Review Article

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Pediatric Pelvis Fracture

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Abstract

Pediatric pelvis fractures are less commonly seen after injuries in pediatric age group. These should be specifically sought for in pediatric poly-trauma and stabilized as an emergency. Clinical diagnosis should be made and patient investigated after hemodynamic stability is achieved. Torode and Zeig is the most widely accepted classification and has its value in planning management of the patient. Recent trend is towards aggressive management of these injuries to minimize mortality and morbidity associated with these fractures. This review on pediatric pelvic injuries elaborates the major differences with adult pelvis and their management with recent trends to understand the injury pattern in this age group and complications associated.

Introduction

Pediatric pelvic fractures are rare. Their incidence has been estimated between 2.4-7.5% of all children fractures. Pediatric pelvic fractures account for only 1% to 2% of fractures seen by orthopedic surgeons who treat children [1]. They roughly account for 1% of total hospital admissions. The acetabular fractures are still more infrequent, but whenever they are associated, they are life threatening [2]. Of pediatric patients with pelvic trauma, acetabular fractures account for 1-15% of cases and resultant premature closure of the tri-radiate cartilage having an overall incidence of less than 5% [3].

Basic Anatomy and Development

The basic structure of pediatric pelvis comprises of three bones which develop from 3 primary ossification centers, viz., Ilium, ischium and pubis which appear at 9th, 16th and 20th weeks respectively. There is endochonral ossification similar to what happens in all long bones [4]. The three distinct physes of each bone that makes up the tri-radiate cartilage allow for hemispheric growth of both the acetabulum and pelvis. These three ossification centers meet and fuse at the tri-radiate cartilage at age 13-16 years. Tri-radiate cartilage separates the ilium, the ischium and the pubis [3]. Subsequently three major secondary ossification centers appear in the hyaline cartilage of the acetabulum: (a) Osacetabula forms most of the anterior wall acetabulum of which acetabular epiphysis forms mostly the superior portion, (b) Posterior acetabular wall is formed by the secondary ossification center of ischium which is first seen at 15 to 17 years of age and fuses at age 19 to 25 years, (c) Pubis bone ossification centers appear at age 8 to 9 years and fuse around 17-18 years of age [5]. Other secondary ossification centers of the pelvis are: Iliac crest which is first seen at age 13 to 15 years and fuses by 15 to 17 years, Anterior superior iliac spine which is first seen at about 14 years and fuses at 16 years of age, Ischial apophysis, Anterior inferior iliac spine, Pubic tubercle, Angle of the pubis, Ischial spine and Lateral wing of the sacrum.

It is important to have knowledge of these secondary ossification centers so that they are not confused with avulsion fractures

Development of the Acetabulum

Interstitial growth within the horizontal flange of the tri-radiate cartilage contributes to the normal growth of the distal third of ilium. Enlargement of the acetabulum during growth is likely the result of this interstitial growth within the tri-radiate cartilage

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[5]. Appositional growth of the periphery of this cartilage and periosteal new bone formation at the acetabular margin contributes in creating depth of the acetabulum. Development of concavity as a response to pressure from the femoral head probably might be the reason for an ill developed acetabulum in developmental dysplasia of hip.

Fundamental differences between pediatric and adult pelvis

There are some fundamental but major differences in bony pelvis of adults and children which is responsible for basic difference in response to trauma, associated morbidity, healing potential, any intervention required and differences in long term outcome. In pediatric age group:

1. Bones are more malleable
2. Cartilage is capable of absorbing more energy
3. Sacroiliac joint and pubic symphyses are more elastic which allows for significant displacement of the joint before fracture occurs. This peculiarity allows for single break in the pelvic ring.
4. Thick periosteum, which in apparent dislocations may form a periosteal tube that has the ability to heal like a fracture [6].

Injury to tri-radiate cartilage can cause growth arrest that may lead to significant deformity [6]. Premature closure of tri-radiate cartilage can result in any of the following sequelae: progressive acetabular dysplasia, thickness of medial acetabular wall, shallow acetabulum and subluxation or a hypoplastic hemi-pelvis. Bucholz et al in their study reported 56% (5/9) rate of growth disturbance in injuries involving the tri-radiate cartilage [7]. In a study by Silber et al on patients of pelvis fracture (both pediatric and adult), he concluded that immature group (with open tri-radiate cartilage) had a higher propensity for isolated pubic rami and iliac wing fractures whereas the mature group (with closed tri-radiate cartilage) had a higher predilection for acetabular fractures and pubic or sacroiliac diastasis. All the patients requiring open reduction and internal fixation had a mature pelvis [8]. The immature pelvis of children is different from the adult pelvis by exhibiting the tri-radiate and Risser's growth nuclei [9]. The tri-radiate physeal cartilage and the sacroiliac joint are well known frail points of the children's pelvis [9-12]. Injuries of growth nuclei before 6–8 years of age have a greater potential for developing skeletal deformities [9-12].

Mechanism of Injury

Paediatric pelvis fractures (PPF) are usually as a result of high velocity injuries. The most common cause of pelvis injury in paediatric age group is road traffic accident, commonest being a pedestrian hit by the car producing a predominantly stable type of injury in skeletally immature pelvis [13-14]. This fact is also supported by the study of Catherine et al in which they concluded that ninety-eight per cent of pelvic fractures were the result of a motor vehicle accident, which included 61% auto-pedestrian accidents [15]. Mosheiffl et al in their series of open pelvic fractures concluded that 93% of the children were involved in auto-pedestrian collisions out of which 40% were the result of heavy motor traffic crush injuries (i.e. tractor, bus etc.,). They emphasized the uniqueness of paediatric open pelvic fractures, which are, in most cases, the result of a direct high energy mechanism, with severe damage to the pelvis and the surrounding area, and less damage to remote organs [16].

History and Associated injuries

Pelvic ring and acetabular fractures usually involve high energy injuries. Associated injuries should be particularly looked in for as they are responsible for the major mortalities in pediatric age group rather than the pelvis fracture itself. Commonest associated injury was long bone fracture followed by head injury [13]. Other injuries may be an associated urologic injury (bladder rupture), vascular injury (less frequent than in adults, rarely life threatening), or a neurological injury.

Physical Examination

After routine evaluation as per basic ATLS protocol and orthopedic examination of extremities and spine, one should move to a systematic approach to pelvis.

Clinical Examination

In inspection one should focus on areas of contusion, abrasion, laceration, ecchymosis, or hematoma, especially in the perineal and pelvic areas, to rule out open fractures in perineum/genital/rectal areas. Palpate for basic bony landmarks. viz., anterior superior iliac spines, sacroiliac joints, crest of ilium, symphysis pubis followed by provocative tests (compress the pelvic ring with anterior-posterior and lateral compression stress) to rule out pelvic ring injuries. The range of

motion of the extremities, especially of hip joint, should be analyzed if the pain permits. Neurologic and vascular exam of the lower extremities needs special attention and documentation

Investigation

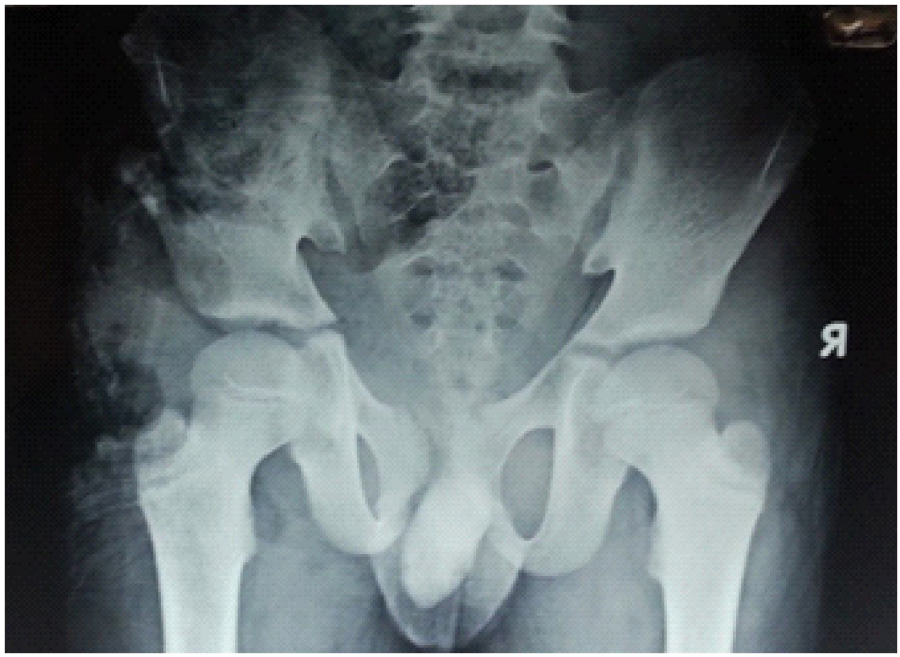
After completing the clinical assessment and ensuring hemodynamic stability one has to get the patient thoroughly investigated to confirm the diagnosis as well as to plan further management. Apart from routine hematological investigations radiographs are the most common and important investigation to be performed. The recommended X-ray views in assessing pelvis are: AP, Judet (to evaluate the acetabulum), Inlets / outlet (to evaluate the pelvic ring) views. Plain radiographs will miss ~50% of all pediatric pelvic fractures. Computed tomography (CT) is considered to be the most effective method of evaluating the full extent of pelvic injury [1]. It is indicated when one is having a strong suspicion of pelvis injury with negative plain radiographs and in preoperative evaluation. MRI is occasionally required to detect apophyseal avulsion injuries. These apophyseal injuries are usually easily detected and adequately imaged with plain radiographs. Cystography / urography is required and indicated if there is blood at urethral meatus following trauma or on bladder catheterization.

Classification of Pelvic Injuries in Children

Torode and Zieg modification of Watts Classification [14]

- Type I: Avulsion fractures,
- Type II: Iliac wing fractures,
- Type III: Stable pelvic ring injuries (Figure 1),
- Type IV: Fracture pattern creating a free bony fragment (unstable pelvic ring injuries).

Fig. 1: Torode and Zeig type III paediatric pelvis fracture



B. Tile Classification

- Type A: Stable Injuries (rotationally and vertically)
- Type B: Vertically stable but rotationally unstable injuries
- Type C: Both vertically and rotationally unstable fractures

Tile's classification [17] is applicable in patients near skeletal maturity and who show more often adult type fracture patterns. Benjamin [18] modified the original Torode and Zeig classification for PPF and subdivided type III stable fracture into sub type III A and III B. Subtype III A were fractures involving only the anterior pelvic ring whereas III B fractures involved both the anterior and posterior pelvic ring. The modified Torode PPF classification [18] is predictive for significant morbidity and death in the setting of poly-trauma. The stable type III-B fractures are indicative of increased blood product use, the

intensive care unit requirement, and total hospital stay. This modified classification scheme will benefit the health care providers at all levels in managing PPF more efficiently during their initial resuscitation and treatment period.

Lane-O'Kelly et al [19] in their study had a striking observation that two-thirds of all patients studied had type A2 fractures - stable minimally displaced fractures of the pelvic ring. The major difference noted is the lack of severe comminution in the childhood fractures, perhaps due to the relative elasticity of paediatric bone.

Treatment

Although pelvic fractures are an uncommon injury in paediatric trauma patients, the morbidity associated with these injuries can be profound. Majority of pelvic fractures in children are treated non-operatively, although, more than one-half of these patients have concomitant injuries requiring operative management. Whenever evaluating and treating paediatric pelvic fractures, a systematic multidisciplinary approach must be taken to evaluate and prioritize the pelvic fracture and associated injuries [21]. Treatment of pediatric pelvis fractures is somewhat different from adult patients, owing to their difference in characteristic as mentioned previously. Emphasizing on the pediatric pelvis, Holden et al concluded that children can tolerate bedrest / traction / immobilization better than adults and by virtue of the periosteal healing potential in children we may be able to treat pubic symphyseal and saccro iliac disruptions conservatively. They also advised to spare the growth plates when possible (if surgical intervention becomes necessary), and use temporary (4-6 weeks) fixation across physes with smooth pins and early hardware removal [22].

Treatment Caveats

One should treat older children and adolescents with pelvic injuries like adults. In general, pelvic injuries where posterior ring disruptions are displaced or unstable need operative treatment for reduction and stabilization. Sometimes isolated anterior ring fractures may also need stabilization which is achieved by using external fixation for a shorter period of time [1].

Most pelvic injuries in children can be treated conservatively without surgical intervention with protected weight bearing and gradual return to activity. Open reduction and internal fixation is required for acetabular fractures with >2 mm of fracture displacement and for any intra-articular or tri-radiate cartilage fracture displacement >2 mm [22].

Type I: Pelvic Avulsion Fracture

Weakness of cartilage is responsible for causing avulsion fractures more often in children and adolescents through an apophysis and causes fractures of the acetabulum into the tri-radiate cartilage with less energy than adult acetabular fractures. Avulsion is caused by forceful contraction at sites of muscle attachments through apophyses [23], occurring most commonly at ischial tuberosity (54%) due to pull of hamstrings followed by AIIS (22%) due to pull of rectus femoris, ASIS (19%) due to pull of Sartorius and less commonly at pubic symphysis (3%) and iliac wing (1%) caused by pull of tensor fascia lata. Most of the avulsion fractures (type I) or Tiles type A fractures can be managed with restricted or no weight bearing [22].

Type II and III

Most of these injuries or Tiles type B fracture can well be managed by conservative means unless there is a gross instability [22]. Niedzielski et al [20] in their study on pelvic fractures in children and adolescents in accordance with Torode and Zieg classification concluded that type I to III pelvic fractures in children do not usually require surgical treatment whereas type IV unstable fractures require operative treatment in order to avoid complications and aid faster recovery.

Type IV

Most of these injuries or Tiles type C fracture need surgical intervention for stabilizing pelvis [22]. Karunakar et al in their study on management of unstable pediatric pelvic fractures treated all of them operatively without any complications and good fracture healing and there after concluded that encouraging clinical results can be achieved with a low incidence of complications in such fractures [24]. Nieto et al in their study on management of unstable pediatric pelvic fractures concluded that unstable pelvic fractures are managed surgically. The mechanism of injury observed in these patients was not lateral compression, as the literature states, but rather a combined mechanism [25]. Oransky et al in their study on unstable pelvis fractures showing long term results concluded that Risser's nuclei lesion explains the hemi pelvis undergrowth, though it

doesn't explains the pathogenesis of sacro-iliac joint fusion. They also emphasized on the surgical treatment in displaced vertical fracture in children with anatomical reduction as it is in adults to minimise the risk of long term functional impairment. Implants should be removed in all patients between three and four months after surgery to prevent growth arrest [26].

Rehabilitation

Short-term function appears to be significantly impaired in a high percentage of children with stable and unstable pelvic fractures. Therefore, the aggressive rehabilitation should be instituted early in all children with pelvic fractures to achieve optimal functional outcomes [27].

Complications

Haemorrhage and mortality

Haemorrhage is one of the life threatening immediate complications which has to be managed as per ATLS protocol of managing shock along with some specific orthopaedic interventions in order to provide pelvis stability and minimize blood loss. According to Silber et al in their analytical study on paediatric pelvis fractures the reported mortality rate was 3.6%. When looked into the cause of mortality, haemorrhage in itself is rarely a cause of death and maximum mortality in such patients was due to head and / or visceral injury. Urethral injury was not seen as often as in adults. In their observation they concluded that anterior ring fractures were the most common type, dominated by pedestrian versus the motor vehicle trauma [28].

Children with paediatric pelvic fractures thus require careful evaluation for other body-area injuries, as these are most likely to be related to haemorrhage or mortality [29]. Ismail et al in their analysis on death occurring from podiatric pelvis injury conclude that children do not die of pelvic fracture-associated hemorrhagic as often as adults. On reviewing 722 pelvic fractures recorded in the NPTR the difference in occurrence of these fractures in paediatric and adult population is statistically significant. Haemorrhage is more often as a result of solid visceral injury rather than from pelvic vascular disruption [30]. Catherine et al in their study observed that head injury was the most common concomitant injury in paediatric population along with pelvis fracture. In contrast to adults, haemorrhage as a result of pelvic fracture was not a major contributing cause of death in their series of patients. All the eight deaths were secondary to severe closed head injury. Therefore other injuries should always be sought for in paediatric population having pelvis fracture in serious state [15]. The probability of abdominal injury in a physiological stable patient as reported by Bond et al was less than 1% for isolated pubic fractures, 15% for the iliac or sacral fractures, and 60% for multiple fractures of the pelvic ring [31]. Paediatric patients having any additional fracture along with fracture pelvis should be taken as an alarming sign and is a significant marker for head and abdominal injury. This constellation identifies patients who may benefit from early transfer to a regional paediatrics trauma centre.

Delayed Complications

The delayed or long-term complications are mostly associated with Tile's type: C fractures or Torode and Zeig type IV fractures of paediatric pelvis.

(a) *Orthopaedic Complications:* Low back pain, gait abnormality, sacroiliac ankylosis and symphyseal ossification are some common orthopaedic ailments presenting lately as a delayed complication in PPF.

(b) *Urologic Complications*: Urethral stricture and urinary incontinence. The anatomical intimate relationship of the bony pelvic ring with the bladder and urethra is such that they are predisposed to a higher risk of injury with reported injury rate of 5% to 10% [32-34]. Renate et al in their paper on management of paediatric urethral injuries, considering retrograde urethrography as the gold standard advocated supra-pubic cystostomy or urethral realignment if possible to ensure bladder drainage as the primary management followed by delayed secondary repair as primary repair is associated with high complication rates. Management should be with the aim to minimize remote damages such as urethrocutaneous fistulae, strictures, peri urethral diverticulae, incontinence and impotence [35]. Judith et al in their review on urethral injuries in paediatric pelvic fractures owing to its controversial management concluded that though being a rare injury it calls for an immediate diagnosis and urgent management. Most accepted protocol being immediate drainage of urine followed by delayed urethral repair [36].

(c) *Erectile dysfunction:* Sexual dysfunction following fracture pelvis is a matter of concern and its incidence is more common than we think of with

rates as high as 30% if specifically sought for. Even without severe urological injury, the damage to delicate vascular and nervous tissues supplying the genitalia can result in sexual dysfunction [37- 38]. In 3% of patients with sexual dysfunction, this will be the secondary to an episode of pelvic or perineal trauma [39]. Harwood et al in their review after analysing thirteen studies concluded that impotence is seen in about 42% of patients who have a urethral injury [40]. Bilateral pubic rami fractures were more commonly associated with impotence [41]. All the impotent men have a type 2 pelvis fracture and type 3 urethral injuries [42]. Erectile dysfunction after injury to the pelvis is due to a combination of neurogenic, corporal, vascular, and psychogenic injury [43-47].

(d) *Psychiatric Problems:* Changes in behavioural traits is a common feature seen in these patients as a prolonged bed rest is the part of treatment protocol which leads to dependency and thus psychiatric ailments in a good number. Mehmet et al analysed and assessed psychiatric outcomes in patients treated non-operatively for unstable pelvic fractures. In their study a total of 31 patients (out of 58) were diagnosed with 41 psychiatric illnesses, including dysthymic disorder, post-traumatic stress disorder, social phobia and major depression. From a holistic standpoint, urologic complications and long hospital stays are associated with serious psychological problems, and thus they should be considered during selection of treatment modality [48].

Conclusion

PPF are rare though important fractures which one cannot afford to miss. Associated injuries are responsible for major mortalities in this injury. A lot many complications are also associated with these fractures which may cause significant morbidity. Being different histologically although very similar structurally owing to its enormous remodeling ability its management differ from that in adults and the treatment needs to be individualized. The trend is towards shifting from conservative to surgical management in most fracture patterns as this has been shown to decrease long term complications and thus reducing morbidity with better functional outcomes. Ongoing studies are focused more on psychiatric ailments and sexual disturbances, especially impotence. Definitive protocol for final management and minimizing long term complications in these fractures is still sought for.

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