Pediatric Pelvis Fractures
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Summary

Purpose: Pelvic fractures are uncommon in children. They rank second to those of the skull in terms of complication.

The present study retrospectively evaluates 200 multi-trauma patients. Mode of injury, type of fracture, associated lesions, morbidity and mortality were assessed.

Methods: Fractures were classified according to the Tile pelvic fractures classification and injury severity was classified according to the Modified Injury Severity Scale (MISS) and Pediatric Trauma Score (PTS).

The type of fracture correlated with injury severity and complications. The greatest morbidity and mortality was found in patients with completely unstable pelvic fractures.

Results: In the pre-hospital stage at the site of the accident, the PTS demonstrated to be a very useful tool to assess injury severity of the patient, to decide on the first treatment measures, and to evaluate the degree of complexity of care the patient needs. The MISS showed to have good predictive value for injury assessment during the in-hospital stage.

Conclusions: Pelvic fractures are rare in children. Early stabilization with external fixation is the gold standard for the management of patients with fractures of the pelvic ring.

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Adequate treatment of this type of fracture allows to minimize sequelae in the growing skeleton. Correct orthopedic treatment is important in the majority of these lesions.

Keywords: Pelvic fractures; Pediatric populations; Trauma scores

Introduction

Pelvic fractures account for 1 to 2 % of fractures in children and is followed by Traumatic Brain Injury (TBI) in the order of severity of complications and mortality. As the mortality rate among polytrauma patients is increased, the orthopedic surgeon should be alert to the possibility that the pelvic contents may be more damaged than the bone structure (mortality rate between 2% and 12%) [1]. Bone plasticity and elasticity determine that stronger forces are necessary to fracture the pelvis of a child than that of an adult; the exceptions are fractures involving the growth plates [2,3].

In the present study we compare fracture patterns, grade and type of associated trauma and treatment.

Anatomy

In children, the ossification of the pelvis varies according to age.

Primary centers of ossification

The pelvis consists of three primary centers, the ilium, ischium, and pubis. These three bones meet at the triradiate cartilage, where they fuse around 16 to 18 years of age. The ischium and pubis meet at the inferior pubian branch and fuse at approximately 6 or 7 years of age. (Figure 1) [4].

Secondary centers of ossification

1. The iliac wing appears between 13 and 15 years of age and fuses between the ages of 15 and 17 years.

2. The ischial tuberosities appear between the ages of 15 and 17 years and fuse between 17 and 19 years of age, but the process may be delayed until 25 years of age.

3. There may be a center of ossification in the anterior inferior iliac spine that appears around the ages of 13 to 15 years and fuses between 16 and 18 years of age; a phenomenon that is more common in boys than in girls.

There may also be secondary centers in the pubic tuberculum, in the pubic crest and angle, and the ischial spines. The secondary centers of the sacrum appear laterally between 16 and 18 years of age and fuse by the age of 25 years. These centers should not be mistaken for avulsion fractures or intra-articular loose bodies (Figure 2A and 2B) [5,6].

Pelvis biomechanics

The three major bones of the pelvis are joined together in a ringed shape. When one part of the ring is broken there will be a fracture or a
dislocation at another portion of the ring. Stability of the pelvis to a large extent depends upon integrity of an intact posterior sacroiliac complex. The strong posterior sacroiliac ligaments maintain the normal position of the sacrum and the pelvic ring and the entire complex has the appearance of a suspension bridge [2,3].

The sacrospinous ligaments link the sacrum with the ischion supporting external rotations, while the sacrotuberous ligaments resist both external rotational movements and vertical shearing forces. The major forces acting on the hemipelvis are: external and internal (by a mechanism of lateral compression) rotation and vertical shear. High-impact forces caused by an accident may be determined by more than one vector resulting in combined displacements with instability depending on the vector force and its intensity [7,8].

Material and Methods

We conducted a retrospective study of 200 multi-trauma patients (patients with trauma involving one or more organs or one or more systems and/or psychological trauma) admitted to the Hospital Nacional de Pediatría Prof. Dr. Juan P. Garrahan between 1988 and 2005, of whom 56 presented with pelvic fractures (40 male, 16 female). Mean age at presentation was 9.2 years. All immature based on the presence of open growth plates at the triradiate cartilage. All fractures were caused by road traffic accidents: 72% of the patients were pedestrians and 28% motor vehicle occupants.

Patients with pelvic fractures who did not require hospital admission were excluded. According to the modified Gustilo and Anderson classification 50 of the fractures were closed and six exposed. On admission, all patients were initially managed by an intensive care therapist and a general surgeon following the guidelines for the management of the pediatric multiple trauma patient. Orthopedic surgeons were consulted while the patient was being stabilized. Frontal X-rays were obtained. When fractures with complex or acetabular components were found, ala and obturator X-ray views as well as axial CT scans were subsequently requested [9,8].

Pelvis fractures were classified according to the Tile classification system: [10,11]

A: stable fractures
A1 avulsion fracture
A2 fracture without displacement of the pelvic or iliac ring
A3 transverse fracture of the sacrum and coccyx
B: partially unstable fractures
B1 open-book fractures
B2 lateral-compression fractures (including triradiate fractures)
B3 bilateral type B fractures
C: unstable pelvic ring fractures
C1 unilateral fractures
C1.1 iliac fracture
C1.2 Sacroiliac dislocation or fracture-dislocation
C1.3 sacral fracture
C2 bilateral fractures, with one side type B and one side type C
C3 bilateral type C fractures

The modified injury severity scale (MISS) [12] was retrospectively calculated for each of the patients based on their clinical charts and numbers from 1 to 5 were assigned for each category: neuroaxis, head and neck, thorax, abdomen and limbs and pelvis (Table 2) [13].

The squares of the scores of the three most affected areas were added 9. The result is the MISS score for each patient. Subsequently, we related type of pelvic fracture to the MISS, type of fracture to morbidity and mortality, and type of fracture to morbidity and mortality and to the MISS.

We also used the Pediatric Trauma Score (PTS) [14,15] on admission to assess weight, airway stability, systolic blood pressure, [16] the degree of neurologic involvement, presence and severity of wounds, and bone fractures. Scores of +2, +1, and -1 were assigned [Table 1].

Treatment instituted in type A fractures (17 patients) was bed rest followed by reduced weight bearing for a short period (35 days) 19. In this fracture type no associated lesions requiring intervention were found. Patients with type B fractures (12 patients) only presented with associated peri- or para-visceral hematomas. The patients were conservatively treated with a hammock easily made of a strong sling of the length of the pelvis and three times the width to adequately apply traction to close the pelvic ring in an orthopedic bed with the patients lying on it. The weight apply is 10% of the total body weight. Subsequently, a Watson-Jones-type cast was placed under general anesthesia to exercise compression to close the pubic symphysis 28 (Figure 3A, 3B and 3C). In type C fractures (21 patients) placement of external fixation [17] as first stabilization allowed adequate management of six patients.
with complex rupture of the ring 2,15, 22. In the technique of the pin placement the thickest zone of the iliac wing was taken into account to avoid possible penetration into the pelvis [18]. Two screws were placed 2 cm posteriorly to the anterior superior iliac spine (ASIS) through the iliac crest.

For adequate reduction placement of two periacetabular screws and temporal wire with two malleable plates via anterior (ilioinguinal) and temporal wire with two malleable plates via anterior (ilioinguinal) and posterior approach (Kocher-Langenbeck) [20] was necessary. (Figure 4A, 4B, 4C and 4D). Acetabular fractures required open reduction with placement of malleable plates to restore the anatomy (Figure 4A and 4B). (One of the latter patients had been referred to the department 3 weeks post injury without treatment.) Patients near skeletal maturity comprised all the acetabular fractures [19].

Results

Overall mortality in the polytrauma patients was 8%. TBI was the first cause of death followed by pelvic fracture (1% of all the patients). Mortality in this series of 56 pelvic fractures was 3.5%. Associated lesions, found in 100% of cases, were the following: neurological 80%; musculoskeletal 73%; thoraco-abdominal 35%; genitourinary 9%. Fractures associated with pelvic trauma were: femur 12; tibia and fibula 7; humerus 6; clavicle 2; metatarsal bones 2; fracture-dislocation of the hip, 2.

In pelvic fractures, (group A), patients returned to their normal activities after 35 days of bed rest. In group B, the casts were removed after 60 days without sequelae. In one case premature removal of the cast at another center led to loss of reduction and subsequent sequelae. In group C, the external fixation was removed after 60 days; all these patients walked before removal of the external fixation, except those with nail placement for stabilization of the posterior sacrum who did so after 60 days.

No growth disturbances were observed after nail placement in the iliac crest.

In the two surgically treated acetabular fractures reduced mobility of flexion and internal rotation was observed [21]. Signs of femoral head necrosis were found in two patients, 18 months later to the first surgical treatment in acetabular fractures. All patients in the group of acetabular fractures are adolescents near the close of the grow cartilage and were in the car the accident event so the mechanism of the injury was a right force into the acetabular with the femur in 90 degrees of flexion

Late sequelae in our follow up of seventeen years were:

Table 1: Pediatric Trauma Score (PTS).

<table>
<thead>
<tr>
<th>Component</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>&gt;20 Kg</td>
</tr>
<tr>
<td>Airway</td>
<td>Normal</td>
</tr>
<tr>
<td>Systolic blood pressure</td>
<td>&gt;90mm Hg</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>Awake</td>
</tr>
<tr>
<td>Open wounds</td>
<td>None</td>
</tr>
<tr>
<td>Skeletal wounds</td>
<td>None</td>
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</tbody>
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Table 2: Modified Injury Severity Scale (MISSS).

<table>
<thead>
<tr>
<th>Body Area</th>
<th>1: Minor</th>
<th>2: Moderate</th>
<th>3: Severe</th>
<th>4: Severe, life-threatening</th>
<th>5: Critical, survival uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neural, face, and neck</td>
<td>GCS score 13-14</td>
<td>Contusions of eye</td>
<td>Laceration of eye, disfiguring, laceration, retinal detachment</td>
<td>GCS score 9-12</td>
<td>Avulsion of optic nerve, displaced facial fracture</td>
</tr>
<tr>
<td>Chest</td>
<td>Muscle ache or chest wall stiffness</td>
<td>Simple rib or sterna fracture</td>
<td>Multiple rib fractures</td>
<td>Pulmonary contusion, laceration, retinal detachment</td>
<td>GCS score 9-12</td>
</tr>
<tr>
<td>Abdomen</td>
<td>Muscle ache, abdominal-wall contusion</td>
<td>Major abdominal-wall contusion</td>
<td>Contusion of intra-abdominal, retroperitoneal, extraperitoneal organs</td>
<td>Thoracic or lumbar spine fractures</td>
<td>Minor laceration of abdominal organs</td>
</tr>
<tr>
<td>Extremities and pelvic girdle</td>
<td>Open fractures of digits</td>
<td>Nondisplaced long bone or pelvic fractures</td>
<td>Displaced long bone or multiple hand or foot fractures</td>
<td>Simple open fractures</td>
<td>Pelvic fractures with displacement laceration of major nerves or vessels</td>
</tr>
</tbody>
</table>

References:

1. Leg-length discrepancies in four patients (Figure 7A and 7B) [22,23]. Two of them had been treated for type C1.2 fracture-dislocation in whom the reduction were not satisfactory (overlap of 1 cm) and in two others patients with avascular femoral head necrosis because of the low height of the head [24].

2. Premature closure of the triradiate cartilage were observed in one patient and Salter’s innominate osteotomy was performed to improved acetabular displasia [13]. (Table 3&4 show the results according to the two scoring systems that were used).

The PTS with a cut-off point of 3 or less had both high specificity and negative predictive value for the identification of patients at low risk of mortality (94%). The positive predictive value was somewhat less, but still satisfactory for the detection of the patients with a high risk of mortality (66%) (Table 3).

Predictive power of the MISS with a cut-off point of 25 was similar to that of the PTS with a slightly higher sensitivity (83%) and a specificity of 78%. However, the positive predictive value was less (38.5) and the negative predictive value was 96.7% (Table 4).

In reviewing the association of scores and fracture type we determined that that group C had a mean MISS of 24, 78 with a SD of 12, 5 and PTS of 4, 2 with a SD of 0, 9.

Group A and B together had a mean MISS of 10.2 with a SD of 7.4, and PTS of 5.4 with a SD of 1.5. The differences between the MISS scores and PTS scores of the two groups was statistically significant (p=0.01) by a two tailed t test.

**Discussion**

In the case of trauma to the pelvis, internal injury should be carefully assessed before evaluating the structure itself [10]. Possible complications for the orthopedic surgeon vary according to the age of the patient. Unlike those in adults, large series in pediatric patients have reported that bed rest is the optimal treatment in the majority cases [25,3,4,19,7].

Based on the guidelines of the American Academy of Orthopaedic Surgeons [26] initial management of the polytrauma patient includes airway, breathing, and circulation stabilization. Intra or extra peritoneal hemorrhages need to be addressed in the emergency situation [6,4].
Pelvic fractures are rare in children. (2% of all type of pediatric fractures patterns). Early stabilization with external fixation is the gold standard for the management of patients with unstable pelvic ring fractures but the most frequent pattern is fractures without displacement of the pelvic or iliac ring so the conservative treatment is he option. We obtain anatomic reduction with the combined method of treatment with a hammock, traction followed by Watson Jones cast under general anesthesia with the patient lying in the lateral decubitus position.

In the pre-hospital stage at the site of the accident, the PTS demonstrated to be a very useful tool to assess injury severity of the patient, to decide on the first treatment measures, and to evaluate the degree of complexity of care the patient needs. The MISS showed to have good predictive value for injury assessment during the in-hospital stage and is, together with the Tile classification, useful for the staging of associated injury and the degree of morbidity and mortality.

Adequate treatment of this type of fracture allows to minimize sequelae in the growing skeleton, improve the final result and allow to treat adequate others injuries associated to these type of fracture.

**Conclusion**

Death due to hemorrhage in spite of emergency stabilization has led us to consider the use of alternative therapies, such as selective arterial embolization [27,16,28], a method currently used at our center led us to consider the use of alternative therapies, such as selective arterial embolization [27,16,28], a method currently used at our center led us to consider the use of alternative therapies, such as selective arterial embolization [27,16,28], a method currently used at our center.