

Malgaigne Pelvic Fractures in Children: An Unusual, Unstable Fracture Pattern of Pelvic Fractures

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Abstract

The spectrum of patients with pelvic fractures ranges from patients with isolated, simple fractures to critically injured patients with multiple other life-threatening injuries. This article reviews the literature available, especially with reference to the 'Malgaigne Fractures in Children', presenting it in a concise form.

Categories: Pediatrics, Pediatric Surgery, Orthopedics

Keywords: malgaigne pelvic fractures, children, pelvic fractures

Introduction And Background

Historical background

Joseph-Francis Malgaigne (1806-1865), was a French surgeon and medical historian born in Charmes-sur-Moselle, Vosges. He studied medicine in Paris, and was later a surgeon of Parisian hospitals, including Saint Louis and Belgium hospitals.

Malgaigne is known for his work with bone fractures and dislocations in children, the subject of the current article. He specialized in orthopaedic surgery of the knee, hip and shoulder. As an advocate of statistical analysis in medicine, he is remembered for statistical hospital surveys in Paris. In 1834, he published *Manuel de Médecine Opératoire*, an influential work on surgical techniques. This book was later translated into various languages. As an historian, he was a scholar of the works of Hippocrates and editor of Ambroise Pare's writings. In 1841, he founded a surgical journal, 'Journal de chirurgie,' and in 1846, he became a member of the Académie de Médecine.

Review

Epidemiology

Motor vehicle crashes, including motor vehicles crashing into pedestrians, cause about 60% of pelvic fractures. Frequency of the fracture is highest for occupants of subcompact or compact automobiles and for occupants of any vehicle struck on the side [1]. Most of the remainder result from falls [2-9].

Child abuse is a rare cause of pelvic fracture, but isolated fracture of the pelvis may be the only

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skeletal manifestation of child abuse. X-rays of the pelvis should be included in the skeletal survey of the child abuse. Avulsion injuries most commonly occur secondary to athletic injuries, especially soccer, gymnastics, and track.

Pelvic fractures generally contribute 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].

Pelvic fractures comprise of less than 0.2% of all paediatric fractures [14-15], but they constitute between 1% to 5% admissions to Level 1 paediatric trauma centres [16-20].

Associated injuries

Multisystem injuries are commonly seen due to high energy nature of these injuries. In a published clinical series involving 585 patients with pelvic fractures, 87% were reported as having at least one, and often several, associated injuries [17-18, 21-23]. Grisoni, et al. [19] reported in their series, 58% with involvement of one or more other body areas, including non-pelvic fractures (49%), neurological injury (26%), significant haemorrhage requiring transfusion (21%), abdominal injury (14%), thoracic injury (7%), and genitourinary injury (4%). Almost all authors agree that the outcome is largely determined by the associated injuries rather than the pelvic fracture itself [16-17, 19-22, 24-25].

The incidence of head injury in association with the pelvic fracture is between 9% and 48% in recent retrospective studies [4, 16-17, 19, 21-22, 26-28], and its spectrum extends from mild concussion to brain death. Brain injury merits the highest priority because it is the leading cause of death in patients with pelvic fractures.

The two largest single centre retrospective studies of paediatric pelvic fractures by Silber, et al. [22] and Tarman, et al. [30] reported 1% incidence of lower urinary tract injury in association with pelvic fracture. Although controversial, most authors agree that microhematuria can be followed expectantly, whereas patients with gross hematuria should undergo imaging with abdominopelvic computed tomography (CT), retrograde urography, and cystography [29].

Vaginal and/or rectal lacerations occur in 2-18% of children with pelvic fractures [28-31]. Their detection and treatment with repair or diversion is of paramount importance to prevent late pelvic abscess formation [32]. However, in open fractures, the incidences of lower urinary tract injury, vaginal laceration, and rectal laceration is significantly higher.

The incidence of abdominal injuries, including solid organ and hollow viscus, is between 14% and 21% [16-18, 22, 27]. The incidence is comparable to the adults with regard to abdominal injury in association with pelvic fractures [18]. It is very important to recognize them early as abdominal injury ranks second to the head injury as a cause of death in children with pelvic fractures [22]. CT scan, ultrasound and diagnostic peritoneal lavage help in diagnosing these injuries.

Fractures of other bones occur to the tune of 40%-50% cases [17, 19, 21-23, 26] and femur as the most frequent fractures [25].

Pelvic fractures with posterior displacement of hemi-pelvis or iliac wing can damage the lumbosacral plexus as well as the sciatic nerve and is seen in 1-3% cases [23-24, 30]. Complete

neurological examination of the extremities assisted by myelography with computed axial tomography or magnetic resonance imaging (MRI) is useful for establishing the diagnosis of lumbosacral plexus or root avulsion injury. Surgical repair of nerve root is rarely performed, and the deficits are usually permanent.

Malgaigne fracture pattern

Malgaigne fracture falls in the 'unstable fracture pattern', where there are double fractures in the pelvic ring anteriorly and posteriorly, through the bony pelvis, sacroiliac joint, or symphysis pubis. Other fractures include double vertical pubic rami fractures (straddle or floating fractures) or dislocations of the pubis that occur as an anterior double break in the pelvic ring anteriorly and multiple crushing injuries that produce at least two severely comminuted fractures in the pelvic ring.

Bilateral anterior and posterior fractures are the most likely fracture pattern to cause severe haemorrhage. Therefore, most important here is to replace blood volume and stabilize the child before considering treatment of the pelvic fracture.

Physiological consideration in a child

Physiologically, the bones of children have a lower modulus of elasticity and are therefore more malleable, so they deform more and absorb more energy as compared to the adults before fracture [32]. In addition, sacroiliac joint and symphysis pubis have greater elasticity, thereby requiring higher energy to cause it to fracture than in adult pelvis [22]. Thus, the presence of a pelvic fracture in a child is a marker of severe injury. Children with pelvic fractures may require blood transfusion; however, death by exsanguination or associated vascular injury is unlikely [17-19] as compared to adults because of more effective vasoconstrictive response with non-atherosclerotic blood vessels [20]. In children with unstable fracture patterns or uncontrolled hypotension with ongoing transfusion requirements, external fixation, angiography and selective embolization may be indicated.

Ossification centers of pelvis

The pelvis ossifies from three primary ossification centers--the ilium, ischium and pubis--which meet at the triradiate cartilage and fuse between 16-18 years of age [33]. The pubis and ischium fuse inferiorly at the pubic rami at six to seven years and occasionally, at this time, a mass of ischiopubic synchondrosis is noticed radiographically, which should not be confused with the pelvic fracture.

The secondary ossification centers appear for iliac crest (13-15 years), ischial apophysis and ischial spine (15-17 years), and anterior inferior iliac spine (14 years). There may be secondary ossification centers for angle of the pubis, pubic tubercle and lateral wing of the sacrum. This knowledge is important to avoid confusion with avulsion fractures [34].

At puberty, three secondary centers of ossification appear in the hyaline cartilage surrounding the acetabular cavity. The os acetabuli, which is the epiphysis of the pubis, forms the anterior wall of the acetabulum, develops at eight years of age and fuses with the pubis at 18 years of age. The epiphysis of ilium, the acetabular epiphysis [34-35], forms a large part of the superior wall of the acetabulum also develops at eight years and fuses with the ilium at 18 years. The small secondary center of the ischium is rarely seen, and it develops in the ninth year, uniting with the acetabulum at 17 years contributing very little to the development of acetabulum.

Radiographic studies and other imaging

Radiographic assessment of the patient should only be done once the child is stabilized with full note of the associated injuries involved. Scout views of the skull, cervical spine, chest, abdomen, pelvis, and long bones should be obtained quickly.

A single anteroposterior x-ray may be sufficient to determine pelvic ring stability in the acute situation [10]. The presence of sacroiliac displacement on the anteroposterior view indicates greater instability and possibility of associated major hemorrhage. Such cases should be further evaluated with inlet (directing the x-ray beam caudally at an angle of 60 degrees to the x-ray plate) revealing posterior displacement of the pelvis and outlet (directing the x-ray beam cephalad at an angle of 45 degrees to the x-ray plate) revealing superior displacement of the posterior pelvis or the superior/inferior displacement of the anterior pelvis, radiographic views [10].

Internal and external rotation views helps to determine fractures of the acetabulum. Comparison views of the contralateral apophysis may be helpful in evaluating avulsion fractures.

CT scanning helps further in evaluating involvement of sacroiliac joint, sacrum, pubis, hip, or acetabulum and soft tissues [36], especially so if some operative intervention is planned [22]. MRI offers similar benefits, with the advantages over CT, including better delineation of soft tissue injuries, absence of ionizing radiation, and improved imaging of posterior wall fractures in the setting of pediatric hip dislocations in which the posterior wall fragment is largely cartilaginous [37]. Rarely, a radioisotope bone scan is useful for the diagnosis of non-displaced pelvic fractures and in the identification of the acute injuries in children and adults with head or multisystem injuries [10, 38].

Classification of pelvic fractures

1. Quinby [39] and Rang [40] classified pelvic fractures in children into three categories:

- (a) uncomplicated or mild fractures with visceral injury requiring surgical exploration,
- (b) fractures with immediate, massive hemorrhage often associated with multiple
- (c) severe pelvic fractures.

This classification system emphasizes the importance of the associated soft tissue injuries, but does not account for the mechanism of injury or the prognosis of the pelvic fracture itself.

2. Watts [41] classified pediatric pelvic fractures according to the severity of skeletal injury:

- (a) avulsion, caused by violent muscle contraction across the unfused apophysis;
- (b) fracture of the pelvic ring (secondary to crushing injuries), stable and unstable; and
- (c) acetabular fracture associated with hip dislocation

3. Torode and Zieg [42] classified on the basis of the severity of the fractures:

- (a) avulsion fracture,
- (b) iliac wing fracture-separation of the iliac apophysis & fracture of the bony iliac wing,

(c) simple ring fractures-fractures of the pubis and disruption of the pubic symphysis and fractures involving the acetabulum, without a concomitant ring fracture, and

(d) fractures producing an unstable segment (ring disruption fracture) - 'straddle fracture' - characterized by bilateral inferior and superior pubic rami fractures, fractures involving the anterior pubic rami or pubic symphysis, and the posterior elements (e.g. sacroiliac joint, sacral ala and fractures that create an unstable segment between the anterior ring of the pelvis and the acetabulum.

4. Pennel, et al. [43] gave the classification on the basis of direction of force producing the injury:

(a) anteroposterior compression,

(b) lateral compression with or without rotation, and

(c) vertical shear.

Burgess, et al. [44] further modified the Pennel system and added subsets to lateral compression and anteroposterior compression groups to quantify the amount of force applied to the pelvic ring. They also created a fourth category, combined mechanical injury, to include injuries resulting from combined forces that may not be strictly categorized according to the Pennel system. Subsequently, this classification was modified and expanded by Tile, et al. [45].

5. Tile and Pennel classification of pelvic fractures involve:

(a) stable fracture,

a1: avulsion fracture,

a2: undisplaced pelvic ring or iliac wing fracture,

a3: transverse fracture of the sacrum and coccyx,

(b) partially unstable fracture,

b1: open-book fractures,

b2: lateral compression injuries (includes triradiate injury),

b3: bilateral type B injuries,

(c) unstable fractures of the pelvic ring,

c1: unilateral fractures,

c1-1: fractures of the ilium,

c1-2: dislocation or fracture-dislocation of the sacroiliac joint,

c1-3: fractures of the sacrum,

c2: bilateral fractures, one type B and one type C,

c3: bilateral type C fractures,

6. AO Association for the Study of Internal Fixation Classification of pelvic fractures:

(a) stable fractures

(b) rotationally unstable fractures, vertically stable

(c) rotationally and vertically unstable fractures

c1: unilateral posterior arch disruption

c1-1: iliac fracture

c1-2: sacroiliac fracture-dislocation

c1-3 sacral fracture

c2: Bilateral posterior arch disruption, one side vertically unstable

c3: bilateral injury, both unstable

7. Silber and Flynn [22] divided the pelvic fractures into two groups:

(a) immature (Risser 0)

(b) all physes open and mature (closed triradiate cartilage).

They suggested that in the immature group the management should focus on the associated injuries because the pelvic fractures in this group rarely require surgical intervention; fractures in the mature group were classified and treated according to adult pelvic fracture classification and management principles.

The multitude of classification systems makes the comparison of incidence, mechanism of injury, morbidity and mortality, and outcome difficult among studies using different systems. Although many recent studies of children's fractures use the Torode and Zieg or Tile's classifications or both, the basic classifications, (a) mature or immature pelvis and (b) stable or unstable fracture, are very useful information for making treatment decisions. Most pelvic fractures in children are stable injuries. Pelvic fractures in patients with closed triradiate cartilage should follow adult fracture classifications and treatment protocols [44-46].

Management

The examination of the pelvic area begins with a visual inspection. Areas of contusion, abrasion, laceration, ecchymosis, or hematoma, especially in the perineal and pelvic areas, should be recorded. Pelvic landmarks like anterior superior iliac spine, crest of the ilium, sacroiliac joints, and symphysis pubis should be palpated. Pelvic compression and distraction test will show abnormal mobility, pain or crepitation in a case of pelvic fracture. The range of motion of the extremities, especially at the hip joint, should be determined. Careful examination of the head, neck, and spine should be performed to assess for spinal and closed

head injury. A complete neurovascular examination, including peripheral pulses, along with rectal and careful genitourinary evaluation, should also be done. Apart from the physical signs stated above, leg-length discrepancy and asymmetry of the pelvis may also be present in these cases due to the displacement of the hemipelvis. Inlet and outlet radiographs and CT scan can show the amount of pelvic displacement.

Numerous treatment regimens have been successful, depending on the type of fracture and the amount of displacement. For fracture with minimal displacement, bedrest in the lateral recumbent position may be all that is necessary. If lateral displacement is severe, closed manipulation in the lateral decubitus position and spica casting can be used. If the displacement is cephalad only, skeletal traction can be used in a small child. Occasionally, manipulation under anesthesia is required. After successful manipulation of the fragments, traction on the involved side can be used to maintain the reduction. Open or percutaneous external fixation of the pelvis has been advocated to maintain accurate reduction of the fracture or dislocation, achieve earlier ambulation (toe-touch weight bearing), and decrease pain secondary to instability.

Reviews by Schwarz [47], Nierenberg, et al. [48] and Silber and Flynn [22] have suggested that younger children with an immature pelvis are unlikely to require operative intervention; however, treatment of children with unstable pelvic fractures and treatment of adolescents with a 'mature' pelvis should follow adult fracture guidelines.

Operative treatment of pelvic fractures is not routinely recommended [49] because (a) exsanguinating hemorrhage is unusual in children, so operative pelvic stabilization to control bleeding is not necessary [28, 49]; (b) pseudoarthrosis is rare in children and fixation is not necessary to promote healing; (c) the thick periosteum in children tends to help in stabilizing the fracture, so surgery is usually not necessary to obtain stability [29]; (d) prolonged immobilization is not necessary for the fracture healing [48]; (e) significant remodeling may occur in skeletally immature patients [49]; and (f) long-term morbidity after pelvic fracture is uncommon in children [19, 28, 50].

Operative fixation may be indicated to facilitate wound treatment in open fractures, control hemorrhage during resuscitation, allow patient's mobility and make nursing care easier, prevent deformity in severely displaced fractures that may not heal or adequately remodel, improve overall patient care in patients with polytrauma, minimize risk of growth disruption, or restore articular congruity.

Keshishyan, et al. [51] advocated external fixation of unstable complex pelvic fractures, especially in children with polytrauma, and Gordon, et al. [52] suggested external fixation or open reduction and internal fixation in children older than eight years of age because spica casting is poorly tolerated in older children. Sometimes even combination of internal and external fixation may be required in some cases with mature pelvis or closed triradiate cartilage [53].

Stiletto, et al. [54] reported good results after open reduction and internal fixation of unstable pelvic fractures in two toddlers. They used AO small-fragment instrumentation in both. So, It is preferable to undertake operative intervention in young children only if there is severe (>3 cm) displacement of the sacroiliac joint is present and it cannot be corrected with adequate traction (distal femoral traction) on the displaced side of the hemipelvis.

Conclusions

The spectrum of patients with pelvic fractures ranges from patients with isolated, simple

fractures to critically injured patients with multiple other life-threatening injuries. The current article sought to review in concise form the available literature, especially with regard to 'Malgaigne Fractures in Children'.

Additional Information

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