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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.

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. 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 ossificatio

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 ossificatio

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

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Figure 1: Primary centers of ossification.

Figure 2: (A&B) Avulsion fractures.

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 with the patient lying in the lateral decubitus position 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

Component	**Category** **+2 +1 -1**		
Weight	>20 Kg	10-20 Kg	<20 Kg
Airway	Normal	Maintainable	Not maintainable
Systolic blood pressure	>90mm Hg or palpable radial pulse	90-50mm Hg or palpable femoral pulse	<50mm Hg or non-palpable pulse
Central nervous system	Awake	Obtunded or loss of consciousness	Comatose or decerebrate
Open wounds	None	Minor	Major or penetrating
Skeletal	None	Closed fracture	Open or multiple fractures

Table 1: Pediatric Trauma Score (PTS).

Body Area	1: Minor	2: Moderate	3: Severe	4: Severe, life- threatening	5: Critical, survival uncertain
Neural, face, and neck	GCS score 13-14 Contusions of eye Conjunctival hemorrhage Fractured teeth	GCS score 9-12 Undisplaced facial bone fracture Laceration of eye,disfiguring, Laceration,retinaldetachment	GCS score 9-12 Avulsion of optic nerve Displaced facial fracture	GCS score 5-8 Bone or soft-tissue injury with minor destruction	GCS score 4 Injuries with major airway obstruction
Chest	Muscle ache or cheswall stiffness	Simple rib or sterna fracture	Multiple rib fractures Pulmonary contusion Hemothorax or pneumothorax Diaphragmatic rupture	Open wounds Pneumomediastinum Myocardial contusion	Tracheal laceration Aortic laceration Hemomediastinum
Abdomen	Muscle ache seal-belt abrasion	Major abdominal-wall contusion	Contusion of intra-abdominal, retroperitoneal or extraperitoneal organs Thoracic or lumbar spine fractures	Minor laceration of abdominal organs Bladder rupture Spine fractures with paraplegia	Rupture or severe laceration of abdominal vessels or organs
Extremities and pelvic girdle	Minor sprains and simple fractures and dislocations	Open fractures of digits Nondisplaced long bone or pelvic fractures	Displaced long bone or multiple hand or foot fractures Simple open fractures Pelvic fractures with displacement Laceration of major nerves or vessels	Multiple closed long bone fractures Amputation of limbs	Multiple open long bone fractures

Table 2: Modified Injury Severity Scale (MISS).

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 small skin incisions with guide wires to avoid damage to the soft tissue [9]. Tubes were placed in the frame using modulates configuration (not parallel) (See Figure 4) separated from the skin to allow exploratory laparotomy by abdominal media insition in six patients who required abdominal exploration for abdominal injuries. The stabilization allows to movilize patients in bloc and to obtain a better nursing care of scars. (Figure 4A, 4B, 4C and 4D). Acetabular fractures required open reduction with placement of malleable plates to restore the anatomy (Figure 5A & 5B). (One of the latter patients had been referred to the department 3 weeks post injury without treatment.)Patients near skeletal mature comprised all the acetabular fractures [19].

For adequate reduction placement of two periacetabular screws and temporal wire with two malleable plates via anterior (ilioinguinal) and posterior approach (Kocher- Langenbeck) [20] was necessary. Only one patient was treated non-invasively with skeletal traction and computed tomography controls with acceptable anatomical reduction. Vertical displacement was reduced with skeletal traction and adequate reduction in two cases; in one patient, who was referred to our center one month post injury, the sacroiliac dislocation was reduced via posterior approach under image intensifier control with pin insertion and placement of a cannulated nail followed by a cast 23 (Figure 6A and 6B) [5]. In the remaining cases (three patients) an external fixation was placed. In a second step cannulated screws were placed percutaneously under image intensifier control with the patient lying in dorsal decubitus position.

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:

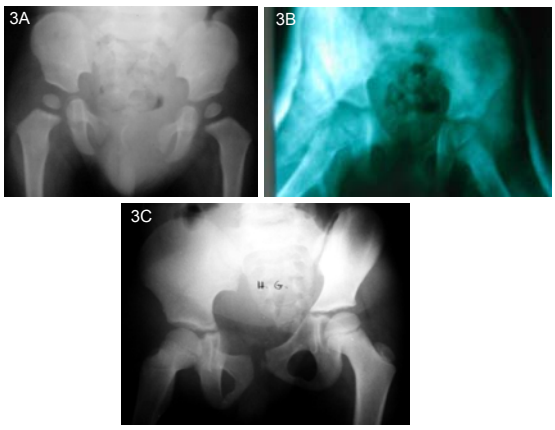

Figure 3: (A, B&C) Type B1: Watson-Jones-type cast was placed under general anesthesia.

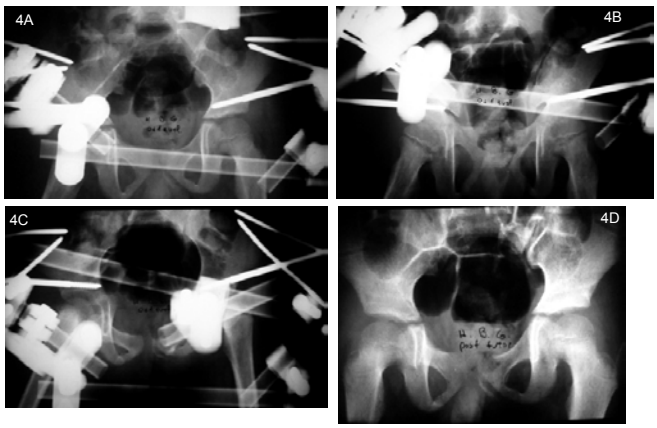

Figure 4: (A, B, C&D) Tubes were placed in the frame to allow exploratory laparotomy and better nursing.

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].

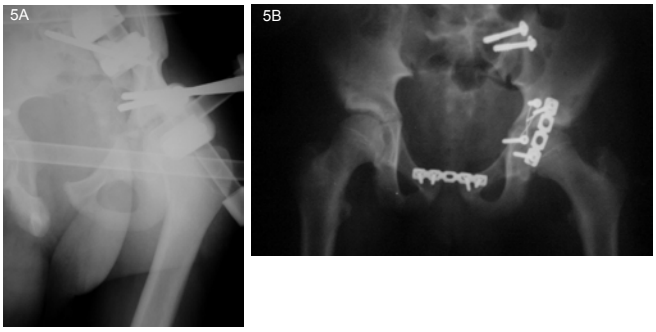

Figure 5: (A&B) Acetabular fractures required open reduction with placement of malleable plates to restore the anatomy.

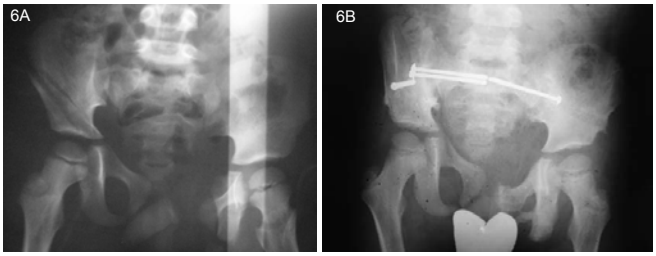

Figure 6: (A&B) The sacroiliac dislocation was reduced via posterior approach under image intensifier control with pin insertion and placement of a cannulated nail.

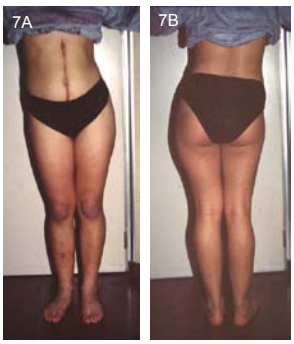

Figure 7: (A&B) Late sequelae were leg-length discrepancies.

Cut-off Point	Outcome Dead Alive	Total
<3	12 4	16
3 or more	4 180	184
Total	**16 184**	**200**

PTS with a cut-off point of 3 or more: Sensitivity 75%; Specificity 97%; Positive predictive value 75%; Negative predictive value 97%.

Table 3: Outcome of Polytrauma Patients According to PTS with a Cut-off Point of 3.

Cut-off Point	Outcome Dead Alive	Total
25 or more	10 24	34
< 25	6 160	166
Total	**16 184**	**200**

MISS with a cut-off point of 25 or more: Sensitivity 10/16 62%; Specificity 160/184 86%; Positive predictive value29.5%; Negative predictive value 98%.

Table 4: Outcome of Polytrauma Patients according to MISS with a Cut-off Point of 25.

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 for other orthopedic pathologies.

We do not have experience with the use of the anti shock clam [29] in pediatric patients.

The Tile classification is adapted to the use in children who have unique fracture types due to the changing skeleton and bone elasticity. It allows correlation with the grade of overall trauma and shows that total disruption has a high rate of associated lesions and high morbidity and mortality (5.5% in our series) [10,11].

Premature closure of the triradiate cartilage has been described in the literature as leading to acetabular displasia in children under 10 years of age, and Salter and Harris lesions type V are found with growth arrest of the iliac ischiatic branches, the most active through direct or indirect mechanism (hinge trauma) [13,30].

We notice only one case of avascular necrosis of the femoral head corresponding to acetabular fracture. This type of fractures have low PTS score because the high forces necessary to fracture acetabulum structures determine another associated injuries like abdominals, urine or femoral injury like another type of fracture or avascular femoral head injury. The usefulness of Severity Scales in pediatric polytrauma patients is undisputable. They are probably most important in the pre-hospital stage in the decision-making process to get the patient to the adequate facility with the appropriate infrastructure in a timely fashion [24].

The PTS is a useful score for the on-site triage of the patient. The advantages of the score are that it is easy to memorize, fast to apply, and has a physiological profile that allows immediate decision making. The PTS also meets the objective parameters to be used in the records of the different operators in the process. In the present study, the PTS proved to be more accurate in the prediction of final outcome of the patients than the MISS which characterizes injury severity within the different anatomic regions with equal values without assessing overall severity but in contrast correlated well with tile classification of Pelvic fracture as useful predictor of associated injuries and long term morbility. These results are in agreement with those of Marcus et al. study [31]. In that series patients with MISS < 25 had a 30% chance of impairment.

Conclusion

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.

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