PAEDIATRIC PELVIC FRACTURES: CLINICAL AND RADIOLOGICAL CHARACTERIZATION OF PATIENTS ADMITTED IN A HIGH COMPLEXITY CENTER BETWEEN 2011 AND 2020

Sergio A. Arroyave Rivera[1], Juan José García G[2], Alejandro Uribe Ríos[3], Damian Martínez Soto[4]

Universidad de Antioquia

Authors:

1 Orthopedics and Traumatology Resident. Department of Orthopedics and Traumatology Universidad de Antioquia
Medellin Colombia. Contact number: +57 (310) 8366323. Email: chechoarroyave@gmail.com

2 Orthopedics and Traumatology Resident. Department of Orthopedics and Traumatology Universidad de Antioquia
. Medellin Colombia. Contact number: +57 (318) 5906914. Email: ronjosegarcia@gmail.com

3 Orthopedics and Traumatology, Universidad de Antioquia. Subspecialist in Pediatric Orthopedics, Universidad Pontificia Bolivariana. Medellin Colombia. Contact number: +57 (301) 4671199. Email: alejandro.uribe1@udea.edu.co

4 Doctor and specialist in epidemiology from the Universidad de Antioquia
. Medellin Colombia. Contact number: +57 (311) 6361332. Email: damian.martinez.soto@gmail.com

Abstract
Pelvic fractures in the pediatric population are infrequent, however they are an indicator of high-energy trauma. There are anatomical and physiological differences with respect to pelvic trauma in the adult population that translate into different mortality rates, fracture patterns, and associated injuries. They present a high rate of associated injuries, and are those that usually dictate prognosis. The purpose of this study is to describe the characteristics of pelvic trauma in a pediatric population attended at a high-complexity institution in the city of Medellín.

Materials and methods: We developed a retrospective analysis of the care of patients with pediatric pelvic trauma for 10 years (2011-2020) in a highly complex center in the city of Medellín, through a database, information on the was obtained relevant variables such as vital signs, associated injuries, radiological classification, mortality etc.

Results: A total of 91 patients under 16 years of age (59 men and 32 women) were included, with an average age of 9.4 years. The most frequent trauma mechanism was the traffic accident as a pedestrian (44%). 65.1% of associated extraskeletal injuries were found, with blunt abdominal trauma (34.1%) and encephalocranial (30.8%) being the most frequent and 38.5% associated orthopedic injuries. Most of the fractures were classified as Torode and Zieg type III in 61.5%. A mortality of 2.2% was found, both deaths secondary to severe brain injury. Only 5 patients required urgent procedures to control pelvic bleeding and most of the patients received orthopedic management (85.7%).

Conclusions: Pelvic fractures in the pediatric population are infrequent and although the mortality rate is low, it presents a high rate of associated injuries which are generally the cause of death. The Torode and Zieg classification, although it is the most used presents important weaknesses in the categorization of patients and when defining a management and prognosis.

Keywords: Pelvic fractures; Torode and Zieg; pediatric fractures; polytrauma

Introduction

According to the current literature, trauma represents the main cause of death in children between 5 and 14 years of age, and the fifth between 0 and 5 years of age (1,2). Pelvic fractures in the pediatric population are unusual injuries, present in between 0.3% and 4% of patients with polytrauma (3-5). They are not a frequent cause of mortality, but they are an indicator of a high-energy mechanism, therefore they should alert health personnel to the presence of other life-threatening injuries such as cranial brain trauma (TEC), chest and abdominal.
To date, we have not found reports published in the literature that characterize these injuries at the local level, therefore, most of the therapeutic behaviors are extrapolated from data extracted from studies carried out in other countries or from recommendations for pelvic trauma in the adult population.
The objective of the study is to describe the epidemiological and radiological characteristics, associated injuries, treatment, and complications of pelvic trauma in the pediatric population treated in a high complexity institution in the city of Medellín.

Materials and methods

A retrospective, observational and descriptive study was carried out of patients under 16 years of age, from January 2011 to December 2020, who presented to the emergency service of the Hospital Universitario San Vicente Fundación and whose diagnoses included trauma or pelvic fracture. The patients were identified through the review of the institutional database with the related CIE-10 diagnoses, which were confirmed by plain radiography (RX) or computerized axial tomography (CT) images.
Once the database was obtained, a Google Docs form was developed where the following variables were recorded: Age at the time of consultation, sex, vital signs at admission, origin, mechanism of trauma, findings on the physical examination of pelvic admission and soft tissues, associated injuries, clinical signs of shock, need for transfusions, length of stay in hospital and in intensive / special care units, classification of trauma according to Torode and Zieg (6), need for orthopedic or other surgical procedures, management definitive and cause of mortality. Those patients in whom images (conventional X-ray or CT) could not be accessed to confirm the diagnosis were excluded from the study.

SPSS 22® statistical software was used for data analysis. The distribution of the variables was verified through the Kolmogorov-Smirnov test. Quantitative variables are described through means and standard deviations in the case of having a normal distribution, those with another type of distribution were described through medians and interquartile range (IQR). The qualitative variables were described in absolute numbers and proportions.

Results

The study included 91 patients under 16 years of age in the analysis period from 2011 to 2020. The distribution by gender was 59 male and 32 females, with a ratio of 1.6: 1 respectively. The mean age of presentation was 9.4 years. The youngest registered in the study was 13 months, who presented a pelvic fracture due to a traffic accident. The mean hospital stay was 12.4 days and a total of 38 patients (41.7%) required admission to the Special and / or Intensive Care Unit, where the mean stay was 4.81 days **(Table 1).**

Mechanism of trauma

The most frequent trauma mechanism recorded was a traffic accident as a pedestrian (44%), followed as a driver and / or occupant (19.8%) and by falling from a height (23.1%). Sports injuries were infrequent (3.3%). 6 patients were classified as “other mechanism”, 3 of them with gunshot wounds and 3 by crushing with blunt objects.

Fracture patterns

The initial imaging diagnosis was made in 53.8% by simple radiology, however, a computed tomography of the pelvis was requested in 76.9%. Detailed radiological evaluation showed that most of them had open triradiate cartilage (signs of skeletal immaturity) (71.4%). According to the Torode and Zieg classification, the most frequent subtype was grade III (61.6%), followed by grade IV (18.7%) (Figure 2). Within the grade III, a pattern of fractures of the pubic branches was also found as the most common subclassification (45.1%), only 8.8% of the acetabular extension presentation (62.5% with transverse pattern) and 5 5% involvement of the triradiate cartilage.

Clinic and associated injuries

In relation to the clinical presentation, the findings were pain on palpation of the pelvic bony prominences (75.8%), ecchymosis (25.3%) and excoriations (23.1%). Soft tissue avulsion without bone exposure was present in 17.6%, while open fractures to the skin (1.1%), or to the rectum and / or vagina (3.3%) and Morel Lavallé type injuries (1.1%) were infrequent.
A total of 29 patients (31.9%) were admitted to the institution with clinical signs of shock, a similar percentage required transfusion of blood products (34.1%) at some point during their hospital stay.
Regarding the associated injuries, the orthopedic ones were in 38.5%, the most frequent: fractures of the distal humerus (13.2%), and diaphyseal (8.8%), forearm (8.8%) and hip (7.7%). More unusual were the tibia with 6.6%, spine (6.6%), foot and clavicle (each with 2.2%).
Associated non-orthopedic injuries occurred in 65.9%. Of these, the most frequent were blunt abdominal trauma (34.1%) and head injury (30.8%), followed by chest injuries (27.5%). Despite the fact that head injury was registered in a significant proportion, only 7 of the 28 were classified as severe. Only one case with associated vascular injury was recorded, it was a 15-year-old patient with type IV Torode-Zieg fracture, bleeding with hemodynamic instability, required external fixation, angioembolization and diagnosis of external iliac arterial thrombosis requiring endovascular management for thrombectomy.
30.8% (28 patients) presented evidence of pelvic or retroperitoneal bleeding by simple tomography. 15 of those 28 (53.5%) presented clinical signs of shock upon admission (compared to 31.9% of the total) and 92.8% were classified by Torode as III, 2 as Torode II, none as type I).

Mortality

Two deaths were recorded (2.2%), both patients with closed triradiate cartilage (signs of skeletal maturity), pelvic fractures classified as Torode-Zieg IV, neither of them attributable to the pelvic injury alone, the cause of death. in both it was a TEC tomb.

Treatment

Regarding acute management, 86.8% of the patients did not require immediate interventions in order to control pelvic bleeding, only 3.3% required emergency external fixation, 3.3% angioembolization, and 1.1% pelvic packing. Definitive treatment was mostly conservative with

rest, protected support and analgesia in 85.7%. In total 13 patients were taken to surgical stabilization, 84.6% underwent internal fixation and 15.3% external, 10 of these 13 patients were performed from 2017 onwards.
The average number of orthopedic surgeries per patient was 0.72 (most for causes other than the pelvis) and 0.57 for non-orthopedic surgeries. A total of 31 patients required transfusion of blood products at some point during their in hospital stay, in 11 of them (35.4%) the need was attributed to pelvic bleeding, with no other potential bleeding sites to explain the decrease in hemoglobin.

Discussion

Trauma is the leading cause of death in children aged 5-14 years in many countries around the world (1,2). Pelvic injuries in the pediatric population are infrequent (3,6,7), variable percentages between 0.3% and 4% of all fractures in children are reported (4,5,7), however they are considered a strong indicator of a high-energy mechanism. There are important structural differences with the adult population, therefore severe bleeding secondary to pelvic trauma is not common and does not seem to contribute significantly to mortality in these patients (8-10).
There are few reports of pelvic fractures in children, from our knowledge to date this is the first to characterize this population in Colombia and the study with the largest number of patients in Latin America.
In relation to demographic characteristics, we found a greater involvement of the male gender with a 1.6: 1 ratio, very similar to that reported by Gansslen of 1.4: 1 (1,11). The mean age of 9.9 years is in agreement with the 9.4 years reported by Smith et al (3) in one of the published studies with a larger population sample in this context.
Regarding the mechanism of trauma, we found that 63.8% was due to a traffic accident with a higher incidence of trauma as a pedestrian (44% pedestrian, 19.8% driver or occupant) as opposed to trauma in adults where it is more frequent as driver or occupant (9,13,27).
In initial descriptions published in 1966 (12) a mortality rate of 25% was reported, however these figures have been gradually decreasing and the most recent publications report percentages ranging between 2% and 25% (5,10,13,14) with an average of 6.4% (1). In this study it was 2.2%, a percentage slightly lower than that registered in the most representative series of recent literature (5.6% - 6.4%) (15,16). The causes are attributable to injuries especially associated with severe head injury (17), similar to that found in other publications (15,16).
The most frequent clinical finding is pain on palpation with 75.8% and ecchymosis or excoriations with 48.4%. 6 of the 8 patients with clinical ring instability on admission were classified as Torode IV, the remaining two Torode IIIA and IIIB. For this reason, in the presence of clinical findings suggestive of an unstable pelvic injury, CT may be useful to characterize complex pelvic fractures and rule out associated injuries.
Classically, it has been considered that in contrast to adults, children have a higher proportion of single bone fractures (9,18,19). In this study, a different distribution was found with a proportion of fractures in two or more segments of the pelvic ring (Torode-Zieg IIIB and IV) of 35.2%. Most of the patients were classified as grade III (61.6%), followed by type IV, type II, and a minority of patients classified as type I (Figure 2). The findings are consistent with the descriptions of some of the most representative series in the literature, such as that by Silber et al (20) and Shaath et al (21) who recorded 63.2% and 67% of type III fractures, respectively. This predominant distribution of high-energy injuries may be explained by a population sample obtained from a center with a high level of complexity and possibly in relation to the most common trauma mechanism (traffic accidents).
The Torode and Zieg classification (14) has shown to have an important prognostic value, especially due to the presence of concomitant injuries rather than the prediction of the prognosis

of pelvic injury as such (Figure 1) (14,22). There are certain descriptive weaknesses of this classification that were evident in this study: the radiological characteristics of grade I and II lesions are clear and reproducible, however the Torode-Zieg III include a large number of patterns that can range from a branch fracture pubic to potentially unstable anterior and posterior ring lesions. This results in a general and nonspecific categorization that ultimately translates into important therapeutic, functional and prognostic differences in the same group of patients. The lack of specification of radiological criteria for the subclassifications can lead to erroneous categorizations that reduce their predictive value in making therapeutic decisions. It is for this reason that more recent studies (3,13,16,21) have made modifications to the classification of those patterns that are not clearly grouped (associated acetabular fractures, bilateral anterior ring fractures, among others) or used systems of extrapolated classification of pelvic fractures in adults such as Tile's. Furthermore, since it is a classification proposed since 1985, it has presented inconsistencies with the advent of more advanced imaging aids with higher resolution like CT, for this reason there may be an under-registration, especially of type I lesions (17). Regarding the radiological diagnosis, it was found that 46.2% of the fractures were not visualized in the plain radiography, it is for this reason that some authors recommend the systematic performance of tomography (23) due to the low sensitivity (54%) of the radiography in the initial diagnosis of pelvic injuries in the pediatric population. Despite these observations, there are no solid recommendations in this regard; however, in patients with high-energy trauma and clinical suspicion of pelvic ring involvement, the request for a simple CT scan may be reasonable in order to confirm or characterize a pelvic fracture, how to evaluate compromise of pelvic and / or intra-abdominal structures.

Associated injuries largely dictate the prognosis of these patients. Chia et al (18) described a proportion of 78%. The most frequent was head injury (44%), lower limb fractures (42%), chest injuries (27%), abdominal and urogenital injuries each with 17%.

Shaath et al (21) performed an analysis of pelvic fractures in patients with immature skeleton versus closed triradiate cartilage, finding concomitant musculoskeletal injuries in 43% and 73%, respectively. They evidenced a thoracic compromise between 87% and 88%, abdominal between 25% and 47% and head injury in 44% in both groups.

In this research, similar figures were found in relation to blunt abdominal trauma (34.1%), however, lower values of head injury (30.8%), concurrent musculoskeletal involvement (38.5%) and even more were observed. low number of closed chest injuries (27.5%). These variations could be related to differences in the mechanism of trauma, since in Shaath's study (21) the majority were traffic accidents as occupants of motor vehicles and there may be variations in the definition of trauma to the abdomen and / or chest in the study concepts.

Previous series report percentages of pelvic and / or retroperitoneal bleeding variables between 9% and 46% (1,10). We found tomographic evidence of bleeding in 30.8% (28 patients) of the patients, however there may be an underreporting both in our series and in the rest of the series since not all of them were subjected to advanced imaging techniques and most of the The analyzes in this study were performed on simple tomography whose sensitivity may be lower compared to contrasted and / or angiographic techniques (24). Only 5 of these 28 required an invasive procedure to control pelvic bleeding (1 for external fixation, 1 packing, 1 angioembolization, and 2 external fixation and angioembolization). This can be explained by the physiological and structural differences that allow better control and containment of bleeding, such as: thicker periosteum that prevents greater bone displacement and the intense vasoconstrictor phenomenon typical of this age group (5,17,25,26).

Surprisingly, the lower hemoglobin values did not appear in patients with signs of shock upon admission or in those with a fatal outcome; it is possible that the follow-up and the magnitude of the fall in hemoglobin represent a more important prognostic factor in the outcome a short term.

Regarding the definitive treatment, 85.7% of patients in our series had conservative management with load restriction and analgesic management, values similar to the international

literature where the percentages are between 77.5% and 94% (5,16,18,26). Pelvic ring displacements greater than 2 centimeters, acetabular involvement and / or triradiate cartilage with articular gaps of 2 millimeters or more have been described as reference points for considering surgical management.
Smith et al. (3) in a long-term study looked for functional outcomes (length discrepancy, limping and sacroiliac pain), for this reason they propose surgical management with ring asymmetries greater than 1.1 cm to look for more anatomical reductions, especially in those lesions with mechanical instability (Torode IV).
Of the 11 patients who underwent internal fixation, 9 of them were performed from 2017 to 2020, reflecting the gradual changes in surgical indications, with a trend towards stricter cut-off points in the pediatric population. The majority of those who underwent surgery (11 of 13) underwent internal fixation.
We find important limitations. The first is the retrospective nature of the study coupled with the impossibility of carrying out a follow-up that allows measuring clinical outcomes and being able to lay a more solid basis with respect to therapeutic indications. Being a study carried out in a high complexity trauma center, a large proportion of cases were referred from primary care sites (70.3%), which can generate biases, especially in assessing hemodynamic status and signs of shock upon admission since most of the patients were initially stabilized in other healthcare centers.

Conclusions
Pelvic fractures in the pediatric population are an infrequent scenario, it is considered an indicator of high energy trauma. The mortality rate is low and is more associated with concomitant injuries than with involvement of the pelvis. The Torode and Zieg classification presents important weaknesses in the categorization of patients, which suggests the necessity of refining certain aspects to increase predictive power, especially regarding therapeutic decisions.
The results of this research describe the clinical and radiological behavior of pediatric pelvic trauma at the local level, we trust that this study will be the first step to understand and optimize the management of this type of injury in our population and may be the starting point for other studies that could lay the foundations to install care protocols and suggests the association of certain variables with high-energy traumas that require a differential clinical and therapeutic approach.

Conflicts of interest:
None of the authors declare conflicts of interest.

Financing:
None of the authors declares specific financing during the study of public and / or private sectors.

Ethics:
The implementation and execution of the project was carried out with a previous endorsement by the research ethics committee of the Hospital Universitario San Vicente Fundación (act No. 28-2020)

Bibliography
1. Gänsslen A, Heidari N, Weinberg AM. Fractures of the pelvis in children: a review of the literature. Eur J Orthop Surg Traumatol. 2013 Dec;23(8):847–61.
2. Snyder CL, Jain VN, Saltzman DA, Strate RG, Perry JF, Leonard AS. Blunt trauma in adults and children: a comparative analysis. J Trauma. 1990 Oct;30(10):1239–45.
3. Smith W, Shurnas P, Morgan S, Agudelo J, Luszko G, Knox EC, et al. Clinical outcomes

of unstable pelvic fractures in skeletally immature patients. J Bone Joint Surg Am. 2005 Nov;87(11):2423–31.
4. Galano GJ, Vitale MA, Kessler MW, Hyman JE, Vitale MG. The most frequent traumatic orthopaedic injuries from a national pediatric inpatient population. Vol. 25, Journal of Pediatric Orthopaedics. 2005. p. 39–44.
5. Grisoni N, Connor S, Marsh E, Thompson GH, Cooperman DR, Blakemore LC. Pelvic fractures in pediatric Level I trauma center. J Orthop Trauma. 2002 Aug;16(7):458–63.
6. Schwarz N, Posch E, Mayr J, Fischmeister FM, Schwarz AF, Öhner T. Long-term results of unstable pelvic ring fractures in children. Injury. 1998 Jul;29(6):431–3.
7. Hargitai E, Szita J, Dóczi J, Renner A. Unstable pelvic fractures in children. Acta Chir Hung. 1998;37(1–2):77–83.
8. Demetriades D, Karaiskakis M, Velmahos GC, Alo K, Murray J, Chan L. Pelvic fractures in pediatric and adult trauma patients: Are they different injuries? J Trauma. 2003 Jun;54(6):1146–51.
9. Ismail N, Bellemare JF, Mollitt DL, DiScala C, Koeppel B, Tepas JJ. Death from pelvic fracture: Children are different. In: Journal of Pediatric Surgery. W.B. Saunders; 1996. p. 82–5.
10. Banerjee S, Barry MJ, Paterson JMH. Paediatric pelvic fractures: 10 years experience in a trauma centre. Injury. 2009 Apr;40(4):410–3.
11. Meyer-Junghänel L, Gänsslen A, Pohlemann T, Tscherne H. Behandlungsergebnisse nach komplexem Beckentrauma bei Kindern. Unfallchirurg. 1997;100(3):225–33.
12. Quinby WC. Fractures of the pelvis and associated injuries in children. J Pediatr Surg. 1966;1(4):353–64.
13. Silber JS, Flynn JM. Changing patterns of pediatric pelvic fractures with skeletal maturation: implications for classification and management. J Pediatr Orthop. 2002 Jan-Feb;22(1):22–6.
14. Torode I, Zieg D. Pelvic fractures in children. J Pediatr Orthop. 1985;5(1):76–84.
15. Vitale MG, Kessler MW, Choe JC, Hwang MW, Tolo VT, Skaggs DL. Pelvic Fractures in Children. J Pediatr Orthop. 2005 Sep 1;25(5):581–7.
16. Zwingmann J, Aghayev E, Südkamp NP, Neumann M, Bode G, Stuby F, et al. Pelvic Fractures in Children Results from the German Pelvic Trauma Registry: A Cohort Study. Medicine (Baltimore). 2015 Dec;94(51):e2325.
17. Holden CP, Holman J, Herman MJ. Pediatric pelvic fractures. J Am Acad Orthop Surg. 2007 Mar;15(3):172–7.
18. Chia JPY, Holland AJA, Little D, Cass DT. Pelvic fractures and associated injuries in children. J Trauma. 2004 Jan;56(1):83–8.
19. Junkins EP, Nelson DS, Carroll KL, Hansen K, Furnival RA. A prospective evaluation of the clinical presentation of pediatric pelvic fractures. J Trauma. 2001 Jul;51(1):64–8.
20. Silber JS, Flynn JM, Koffler KM, Dormans JP, Drummond DS. Analysis of the cause, classification, and associated injuries of 166 consecutive pediatric pelvic fractures. J Pediatr Orthop. 2001;21(4):446–50.
21. Shaath MK, Koury KL, Gibson PD, Adams MR, Sirkin MS, Reilly MC. Associated Injuries in Skeletally Immature Children with Pelvic Fractures. J Emerg Med. 2016 Sep 1;51(3):246–51.
22. Shore BJ, Palmer CS, Bevin C, Johnson MB, Torode IP. Pediatric pelvic fracture: a modification of a preexisting classification. J Pediatr Orthop. 2012 Mar;32(2):162–8.
23. Guillamondegui OD, Mahboubi S, Stafford PW, Nance ML. The utility of the pelvic radiograph in the assessment of pediatric pelvic fractures. J Trauma. 2003 Aug;55(2):236–9; discussion 239-40.
24. Do AS, Childs BR, Gael S, Vallier HA. Contrast blush on CT is a poor predictor of active bleeding on pelvic angiography. OTA Int Open Access J Orthop Trauma. 2018

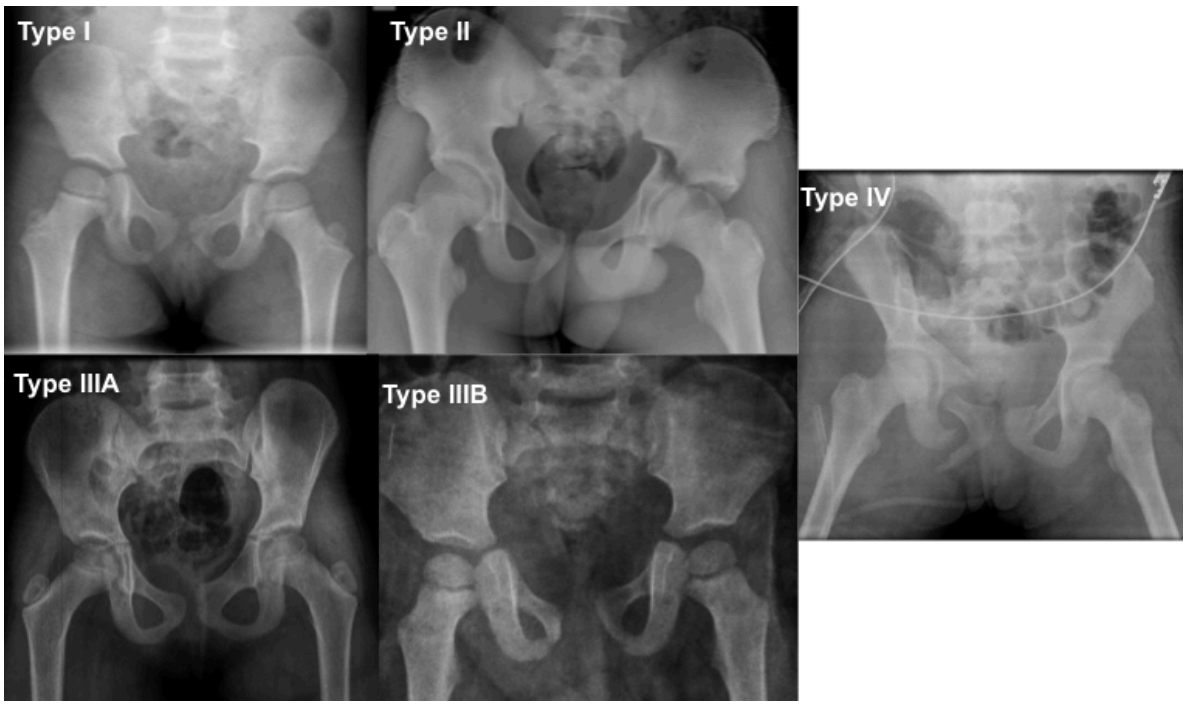
Dec;1(3):e009.
25. Karunakar MA, Goulet JA, Mueller KL, Bedi A, Le TT. Operative treatment of unstable pediatric pelvis and acetabular fractures. J Pediatr Orthop. 2005 Jan;25(1):34–8.
26. Amorosa LF, Kloen P, Helfet DL. High-energy pediatric pelvic and acetabular fractures. Orthop Clin North Am. 2014 Oct 1;45(4):483–500.

Apendix

Table 1: Sociodemographic and clinical variables

Variables	
Demographic	
Average age (years)	9.96 (8.98 - 10.93)
Gender (male/female)	59/32
Mechanism of trauma (%)	
Traffic accident as a pedestrian	44%
Fall from heigth	23,1%
Driver or occupant accident	19,8%
Sports trauma	3,3%
Others	6,6%
Clinics	
Systolic blood pressure on admission in mmHg (media)	108.63 (104.65 - 112.6)
Clinical sings of shock on admission (%)	31,9%
Mortality (%)	2,2%
Associated injuries (%)	
Blunt abdominal trauma	34,1%
Head injury	30,8%
Chest injuries	27,5%
Genitourinary trauma	15,4%
Maxillofacial trauma	7,7%
Peripheral vascular lesion	1,1%
Hospital stay in days (mean)	12.47 (7.7 - 17.17)
Stay in ICU/SCU in days (mean)	4.81 (0.59 - 9.02)
No. of orthopedic surgeries required per patient (mean)	0.72 (0.48 - 0.96)
No. of non-orthopedic surgeries required per patient (mean)	0.57 (0.26 - 0.88)

Figure 1. Modification of the Torode and Zieg classification made by Shore et al. (22)



Type I Avulsive fracture of the (iliopubic branch), **Type II** Fractures that involve the ilium (Separation of the iliac process with extension to the acetabulum), **Type IIIA** Simple fractures of the annulus that involve the anterior part (fracture of the branch and disruption of the symphysis pubis), **Type IIIB** Fractures that compromise the posterior part of the annulus but remain stable (disruption of the symphysis and opening of the sacroiliac) **Type IV** Unstable disruption of the annulus (fracture of the right and left ilium and ischioubic branches with posterior component and displacement vertical).

Figure 2: Percentage distribution of fracture patterns according to the Torode and Zieg classification modified by Shore et al (14).