Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/14296
DOI URL: http://dx.doi.org/10.21474/IJAR01/14296

RESEARCH ARTICLE

PEDIATRIC PELVIC FRACTURES: AREVIEW ARTICLE AND A CASE REPORT

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Manuscript Info

Manuscript History
Received: 18 December 2021
Final Accepted: 20 January 2022
Published: February 2022

Key words:-
Pediatric, Pelvic Fracture, Management

Abstract

Introduction: Pediatric pelvic fractures are most commonly associated with high energy fractures, mostly due to motor vehicle accidents. Children poorly tolerate any significant blood loss, so, any child presents with a pelvic fracture must be investigated for multi-organ injury, or possible life -threatening retroperitoneal hemorrhage, with an increased potential for death.

Method: A literature search was conducted to included articles from 2001 till 2017on pediatric pelvic fracture, including stable and unstable fractures, acetabular, and sacroiliac joint injuries, and excluded adult population.

Results: Conservative management is the main treatment in hemodynamically stable patients, with good anatomical reduction, however, in a hemodynamically unstable patients, external fixator is the gold standard as a temporary management.This, most often is followed by open or closed reduction with internal fixation by screws only or plates and screws, which is consistent with achieving early stability, better union rates and hence early return to normal daily activities.

Introduction:-

Case Report:

A 7-year-old boy presented to the emergency room after being struck by a motorbike. Initial management was according to ATLS protocol. His Radiological investigations revealed multiple fractures including: an unstable pelvic ring fracture (Tile type C) (figure 1), in addition closedright femur and left tibia fractures.

His past medical history included: sickle cell disease, for which he had been admitted several times to the hospital for exchange transfusion and frequent seizures that have been controlled using Kepra.

On the day of admission, an external fixator was applied to his right femur and a short-leg cast was applied on the left leg. The pelvic fracture was stabilized using Iliac Schanz Screws and an anterior pelvic frame (figure2). To reduce the vertical migration of the left hemi-pelvis, a skeletal traction was also applied through the left distal femur. Despite wide displacement of anterio-pelvis at pubic symphysison x-ray, he was hemodynamically stable.

Four days after the accident, he underwent closed reduction of left sacro-iliac joint reduction and fixation achieved with a percutaneous 7 mm sacro-iliac screw into S1 body. The anterior pubic symphysealdisruption was reduced via Pfannenstiel incision and fixed with a mini-plate and 2.7 mm screws. His postoperative X-ray showed less than

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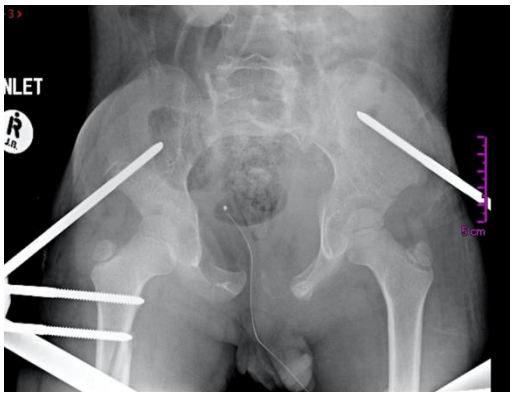
anatomicalbut an acceptable reduction and fixation of the pelvic ring (Picture 3).Unfortunately one of the two screws in the plate on right side was extra-osseous. The patient was referred back to his pediatric orthopaedic surgeon who decided to keep femoral fixator for definitive fixation. Three weeks later, the fixator was removed and a bilateral hip spica was applied for fractures to consolidate.

Picture 1:- Type C fracture (unstable pelvic fracture, with wide displacement).

On follow up, the patient had complete union of all his fractures. He had no pain or tenderness. He walked with a limp due to 1 cm shortening of his left lower limb. The study of pelvis showed some loss of reduction of the left hemi-pelvis resulting in shortening. In addition the head of the sacro-iliac screw snuck into the outer table of iliac bone.

Picture 2:- A.Outlet, B.Inlet views of anterior pelvic frame.

A. Outlet.



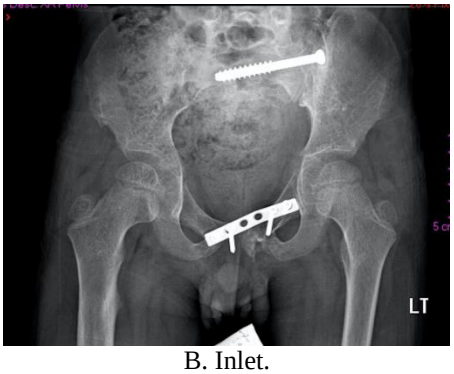
B. Inlet.

There were few challenges that were met during fixation.

1) The small size of the pelvic bones relative to the available fixation hardware.
2) Immature and soft pediatric pelvic bone.
3) Size 7 mm screw for scaro-iliac joint comparatively was large for small paediatric bones of a 7-year-old child, whereby the safe zone for screw placement is smaller as compared to the adult patients, however with carful advancement we were able to pass into S1 body. Tightening of the screw reduced the sacro-iliac space. This was done cautiously for fear of driving the screw head into the soft iliac bone. A screw washer was found to be too big to use. The size and shape mismatch came into effect on plating the symphysis pubis. Although a mini-plate was used, it seemed rather big for the pediatric pubic symphysis which was also too curved to accept a straight plate.

Picture 3:- A.Outlet, B.Inlet views showing post-operative X-rays after ORIF.

A. Outlet.



B. Inlet.

Comments:

Type C fracture pelvis in children is challenging in terms of management. Surgical management of this type is a valid option. Using an anterior pelvic frame with or without traction is not enough as it has no effect on the posterior element stabilizing the ring. Whenever possible, with use of anterior pelvic frame one should avoid the high (iliac) Schanz Screws in children for two reasons. First, Schanz Screws pass through the iliac apophysis and may damage it.Second, bone purchase in the pediatric iliac bone is very weak. The supra-acetabular placement provides a safer and a stronger alternative.

Extreme care in sacro-iliac screw insertion cannot be overstressed.One is only restricted to S1 as the bodyof S2 is very small to place a second screw. When force is required to reduce the sacro-iliac space, a washer can be used to avoid later loss of reduction due to screw head penetrating into the bone.

The anatomical features of pediatric pubic symphysis make fixation with regular plates very difficult. This is particularly true due to the paucity of pediatric anatomical plates for the very small size of bone in that area.

We believe that a supra-acetabular frame would be an excellent adjunct to posterior sacro-iliac screw fixation.

Introduction:

Fractures of the pelvis comprise, high energy and low energy fractures[1]. Pediatric pelvic fractures are most commonly associated with high-energy fractures, mostly due to motor vehicle accidents[2].

Pelvic fractures are relatively uncommon in children, it comprises between 2.4% to 7.5%.[7]Other study showed that it is less than 0.2 % of all pediatric fractures, with admissions rate reached up to 5 % in a level-one pediatric trauma centers.[3]

In high energy complex pelvic fractures, local soft tissue complication can be severe. This is probablydue to the nature of the elasticity in pediatric pelvic bones that makes the internal pelvic organsinsufficiently protected[2-7]. Hence any child that presents with a pelvic fracture must be investigated for multi-organ injuries[3], or possible life - threatening retroperitoneal hemorrhage, with an increased possibility of death[5]as the children poorly tolerate any significant blood loss.

Most of the low energy pediatric pelvic fractures heal with very low incidence of local or general complicationslike delayed union, pseudoarthrosis, or persistent ligamentous instability. This is not the case, however with severe and complex pelvic fractures. 31% of patients with these fractures, have a higher ratesof significant complications like; chronic low back pain, leg-length discrepancy, difficulty urinating, or malfunction of the anal sphincter.[7]

Aim:

The purpose of this study is toreview literatures onpediatric pelvic fractureswith emphasis on surgical management within this category of fractures.

Method:-

The literature search included articles from 2001 till 2017 in English language. The articles were selected utilizing the following electronic search engines: PubMed, Cochrane, and Google scholar by two investigators. “Pediatric” ,“pelvic”, “fracture”, “children”, “surgery”, “intervention“were the key words used to search for the related articles.

Selection process:

The initial search yielded 42 articles; every article was assessed independently by 2 authors.This review included articles aboutpediatric pelvic fracture, including stable and unstable fractures, acetabularfracturesand sacroiliac joint injuries.

The review excluded adult injuries. Gray literature defined as “protected by intellectual property rights”, of sufficient quality to be collected and preserved by library holdings or institutional repositories’[18]was not searched for during the selection of the articles.

By the end of the selection process, 14 articles were considered.

Data extraction:

The following data were reviewed and extracted: year of publication, research design, study population, method of diagnosis, fracture classification, type of management whether (conservative, or surgical)and the intervention outcomes (in the form ofregaining motor and sensory function, return to normal life activities, normal growth and thesymmetrical radiographic appearance).

Risk of bias assessment:

Qualitative studies were assessed for a clear description of eligibility, sample selection, and study sample (including number/size, age and gender)

Due to limited number of studies and low number of pediatric patients with pelvic fracture, there were some limitation in this literature review. No conflicts of interest wasdeclared in any of the articles reviewed.

Result:-

Junkins, et al, conducted a prospective study with an aim to evaluate the sensitivity and specificity of the physical examination for the diagnosis of pelvic fractures at The Primary Children's Medical Center over one year period. 140 patients were included (n= 124) (who did not have pelvic fracture) and patients with pelvic fracture (n=16). Glasgow Coma Scale (GCS) score, Revised Trauma Score, The Abbreviated Injury Scale (AIS) grade and the corresponding Injury Severity Score (ISS) were used to evaluate a concomitant injuries. Key and Conwell classification system[24]were used to analyze Pelvic fractures **(Table 1)**. Positive physical examination included pelvis tenderness, instability, ecchymosis, abrasions, or urethral bleeding. Eleven patients with pelvic fracture had abnormal physical examination (69% sensitivity; 95% confidence interval, 0.46-0.92) and 6 with no pelvic fracture patients had false-positive physical examination (95% specificity; 95% confidence interval, 0.92-0.98). Five patients (one type II, one type III, and two type IV) with pelvic injury had a false- negative pelvic examination, three had depressed level of consciousness, one had associated major orthopedic injury and one had had a clinically minor fracture of the ilium (type I). [18]

Melanie et al[19], studied the importance of pelvic screening radiograph for children after trauma. The study was conducted at the Starship Children's Hospital during 1997. ATLS protocols were used in all the patientsincludingpatients who had an unstable physiological state (Glasgow Coma Scale<12, evidence of shock, unstable airway, etc). Type and mechanism of injury werealso included in the criteria. 347 patient were included (129 female, 218 male), with an age range from 2 months to 15 years. 286 patient had a known mechanism of injury, 70% were involved in road traffic accidents and 29% were involved in falls. Patients underwent a series of radiographs included Cervical Spine, AP chest, AP pelvis. Despite the large number of patients who were involved in high energy trauma, only one (0.2%) patients had a pelvic fracture in the screening radiographs (a stable fracture of the left superior pubic ramus). The patient was 2 months old, ejected10meters from the car. Hematuria was noted during the admission. Patient was kept for observation over the next three days and discharged. [19]

Conservative and surgical management:

The goal of the surgical treatment is to provide stability of the pelvic ring with a good radiological and clinical outcomes. Achieving this good outcome depends upon anatomical reduction and stable internal fixation of both the anterior and posterior rings[4].

Table 1:- Key and Conwell classification system[24]

Type	Fracture Geometry
I	No break in pelvic ring
II	Single break in pelvic ring
III	Double break in pelvic ring
IV	Isolated fractures of the acetabulum
Multiple	Includes types III, II and IV, III and IV

Table 2:- Torode and Zeig classification[17].

Type I : Avulsion fractures
Type II: Iliac wing fractures
Type III:Stable pelvic ring injuries
Type IV: Any fracture pattern creating a free bony fragment (Unstable pelvic ring injuries)

Another retrospectively review conducted between 2002-2012, on patients diagnosed with pelvic fractures under the age of 16 years. 26 patient were included (16 boys and 10 girls), the fracture was classified according to Torode and Zeig[17]**(table 2)**. Average hospitalization time was 3.53-+ 3.52 days (1-17), one patient who had grade 4 pelvic injury and additional femoral and tibial fractureswas hospitalized for 17 days. Conservative treatment was considered for all types of patients.

Table 3:- Tile Classification[25-26]

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

One patient had a separation of the symphysis pubisfor which he was treated conservatively by a pelvic sheet. Type 2 and 3 fractures had the same management by bed rest for 3-6 weeks, followed by progressive load bearing with crutches. In type 3 injury, simple pelvic sheet was used.Skeletal traction was not used in these patients[11].

A retrospective review on pediatric patients with either a pelvic or acetabular fracture was done at the University of Michigan Medical between the years of 1993, and 2000. 148 patients under the age of 16 were included, only 20 patients with unstable injury were treated surgically and are included in this study.Two patients lost the follow-up.

According to the growth plates at the triradiate cartilage patients were divided into two groups: Mature (closed growth plates) and Immature (open growth plates). Six patients (four pelvic fractures and two acetabular fractures) were included in the immature group (3 males& 3 females), with an average age of 7 years and 7months, and an average follow-up for 31 months (range 19–77 months). Twelve patients (seven pelvic and five acetabular fractures) were included in the mature group (four boys and eight girls) with an average age of 14 years and 5 months, with an average follow-up of 22 months (range 3–75 months). During the follow-up, patients were assessed radiographically for anatomic or near anatomic reductions, fracture healing, pelvic asymmetry, and triradiatephyseal growth arrest. Patients were clinically assessed for gait abnormalities, limb length discrepancy, pelvic obliquity and hip range of motion. According to the author all patients had an excellent outcome with the operative management in which they regained normal gait activity, with no wound complications, noinfections, and no growth arrests of the triradiate cartilage or pelvic asymmetry. There were only two patients (one in both groups) who had leg length discrepancy with ipsilateral femoral shaft fracture and the other developed avascular necrosis and degenerative arthritis of the hip after an acetabular fracture with a hip dislocation. In this case the reduction of the dislocation was delayed for more than six hours[15].

InDellorusso (2012) review entitled (Pediatric Pelvis Fractures), to correlate the type of pelvic fractures with severity and associated soft tissue complications.Pediatric pelvic fractures are uncommon in childrencounting 1 to 2 % of all pelvic fractures. A retrospective review evaluated 200 multi-trauma patients. Mode of injury, type of fracture, associated lesions, and morbidity and mortality were assessed. The fractures are classified according to the Tile pelvic fractures classification[25-26]**(table 3)** and injury severity was classified according to the Modified Injury Severity Scale (MISS) and Pediatric Trauma Score (PTS).

Results of this review showed that in the pre-hospital stage at the site of the accident, the PTS was a very useful tool to assess injury severity of the patient in order to decide the initial treatment measures and to evaluate the degree of complexity of care the patient needed. The MISS showed to have good predictive value for injury assessment duringin-hospital stage and together, with the Tile classification is useful for the staging of associated injuriesand associated degree of morbidity.The greatest morbidity was found in patients with completely unstable pelvic fractures. Adequate treatment of this type of fractures allowminimizingsequelae in the growing skeleton. Correct orthopedic treatment is important in the majority of these lesions. Early stabilization with external fixation is the gold standard for the management of patients with fractures of the pelvic ring[20].

R. Pascarella, et al, conducted a review of patients between January 2000 to July 2011. It included 524 patients with pelvis and acetabular fractures, treated surgically. Only 8 patients were under the age of 16 years, four male and four female, with a mean age at injury of 12.1 years (range 8–16) years. Radiographic and CT scan were used for evaluation of the fractures. Mean hospitalization of the patients was 16. 8days (range 8–24days), three of them needed in intensive careunit. The review showed the physeal injuries (before the age of 6-8 years) , had high susceptibility to have future skeletal deformities and serious disabilities like scoliosis, pain and complications of the genitourinary system. This study showed that there is no difference in surgical treatment between adults and pediatric pelvic fracture unless the vertical displacement in the pelvic fracture is more than 2 cm. The authors recommend Pelvic stabilization with external fixator in hemodynamically unstable patients[8].

Baskinet al, conducted a prospective study from 2000 to 2003, included three children two girls and one boy, ages 8–14 years with a high-energy trauma withan unstable fracture-dislocations of the sacro-iliac (SI) joint. The authors stabilized the unstable fracture with minimally invasive surgery after closed reduction was achieved. A temporary reduction was used by anterior external fixator as a management.All patients underwent laboratory and radiographic studies and pelvic CT scan to assess the pathologicalanatomy of pelvic injury. Percutaneous fixation was carried on under CT control. The route for the screws was planned in such a way to avoid violating the sacral cortex, and to be the most perpendicular axis to the SI joint, avoiding neural foramina and other neurovascular structures. CT scan was done after the procedure to assess the location of the screws. As the authors expected, this procedure resulted in a stable reduction with minimal complications of blood loss, neurovascular injuries and wound complications . Long-term complication showed a chronic pelvic pain related to the injury, mild low-back pain with exertion and self-limited discomfort related to screw migration [13].

Gagné et al, reported on a 14-year-old girl with multiple fractures of the pelvic ring including a slightly displaced longitudinal fracture of the right iliac bone and an acetabular roof fracture.All fractures were visible using the skeletal radiographs and CT scan of the pelvis. The authors reduce these fracture with a minimally invasive approach . Closed reduction was performed under CT guidance and C-arm lateral fluoroscopy. The patient needed 3 screws, 2 screws were positioned in theiliac wing fracture and one screw fixing the acetabular roof fracture both via anterior approach. The surgery ended up with incomplete reduction of the iliac fracture, and a perfect reduction of the acetabular roof without involvement of the articular surfaces. There were no complication and no significant blood loss. Follow up one month later using a radiographic evaluation and showed satisfactory result with consolidation of the iliac and the acetabular roof fracturesand patient was slowly regainingnormal daily activities[14].

Abdelgawad, et al, conducted a retrospective reviewon eleven pediatric patients (six males, and five females) with an average age of 14 years, who sustained an unstable sacral fracture (four patients) or sacroiliac joint disruption (seven patients), and were treated by iliosacral (IS) screw fixation in the period from 2000 to 2012 at a level 1 trauma center.Posterior IS screw fixation by 1 screw wasused in six patients, whereas 2 screws for5 patients. Five patients needed further fixation of the anterior part of the pelvis by open reduction and internal fixation using plates and screws (three patients), external fixation (one patient) and internal external fixation, in (one patient). The average follow-up was 15.1 months, one patient was lost to follow-up. Nine patient had a good union of the fracture by radiologically. Two patients developed complications: 1 had early failure of fixation (initially treated with 2 SI screws), initial radiographs showed pelvic instability, she had a revision surgery. The other case had postoperative neurological deficit [23].

Kenawey conducted a retrospective study on pediatric patients with pelvic injury at a level I trauma center between 2010 and 2016. A total of 62 patients were identified. Of them, 29 patients (17 males and 12 females) had operative fixation of unstable pelvic ring injuries. Tile classification was used to identify the type of pelvic fracture. Six patients had fracture pelvis Tile's type B while 23 had Tile's type C injuries. Only Radiographical studies were used in pre, and post-operative assessment.

The Surgical fixation used for the anterior pelvic failure injury was anterior supra-acetabular external fixator in 21 patients. The other methods of anterior ring fixation were symphyseal plating, pelvic brim plating, or percutaneous acetabular columns screws. On the other side, posterior ring fixation,ilio-sacral (IS) screws method were used in 13 patients.Iliac wing screws were used in case of trans-iliac sacroiliac joint fracture/dislocation, followed by direct posterior iliac wing plating and ilio-iliac posterior bridge plating. Intraoperative complications were not seen except in patients with IS screws (IS screws pierced the iliac wing in our three patients despite the use of washers underneath the screw heads) or the retrograde LC screws (weak strength and stability). The author doesn't

recommend the use of retrograde LC screws in young children, but recommend the IS screws and prevent the complication of piercing the iliac wing by inserting the screw through the holes of a plate. For the anterior ring fixation, anterior supra-acetabular external fixator is considered a very good option with superior stability[22].

Outcome and mortality:
A retrospective study about pelvic fractures in children was conducted between 1992- 2004, at a Level One trauma center including 74 pediatric patients below the age of 16 years with pelvic fracture. All patients wereclassified according to the Injury Severity Score (ISS). ISS was 9 in 18% of patients, 9- 15 in 36%, and more than 24 in 15% of patients, 14% of the patients were hemodynamically unstable, 26% of patients needed blood transfusion. Central nervous system injuries were found in 27% of patient, and ICU admissions was 58 % of all patients. 13 patients with unstable pelvic fracture needed operative fixation of pelvic injuries, others were managed conservatively. 5 % mortality rate, with bleeding as the commonest cause, followed by associated severe headinjuries[9].

Tuovinen, et al, conducted a retrospective study in Finland between 1998 and 2007 included all pelvic ring and acetabular fractures of pediatric patients younger than 16 years old. There were 40 males and 31 females. The average age of the patients was 12.7 ± 3.6 years, with females being slightly older than males. Either X-ray or CT scan were used to classify the pelvic into mature or immature pelvis (immature if the tri-radiate cartilage was still open). 26 patients underwent open reductions and internal fixations (Immature= 6 -Mature = 20). Four patients (5.6%) had severe bleeding in the pelvic area, 3 of them stopped spontaneously without any intervention and one needed temporary external fixation combined with non-selective pelvic angio-embolization. Two patients died from head injuries (mortality 2.8%) [10].

Banerjee, et al, conducted a retrospective study between 1993 and 2003 on pediatric patients with pelvic fracture below the age of 16 years. Fourty four patients were included (28 boys and 16 girls), with a mean of 11.4 years. The patients were divided according to the stability of the pelvis using imaging studies.Open ring type pelvic fracture (unstable) or closed pelvic ring fracture (stable). Other trauma classifications systems were used as Glasgow coma scale (GCS), and Injury Severity Score (ISS). Four patients had unstable pelvic injury, three of them had (GCS of 15, ISS of 34–75), and one had (GCS of 3) later the patient died due to severe head trauma. 34 patients were treated conservatively (bed rest followed by progressive gradual mobilization). Only one patient needed an external fixator for his open book pelvic fracture. Overall mortality rate of 16% (low GCS=5, high ISS). Mean hospitalization= 22 days with 28% needed ICU admissions. Patients were followed for a mean of 24 months, and one case developed secondary osteoarthritis at the previous acetabular fracture[12].

In 2017, Hermans, et al, conducted a retrospective study on children <16 years, with pelvic fracture between 1 January 1993 and 31 December 2013. A total of 51 children were included in this study; 44 of them had anisolated pelvic ring fracture, and 7 had an associated acetabular fracture. The general condition of the patient status was measured using mechanism of injury, pre-hospital treatment, Glasgow Coma Scale (GCS), Injury Severity Score (ISS) and associated injuries. Pelvic fractures were classified according to Tile classification27 (table 3). Surgical management was indicated only when there was rotationally or vertically unstable pelvic fracture, or a fracture with severe displacement. Children with associated injuries included femoral fractures (24%), intracranial bleeding (24%), pneumothorax (16%) and urinary tract injuries (12%)

Children with type B fracture (3 children), type C fracture (8 children), were treated surgically (21%). An external fixator was used in 7 children, only 3 of these had a follow up surgery with internal fixation with a SI screw and plate. The remaining children underwent an immediate open reduction and internal fixation with plates and screws. Urethral injury, ruptured rectum, ruptured bladder and a retroperitoneal hematoma were found in those children as a complication of the injury. Mortality of children were related to the associated injuries and severe head injuries. 94% of the children recovered with a painless full range of motion in normal daily activities. Only one patients with type C fracture had an insignificant leg-length discrepancy of 1 cm[21].

Discussion:-

We reviewed the articles that are related to pediatric pelvic fractures in a systematic manner.

As evident from the articles, fractures of the pelvic ring and acetabulum in children are reported to be rare [10-19-20], with road traffic accidents as the major cause and number one factor [19].

During the assessment of the pediatric patients, pelvic tenderness is highly specific to pelvic fractures, but false-positive examination can be found in depressed level of consciousness (specificity 95%, sensitivity 69%). Pelvic tenderness can be an indication for pelvic radiographs, as only 0.2% of pediatric patients will have positive radiographical manifestation of pelvic fracture in all patients with high energy trauma [18-19].
Conservative management is the main treatment in a hemodynamically stable patients, with good anatomical reduction[11], but in a hemodynamically unstable patients, external fixator is the gold standard to provide stability as a temporary management [8-11-13-20].

This could be followed by open or closed reduction with internal fixation by screw only, or plate and screws construct, which are more consistent with early achievement of good union and regaining normal daily activities [13-14-22].

Local complications are not common in this age group, unless the growth plate is injured causing skeletal deformities and serious disabilities, scoliosis, pain and complications of the genitourinary system[8-15-23].

Mortality in this age group is not caused by the pelvic fracture directly, but head injuries and bleeding are considered the major cause of early death in pediatric patients [9-10-21.]

Conclusion:-

Pediatric pelvic fractures are rare. Conservative (non-operative) management is considered in hemodynamically stable patients. In hemodynamically un-stable patients early stabilization with external fixator followed by internal fixation is the optimal treatment.

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