only a 3% major pelvic bleeding risk [20]. In addition, pelvic hematoma along the pelvic sidewall is associated with a relative risk of pelvic arterial injury of approximately 3.0 when compared to subjects with pelvic hematoma elsewhere [21].

The location of pelvic fracture can also be used to stratify subjects with pelvic ring disruption into high and low major hemorrhage risk. Identification of displaced fractures of the pubic symphysis, or obturator ring, combined with tachycardia, and low hematocrit can be used to stratify subjects into major hemorrhage risk ranging from 2 to 60% [22].

Because of the proximity of the bony pelvis to the bladder, urethra, penis, and vagina, with pelvic fracture both acute and chronic injuries to these genitourinary organs are common. Acute injuries include rupture of the bladder in approximately 10% of pelvic fracture victims and injury to the urethra in approximately 5% of male subjects with pelvic fracture [23, 24]. These acute GU injuries are generally diagnosed in the initial trauma care admission. In addition, chronic GU dysfunction also may occur from pelvic fracture in the absence of overt organ injury, and usually is not apparent in the initial hospitalization. Overall, approximately 20% of younger subjects with pelvic fracture will sustain GU dysfunction [25-27], with substantial impact on quality of life [2-4].

Bladder injuries can also be predicted by location of pelvic ring disruptions. In particular, male subjects with diastasis of the pubic symphysis of >1cm are 9.8 times more likely to have bladder injury than those without [28].
The probability of urethral injury is also predicted by the appearance of the pelvic fracture. Increasing diastasis of the symphysis or increasing fracture displacement through the medial portion of the inferior ramus connotes increase probability of urethral injury.

Conclusion

In summary, pelvic ring disruptions are an important source of morbidity and mortality in trauma patients. Key concepts in the understanding of pelvic ring disruptions include stability and prediction of arterial hemorrhage and other associated injuries.

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