Clinical analysis of 60 children with pelvic fracture and associated injuries: an observational study

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BACKGROUND: *The injury mechanism of a pelvic fracture is primarily high-energy injury, and it is easily combined with injuries to other tissues and organs. This study aimed to investigate the clinical effectiveness of early diagnosis and treatment of pelvic fractures and associated injuries in children.*
METHODS: *The diagnosis and treatment of 60 children with pelvic fractures and associated injuries who were admitted to our hospital from January 2005 to December 2016 were retrospectively analyzed. Among these patients, 36 were male, and 24 were female. The patients' ages ranged within 2–15 years, with an average of 7.6 years old. The pelvic fractures were classified based on the Torode and Zieg classification; among the patients, 12 had type I, 16 had type II, 20 had type III, and 12 had type IV. All patients received early diagnosis, immediate anti-shock measures, aggressive treatment of associated injuries, and early reduction and fixation of the pelvic fractures after admission.*
RESULTS: *Of the 60 patients, 28 had injuries caused by traffic accidents, 26 had injuries caused by falling from high places, and 16 had injuries caused by compressing or crushing. Eight patients had unilateral pubic bone fracture or pubic symphysis separation that involved posterior pelvic fracture or sacroiliac joint separation, and two had fractures that affected the anterior ring or acetabulum. Moreover, 26 patients had hemorrhagic shock, 18 had traumatic brain injury, 14 had fractures at other sites, 8 had pelvic large vessel injuries, 8 had ipsilateral femoral and proximal femoral fractures, 8 had retroperitoneal hematoma, 8 had urinary system injury, 6 had perineal laceration and vaginal trauma, 6 had spinal cord injury, 4 had intestinal injuries, 4 had soft tissue contusions, and 4 had sacral nerve injury. During the follow-up (average: 48 months), six children died. The evaluation results of the curative effect were excellent in 32 children, good in 18, and poor in 4; the 'excellent' and 'good' rate was 92.5% (50/54).*
CONCLUSION: *Early diagnosis, reduction, and fixation and timely treatment of associated injuries might achieve better clinical efficacy and are worthy of clinical promotion.*

KEY WORDS: Associated Injuries, Childhood, Diagnosis, Fracture, Pelvic, Treatment

Introduction

Pelvic fractures account for 0.5%-7.0% of fractures in children [1,2]. The injury mechanism is primarily high-energy injury, which is easily combined with injuries to other tissues and organs. The incidence of associated injuries can reach as high as 78%, and the mortality rate is 28.7%. Pelvic fracture treatment for children is different from that for adults [1], and rescue is difficult. In this study, the investigators collected information about children with pelvic fracture and associated injuries who were admitted to our hospital from January 2005 to December 2016 to investigate the clinical effectiveness of early diagnosis and treatment of pelvic fractures and associated injuries in children.

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Data and Methods

General information

This clinical retrospective study was conducted between January 2005 and December 2016. A total of 60 patients diagnosed with pelvic fractures and associated injuries were included. The classification of pelvic fractures was based on the Torode and Zieg classification [1,3]. Written informed consent was obtained from all patients prior to participation. The present study complied with the requirements of the Ethics Committee of our hospital. All included patients received early diagnosis, reduction, and fixation and timely treatment of associated injuries.

Treatment of associated injuries

The fatality rate of pelvic fractures in children ranges from 2% to 25%, and death is primarily affiliated with severe associated injuries [2,4].

Combined shock

The blood volume should be replenished in a timely and effective manner before the patient is hemodynamically stable to rapidly establish venous channels.

Brain trauma

This is the most severe and common associated injury. The degree of traumatic brain injury can be quantified using the Glasgow Coma Scale (GCS), and intracranial pressure should be monitored. For children with pelvic fractures complicated with severe brain trauma, early effective immobilization helps control intracranial pressure. Therefore, once diagnosed, immobilization of the the pelvic girdle and pelvis with C-shaped forceps and other methods should be performed. If associated injuries require surgery, pelvic ring external fixation should be considered during the operation for older children [5,6].

Hemorrhage and retroperitoneal hematoma

Pelvic fractures in children are often caused by side impact of motor vehicles. Most are lateral crush fractures, wherein the pelvic volume decreases and fatal bleedings are few. Such fractures can be diagnosed via imaging examination. For children with unstable blood pressure, blood transfusion and external fixation should be provided in time, and vascular embolization should be considered if necessary [6,7].

Urinary system injuries

These injuries are primarily bladder and urethral injuries. The incidence of urethral injuries in children with pelvic fractures ranges from 4.7% to 25.0% [8,9]. Urethral catheterization and an indwelling catheter are necessary for these patients. If hematuria or urethral blood drop is observed, the injury site can be diagnosed by cystoscopy or endoscopy. If urethral rupture is found, emergency urethral anastomosis, early urethral realignment, delayed bladder repair, and delayed urethral repair can be performed. Early reduction and effective fixation of pelvic fractures are the anatomic bases for tension-free urethral repair [9,10]. In the present study, one patient received urethra, perineum, and bladder fistula.

Laceration of the perineum

This injury causes massive bleeding in the perineum. Furthermore, the wound area is large, and contamination is heavy. The wound may involve the hip and inguinal region and extend deep into the anal canal, rectum, and presacral area. This is complicated with a large amount of oozing blood. Pelvic fractures often associate with perineal wounds, which reduce the pressure of possible pelvic hematoma and increase the amount of bleeding, causing further harm to the patient. For this fracture, thorough debridement should be performed, and selective fecal diversion should be considered according to the degree of trauma [11,12].

Inferior digestive tract injuries

Small intestine injury should be treated with primary sutures, as should rectal injury above the peritoneal fold when possible. An anal canal catheter should be placed for gas exhaustion after the operation. For injuries below the peritoneal fold, the wound should be closed by first intention, and a colostomy should concurrently be performed. The distal bowel should be cleaned, the perianal area should be thoroughly drained, and the anal canal exhaust should be retained.

Statistical analysis

The statistical analysis was performed using the SPSS version 20.0 software. The binary classification variable was expressed as a percentage.

Results

Patients' general characteristics

A total of 60 patients admitted to our hospital from January 2005 to December 2016 were included in this study. Among them, 36 were male, and 24 were female. Their ages ranged within 2–15 years old.

Types of injury

Of the 60 patients, 28 had injuries caused by traffic accidents, 26 had injuries caused by falling from high places, and 16 had injuries caused by compressing or crushing. Moreover, 12 patients had avulsion fracture (type I), 16 had fracture of the iliac ala (type II), 20 had a single fracture of the pelvic ring (type III, including fracture of the pubic ramus or separation of pubic symphysis), and 12 had fracture of the bilateral pubic ramus (type IV, fracture of the pelvic ring, also called straddle injury). Eight patients had unilateral pubic bone fracture or pubic symphysis separation that involved posterior pelvic fracture or sacroiliac joint separation, and two had fractures that affected the anterior ring or acetabulum.

Associated injuries

All patients had two or more injuries that involved almost all body systems. Among them, 26 had hemorrhagic shock, 18 had traumatic brain injury, 14 had fractures at other sites, 8 had pelvic large vessel injuries, 8 had retroperitoneal hematoma, 8 had urinary system injury, 8 had ipsilateral femoral and proximal femoral fractures, 6 had perineal laceration and vaginal trauma, 6 had spinal cord injury, 4 had intestinal injuries, 4 had soft tissue contusions, and 4 had sacral nerve injury.

Treatment according to injury type

Posterior pelvic ring fixation techniques include the following: (1) Sacroiliac joint screws can provide stable internal fixation but require a high technique, as a slight direction deviation can damage the nerves. For children <10 years old, the S1 vertebral body is small, but the ilium can be fixed directly to the articular surface of the sacrum by screws. (2) Miniplate fixation of the iliac spine and sacral alae is suitable for severe fractures of the sacroiliac joint surface. (3) Intrasacral fixation via a rod passing through the ilium is suitable for patients who have good soft tissue condition. However, the end of the rod may induce local irritation and produce pain; hence, it cannot be used for patients with posterior superior iliac spine fracture. Pelvic anterior ring injuries can be fixed with reconstruction plates or an external pelvic fixator. For unstable pelvic fractures in children, pelvic symmetry and stability can be surgically restored, and the prognosis is satisfactory.

In the present study, all children received early diagnosis, immediate anti-shock measures, aggressive treatment of associated injuries, and early reduction and fixation of the pelvic fractures after admission. Twenty-eight patients were treated with emergency anterior fixation using an external fixator; among them, eight were treated with internal fixation during emergency open surgery, six were treated with internal fixation with steel plates, and three were treated with continuous lower extremity traction.

Clinical prognosis

During the follow-up, which ranged from 6 months to eight years (average: 48 months), six of the children died. The evaluation results of the curative effect were excellent in 32 children, good in 18, and poor in 4, and the 'excellent' and 'good' rate was 92.5% (50/54). Regarding the curative effect, X-ray films revealed anatomical or near-anatomical reduction of the fractures, complete restoration of the pelvic ring, and fracture healing. These patients had no pain and were able to live and study normally. For the four children with the poor effect (7.5%), X-ray films revealed poor fracture alignment, malunion of the pelvic ring, and upward displacement of the ilium by >1 cm. These patients experienced limping and frequent pain, and their lives and studies were affected [13]. The good effect was between the curative and poor effects (Figs. 1-3) (Table I).

Fig. 1: Multiple thrypsis (comminute fractures), separation of the right sacroiliac joint, perineal vestibular lacerations, large area avulsion of the left lower limb, and open fracture of the left fourth and fifth toes. The patient received early fixation of pelvic fractures after admission. Nine days later, X-ray films revealed anatomical or near-anatomical reduction of the fractures, complete restoration of the pelvic ring, and fracture healing.

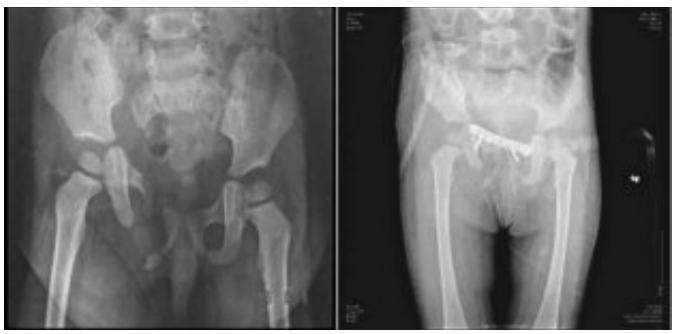

Fig. 2: Multiple fractures of the pelvis and left ribs combined with renal contusion.

Fig. 3: Hemorrhagic shock and pelvic thrypsis, right sacroiliac dislocation, avulsion of the penis, and severe laceration of the perineum. The patient received immediate anti-shock measures, aggressive treatment of associated injuries, and early reduction and fixation of the pelvic fractures after admission. Four months later, X-ray films revealed anatomical or near-anatomical reduction of the fractures, complete restoration of the pelvic ring, and fracture healing.

Table I - *The results of the effectiveness*

Index	Case N(%)
Death	6 (10.0)
Excellent effect	32 (53.3)
Good effect	18 (30)
Poor effect	4 (6.7)
No effect	6 (10.0)

Discussion

Pelvic fracture classification

There are many classifications of pelvic fractures in children, such as the Torode and Zieg classification, Tile classification, and Young–Burgess classification. The Torode and Zieg classification is the most cited and can guide the treatment and prognosis estimation of associated injuries. This classification is based on X-ray films, and injuries are classified as follows: type I, avulsion fracture, which is primarily avulsion of the cartilage plates; type II, fracture of the iliac ala, which is primarily caused by lateral impact; type III, simple pelvic ring fracture, in which the pelvic ring is stable; type IV, fractures wherein the pelvic ring ruptures, which is a fracture or separation of the joints that results in pelvic ring instability. This can be divided into fractures of the bilateral pubic rami, fractures of the unilateral pubic ramus or separation of the pubic symphysis affecting the posterior pelvic fracture or separation of the sacroiliac joint, and fractures that affect the acetabulum or ipsilateral anterior or posterior pelvic ring [7].

Pelvic fracture treatment in children

Due to a high healing rate and strong shaping ability, pelvic fractures in children are often treated by bed rest, traction, and hip spica plaster. Recent studies have suggested that pelvic self-shaping often corrects only partial deformities and that non-surgical treatment of severe pelvic fractures leads to lower back pain and lower limb inequality [4,14,15]. The stability of pelvic fractures in children is the key to deciding the treatment plan. For stable pelvic ring fractures, e.g., avulsion fractures at the iliac crest, anterior superior iliac crest, and ischial ramus, early ambulation, weightlifting, and adequate analgesia can be performed, the outcomes of which are relatively satisfactory [16-18]. However, for patients with large displacement and high motor function requirements, surgical fixation should be performed to restore pelvic stability and promote pelvic fracture healing. For patients with partial stable fractures of the pelvic ring, since the sacroiliac ligaments remain partially intact, closed reduction under anesthesia and spica plaster fixation until healing should be performed. For older children, anterior ring external fixation and early ground ambulation should be provided. However, the stability of the external fixation should be evaluated regularly via observing the distance between the bilateral anterior superior iliac spines or the pubic symphysis distance. If stability disappears, measures should be taken as soon as possible, e.g., the external fixation should be replaced, or the reduction and internal fixation should be surgically opened.

Causes of bleeding

The causes of bleeding include external bleeding of the wound, parenchymal internal bleeding of the organs, fracture surface bleeding, and pelvic wall venous plexus and pelvic small vessel bleeding. For hemorrhagic shock treatment, fracture dislocation of the posterior ring should be rapidly repaired as much as possible, and movement should be reduced. Furthermore, hemorrhagic shock should generally be treated with blood transfusions, which often require great volumes. If blood pressure cannot be maintained after a certain volume of rapid blood transfusion, bilateral internal iliac artery ligation should be considered. If any macrovascular injuries are

suspected, e.g., internal iliac artery injury, surgical exploration should be performed timely to control bleeding and rescue the lower limb. In the present study, 26 patients with hemorrhagic shock were treated with anti-shock therapy, e.g., blood transfusion, fluid replacement, and dilatation; among them, 20 were successfully rescued, and 6 died.

Craniocerebral injury

Great importance should be attached to pelvic fractures with brain trauma in children, as brain trauma is not only the leading cause of death in such cases but also changes in the state of consciousness can affect the diagnosis and treatment of associated injuries. Therefore, after injured children are hospitalized, the GCS and other grading systems should be used to determine the degree of and coma caused by brain trauma. Regular monitoring of intracranial pressure should be performed to assess whether the patient requires neurosurgery intervention. For children with pelvic fractures complicated with severe brain trauma, early effective immobilization, e.g., pelvic bandaging and pelvic fixation, is helpful to control intracranial pressure. In the present study, six patients with indications of craniotomy underwent emergency craniotomy; two of them died.

Bladder and urethral injuries

Urethral injuries are common complications of pelvic injuries, and their incidence ranges within 3.5%-28.8%. A bladder rupture should be treated via surgery, exploration, and sutures. Inability to urinate, urethral bleeding, and extravasation of urine are signs of urethral injury. Fine soft catheters can be placed, but harder catheters cannot, due to roughness. In some lacerations, the catheter should be retained for 10-20 days, and the urethra should be expanded regularly to prevent urethral stricture. In the present study, of the six patients with urinary system injury, one was treated with urethral realignment, one was treated with urethral end-to-end anastomosis, one was treated with cystostomy, and the two with vaginal laceration were repaired. Satisfactory results were achieved in all cases.

Anorectal injuries

Rectal injuries should be repaired and treated via colostomy. In patients with low rectal injuries, suturing of intestinal wall breakage often fails to achieve satisfactory outcomes; hence, local drainage should be emphasized. Transperineal drainage should cover the above pelvic diaphragm and enable the ischiorectal fossa to be completely open. Debridement should be performed as thoroughly as possible, and the exposed fracture ends may be covered with adjacent active tissues. Drainage tubes should be placed in the groin and other appropriate positions, and continuous negative pressure suction should be performed if necessary. Additionally, sensitive antibiotics should be administered to control infection.

Limitations

First, this was only an observational study rather than a randomized controlled trial. Second, the sample size was small; hence, further research with a larger sample size is still needed. Third, no control group was designed in this research.

Conclusions

Early diagnosis, reduction, and fixation and timely treatment of associated injuries can achieve better clinical efficacy and are worthy of clinical promotion.

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Riassunto

Il meccanismo di lesione di una frattura pelvica è principalmente una lesione ad alta energia ed è facilmente combinabile con lesioni ad altri tessuti e organi. Questo studio mirava a studiare l'efficacia clinica della diagnosi precoce e del trattamento delle fratture pelviche e delle lesioni associate nei bambini.

Sono stati analizzati retrospettivamente la diagnosi e il trattamento di 60 bambini con fratture pelviche e lesioni associate che sono stati ricoverati nel nostro ospedale da gennaio 2005 a dicembre 2016. Tra questi pazienti, 36 erano maschi e 24 erano femmine. L'età dei pazienti era compresa tra 2 e 15 anni, con una media di 7,6 anni. Le fratture pelviche sono state classificate in base alla classificazione Torode e Zieg; tra i pazienti, 12 avevano tipo I, 16 avevano tipo II, 20 avevano tipo III e 12 avevano tipo IV. La diagnosi dopo il ricovero è stata precoce in tutti i pazienti, che sono stati trattati immediatamente per lo stato di shock, e con un trattamento aggressivo delle lesioni associate, e con riduzione e fissazione precoci delle fratture pelviche.

Risultati: Dei 60 pazienti, in 28 le lesioni erano derivate da incidenti stradali; in 26 le lesioni erano conseguenti a precipitazioni dall'alto; in 16 le lesioni derivavano da compressione o schiacciamento.

Otto pazienti presentavano una frattura unilaterale del-

l'osso pubico o separazione della sinfisi pubica che comportava una frattura pelvica posteriore o una separazione dell'articolazione sacroiliaca e due presentavano fratture che interessavano l'anello anteriore o l'acetabolo.
Inoltre, 26 pazienti presentavano shock emorragico, 18 avevano trauma cranico, 14 avevano fratture in altri siti, 8 avevano lesioni dei grandi vasi pelvici, 8 presentavano fratture ipsilaterali e prossimali del femore, 8 avevano ematoma retroperitoneale, 8 avevano lesioni del sistema urinario, 6 avevano lacerazione perineale e trauma vaginale, 6 avevano lesioni del midollo spinale, 4 avevano lesioni intestinali, 4 avevano contusioni dei tessuti molli e 4 avevano lesioni del nervo sacrale.
Durante il follow-up (media: 48 mesi), sono morti sei bambini. I risultati della valutazione dell'effetto curativo sono stati eccellenti in 32 bambini, buoni in 18 e poveri in 4; la percentuale "eccellente" e "buona" era del 92,5% (50/54).
In conclusione la diagnosi precoce, riduzione e fissazione e trattamento tempestivo delle lesioni associate potrebbero raggiungere una migliore efficacia clinica e sono altamente consigliabili per la pratica clinica.

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