

# Paediatric pelvic fractures: how do they differ from adults?

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## Abstract

**Background** The aim of this article was to review the incidence, presentation, treatment and complications of paediatric pelvic fractures of children who were admitted to our level 1 trauma centre and to compare them with our data from adult pelvic fracture patients.

**Methods** We conducted a retrospective chart review of all children with pelvic fractures who were managed at our institution between January 1993 and December 2013 and compared the data with our database on pelvic fractures in adults during the period 2007 to 2012.

**Results** We identified 51 children and 268 adults with pelvic fractures. The median age of the paediatric patients was 11 years. Children were significantly more involved in traffic accidents than adults ( $p < 0.001$ ). Adults had a significantly higher Injury Severity Score (ISS) (31 vs 24.5;  $p < 0.03$ ) and were significantly more often haemodynamically unstable ( $p < 0.01$ ). Adults had a type C fracture more often, while children had a type B fracture ( $p < 0.001$ ). Associated injuries were seen in both groups; however, thoracic injuries were significantly higher in adults ( $p < 0.01$ ) and injuries to the extremities were higher in children ( $p < 0.01$ ). Adults were significantly more often treated with open reduction and internal fixation ( $p < 0.001$ ). Mortality in both groups, however, did not differ (6% vs 8%).

**Conclusion** Paediatric pelvic fractures are rare. They differ from adult pelvic fractures in presentation, associated injuries and management. Mortality, however, is substantial and does not differ from the adult population. Mortality is often

due to concomitant injuries and not to exsanguination from the pelvic fracture.

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**Keywords:** pelvic fracture; children; adult; treatment

## Introduction

Pelvic fractures in children are rare, with an incidence estimated to be in the range of 0.5% to 7.0%<sup>1-4</sup> of all blunt paediatric traumas. However, mortality is significant with a reported range of 1.4% to 25% and an average of 6.4%.<sup>1,2,5-7</sup>

The immature pelvis has greater elasticity at the sacroiliac joints and symphysis, which makes fractures dependent on high energy forces.<sup>8</sup> Most patients with a pelvic fracture are therefore multi-traumatised patients with injuries to the head, chest, abdomen and extremities.<sup>6,9</sup> The extent of the associated injuries and the complications result in greater morbidity and mortality than the fracture itself.<sup>5,6,10</sup>

Acetabular fractures co-occur with pelvic fractures, but they do not constitute life-threatening injuries by themselves. However, due to articular involvement, the clinical outcome can be very disappointing. The development of the acetabulum starts with three great ossification centres of the ischium, ilium and pubis, and join in the triradiate cartilage. Fusion of these growth plates is seen between the age of 13 and 16 years.<sup>11</sup>

Several classification systems aim to describe the stability of pelvic fractures and to predict morbidity and mortality after severe trauma. These models include those developed by Torode and Zieg<sup>12</sup> and Tile.<sup>13</sup> Both are widely used. Torode and Zieg divide fractures into stable and unstable but did not differentiate between fracture type and degree of instability.<sup>12</sup> The Tile system<sup>13</sup> combines the mechanism of injury and pelvic ring stability and makes a distinction between stable (type A), rotationally unstable (type B) and vertically unstable (type C) pelvic fractures.

In this article, we review the incidence, presentation, treatment and complications of paediatric pelvic fractures in patients admitted to our trauma centre, and compare these with a group of adult patients with a pelvic ring

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fracture from our institution, and with the existing literature. All paediatric and adult patients were treated by the same group of six trauma surgeons.

## Methods

A retrospective chart review was performed of children younger than 16 years with a pelvic fracture who were managed between 1 January 1993 and 31 December 2013 at a referral centre for pelvic and acetabular surgery, the Radboud University Nijmegen Medical Center (RUNMC). Data including patient details, mechanism of injury, pre-hospital treatment, vital signs on admission, Glasgow Coma Scale (GCS), Injury Severity Score (ISS)<sup>14</sup> and associated injuries, treatment, length of stay (LOS), ICU admittance, outcome and clinical outcome in follow-up were extracted from our prospectively collected trauma database. All available radiology examinations were re-evaluated and classified by two senior authors, both trauma surgeons with extensive experience in the field of pelvic trauma. Pelvic fractures were classified according to Tile.<sup>13</sup> Additional acetabular fractures were noted. All pelvic fractures were discussed in the trauma group, supervised by one of the authors (JB); our current consensus is that if the displacement of the acetabular fracture was 2 mm or more, operative treatment was indicated.

Operative treatment for pelvic fractures was indicated when the pelvic fracture was rotationally or vertically unstable or there was severe displacement of the fracture.

Associated injuries were classified into five groups: intra-abdominal, intrathoracic, intracranial/head, extremities and vertebral column. Our database of children was compared with a database composed of pelvic fractures in adults (age > 16 years) from our clinic and with the literature. Data retrieval on adults was done in a similar way as

in children. All adult patient data were collected between 2007 and 2012.

## Results

### Children

Between 1 January 1993 and 31 December 2013, we identified 51 children with a pelvic fracture; 44 sustained a pelvic fracture only and in seven the acetabulum was also involved. The median age was 11 years (3 to 16) and 57% were boys (n = 29) (Table 1). Figure 1 shows the age distribution of the children.

The most common causes of injury were motor vehicle accident, fall from height and injuries during sport (Table 1). The incidence of pelvic fractures varied over the years between one and seven children, with a mean incidence of two to three children a year.

Of the 51 children, 14 (27%) sustained a Tile A fracture, 29 (57%) a type B fracture and eight (16%) a type C fracture (Table 2).

At their presentation in the emergency room, 21 children (43%) exhibited a depressed level of consciousness (GCS < 15 (mean 4, 3 to 13)), and four were haemodynamically unstable (Table 1). A blood transfusion was required in eight children (16%) within the first 48 hours. Three of the four haemodynamically unstable children underwent surgery acutely, one patient responded to blood transfusion and stabilised haemodynamically.

The median ISS (as calculated by the national trauma registry) was 24.5 (7 to 50). Only four children scored ≤ 16. There was no significant link between type of fracture and ISS score.

A total of 34 patients (68%) were initially admitted to the intensive care unit (ICU); 31 recovered and spent a mean of eight days (1 to 23) in the ICU. Their median hospital stay was significantly longer than that of patients who were not admitted to the ICU (p < 0.05).

**Table 1.** Characteristics of paediatric pelvic fracture compared with adults

	Children (n = 51)	Adults (n = 268)	p-value
Age (yrs)	11 (3 to 16)	42 (17 to 90)	-
Male	57% (n = 29)	66% (n = 178)	0.19
<i>Clinical presentation</i>			
Mean ISS (range)	24.5 (7 to 50)	31 (4 to 66)	<b>0.03</b>
Haemodynamic unstable	2 (4%)	89 (33%)	<b>&lt; 0.01</b>
Blood transfusion	10 (20%)	50 (19%)	0.15
Length of stay (days)	17 (1 to 80)	17 (1 to 142)	NS
ICU admission	34 (68%)	150 (56%)	0.16
Length of ICU stay (days)	9 (1 to 44)	5 (1 to 39)	NS
<i>Outcome</i>			
Death	3 (6%)	22 (8%)	0.57
<i>Mechanism of injury</i>			
Motor vehicle accidents	40 (78%)	150 (56%)	<b>0.003</b>
Fall from height > 2 m	6 (12%)	57 (21%)	0.12
Crush	1 (2%)	25 (10%)	0.08
Other	4 (8%)	36 (13%)	0.27

Data are presented as mean

Type of pelvic fracture was not significantly related to admittance to the ICU ( $p = 0.33$ ) or to length of stay on the ICU ( $p = 0.075$ ).

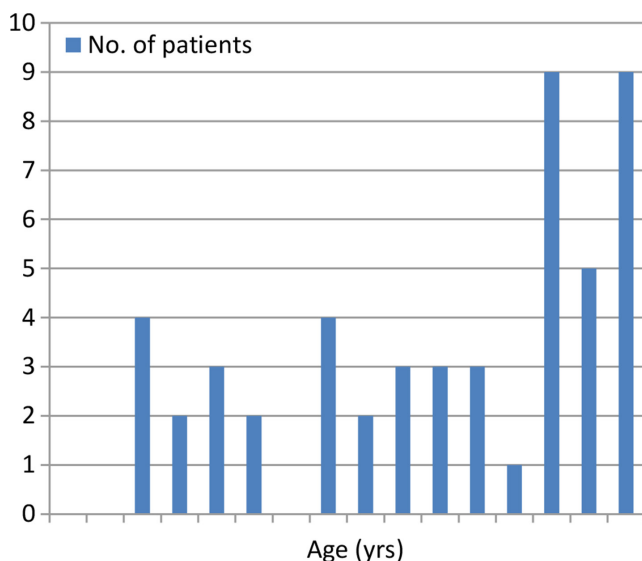
The median length of stay of patients with a pelvic fracture was 17 days (0 to 80). Length of stay was significantly related ( $p = 0.042$ ) to type of pelvic fracture; longer admissions were associated with more severe pelvic fractures (B and C types).

Five patients (10%) did not require hospital admission; all of these patients had a type A pelvic fracture and were instructed to begin movement within the limits of pain. These patients were followed in our outpatient clinic according to protocol.

The median length of stay of the seven patients with a pelvic ring fracture and an acetabular fracture was 22 days (5 to 68).

**Adults**

In the period between 1 January 2007 and 31 December 2012, the data of 268 adult patients were reviewed. We encountered 63 Tile type A fracture (23%), 79 type B fractures (30%) and 126 type C fractures (47%). The most common cause of accident was a motor vehicle accident (MVA) (56% of the patients). A crush injury was the cause in 10% of the patients and a fall from height in 21%.



**Fig. 1** Age distribution (years).

**Table 2.** Fracture type

	Children (n = 51)	Adults (n = 268)	p-value
Tile A	14	63	0.67
Tile B	29	79	< 0.001
Tile C	8	126	< 0.001

Of the 268 patients, 178 were male (66%). The mean age was 42 years (17 to 90) with a mean ISS of 31 (4 to 66).

In total, 89 patients (33%) were haemodynamically unstable and 50 of these patients required a blood transfusion. The other 39 patients responded to volume therapy and placement of a pelvic binder alone.

Median length of stay was 17 days (1 to 142). All patients were admitted for at least one day to our hospital. Patients with a non-displaced type A fracture (e.g. a pubic ramus fracture) who could be mobilised at the ER were dismissed and were seen in our outpatient follow-up but were not included in this analysis. Of the patients, 56% were admitted to the ICU with a median length of stay of five days. Also in our adult group, longer admissions were associated with more severe pelvic fractures (B and C types).

**Associated Injuries**

*Children*

In addition to their pelvic fracture, 70% of patients had associated injuries. A total of 50% sustained associated injuries in two or more separate regions. The most frequent associated injuries were femoral fractures (24%), intracranial bleeding (24%), pneumothorax (16%) and urinary tract injuries (12%) (Table 3). There was no significant link between fracture type and associated injuries in any of the subgroups.

*Adults*

In adults, almost 85% of the patients had one or more concomitant injuries. Concomitant injuries are listed in Table 3. Thoracic injuries were most frequently seen in adults. However, the number of urogenital and neurological injuries was considerably low (6%), especially considering the amount of complex pelvic fractures in our patient group.

**Management**

*Children*

A total of 11 patients (21%) were managed surgically, based on the stability of the fracture and the clinical

**Table 3.** Concomitant injuries

AIS region	Children (n = 51)	Adults (n = 268)	p-value
Head/neck	22 (43%)	85 (32%)	0.11
Face	4 (8%)	8 (3%)	0.09
Chest	12 (24%)	158 (60%)	< 0.01
Abdomen	19 (37%)	85 (32%)	0.43
Extremities	39 (76%)	142 (53%)	< 0.01

condition of the patient. Three patients had a type B fracture and eight had a type C fracture. Seven patients (14%) underwent external fixation to stabilise their pelvis, in three cases this was followed by internal fixation with a SI screw and plate. Four children had immediate open reduction and internal fixation with plates and screws (Table 4). Non-operative treatment consisted of bed rest followed by progressive mobilisation within the limits of pain.

Three patients had an open pelvic fracture as a result of skin lacerations, degloving or wounds from burns. Antibiotics were prescribed for all of these patients. One patient had a ruptured rectum and another had a ruptured bladder and a retroperitoneal hematoma. In all cases of urological damage, the Urology Department was consulted for advice on treatment. Five other patients with urethral injury were initially primarily managed with a transurethral catheter; of these, two were managed with secondary reconstruction in the operating room at a later time by a paediatric urologist. Seven patients with a pelvic fracture sustained an additional acetabular fracture which, due to minimal displacement, were all managed non-operatively. Figures 2 to 4 demonstrate a pelvic fracture in a 12 year old patient, operative treatment and one year later with fracture healing.

**Adults**

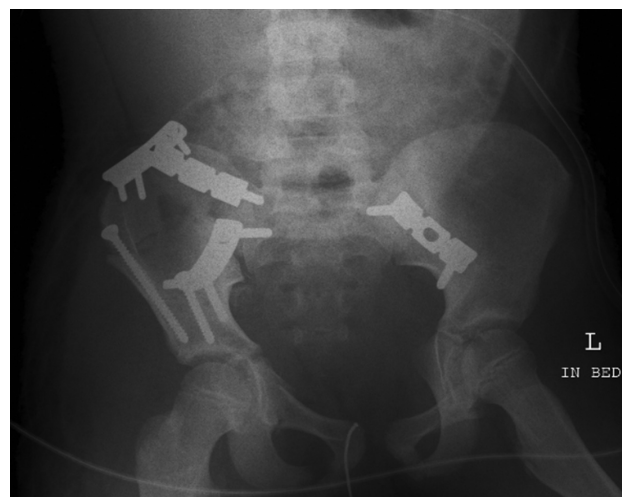
Of the adult patients, 56% were managed surgically; of these, 42% had a form of operative treatment in the acute

setting. In most cases, a form of open reduction and internal fixation was performed. An external fixator or C-clamp was also placed in several patients. We consider plating of the symphysis pubis in a type B or C fracture a fast and relatively easy procedure and prefer this over the external fixator. The posterior ring was often treated in a second session. Treatment in adults varied. Type B injuries were treated with symphyseal plating or percutaneous pubic screws. When patients had rotational instability in the sagittal plane (bucket handle lesions), the preferred treatment was the placement of percutaneous SI screws.

Type C fractures were treated the same, but for complex sacral fractures plates were used.

**Table 4. Definitive operative treatment**

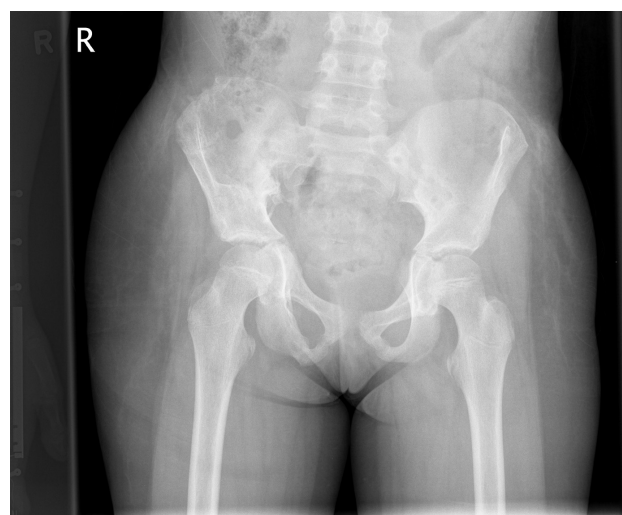
	Children (n = 51)	Adults (n = 268)	p-value
External fixation	4 (8%)	12 (4%)	NS
Internal fixation	7 (14%)	151 (56%)	< 0.001
Laparotomy	7 (14%)	51 (19%)	NS



**Fig. 3** Post-operative radiograph with bilateral plate osteosynthesis.



**Fig. 2** Type C pelvic ring injury in a 12-year-old girl.



**Fig. 4** Pelvic radiograph one year after injury: uncomplicated fracture healing, removal of hardware, non-operatively treated anterior pelvic ring shows re-alignment. At follow-up after two years, the patient had a normal gait and was able to enjoy soccer and jazz ballet.



Open fractures were seen 13 patients (5%). Three patients had a grade 1 open injury, six had a grade 2 open fracture and four had a grade 3 open injury. In this group, no traumatic hemipelvectomies were encountered. Grade 1 open fractures were treated with antibiotics alone. Grade 2 and 3 injuries were treated with aggressive surgical debridement and antibiotics. Five patients had a colostomy due to perineal injury.

## Mortality

### Children

Three children (6%) died due to their associated injuries; two due to their severe head trauma (two and five days after trauma) and the third hours after abdominal surgery. Autopsy later revealed a massive pulmonary embolism.

On arrival, all of these children exhibited a depressed level of consciousness (mean GCS 6) and non-reactive pupils. The two patients who died of head trauma had a type B pelvic fracture. The third patient had a type C fracture.

### Adults

Overall mortality in our group was 8% (22/268). Mean ISS of diseased patients was 47 (4 to 75). Packed red blood cells were given to 14 of the 22 patients (62%). The remaining eight patients responded to volume replacement alone in conjunction with placement of a pelvic binder.

Within the first 24 hours of the accident nine patients (41%) died. Two of 22 (9%) patients died solely due to severe head trauma; two died primarily of a respiratory problem. One patient died due a tracheal rupture and one patient of a bilateral tension pneumothorax. This last patient had end-stage chronic obstructive pulmonary disease (COPD) and died of progressive respiratory failure. In 18 patients (82%), haemorrhagic shock contributed to or was the cause of death.

## Outcome

### Children

The mean follow-up time was seven months (six weeks to six years). The large variation in follow-up time was due to the associated injuries. Patients with an acetabular fracture were observed for a longer period to identify growth disturbances, until the growth plates were closed. Four children were transferred to a hospital in their home country, including one in the United Kingdom and three in Germany, and were lost to follow-up. None of these patients had an acetabular fracture.

Three children suffered a persistent disability due to the pelvic fracture that consisted of pain and reduced stamina at the end of outpatient follow-up (mean follow-up of 10 months). All three had a type B fracture and were treated conservatively. One patient had a leg-length discrepancy of 1 cm due to a type C fracture that was without clinical significance. This patient also had an acetabular fracture. In none of the patients with an associated acetabular fracture, preliminary closure of the growth plates was observed. No growth disturbances were observed during follow-up. Good clinical results after operation were achieved in 11 of 51 (22%) children. The 48 patients (94%) achieved full range of motion without pain in the hip or lower back in active daily life. Nine of 11 patients that were operated upon were in this group. In 6/7 patients who had internal fixation, the plates and screws were removed after fracture healing.

### Adults

Mean follow-up time in adults was five months (six weeks to eight years). Approximately 47% of all patients could be discharged to their homes with physical therapy and no further need for clinical rehabilitation. Outcome was therefore considered generally good. However, no functional outcome scores were measured during follow-up. Information regarding walking, pain and return to former jobs could only be found in a select number of patient-charts so no conclusions can be made of this retrospective data. In only a select group of patients, the plates and screws were removed after fracture healing.

### Comparison with pelvic fractures in adults

Compared with pelvic fractures in children, adults had higher ISS scores and had a greater frequency of hemodynamic instability at presentation at the emergency room (Table 1).

However, the requirement of transfusion with packed red blood cells was not higher in adults. Fracture type differed significantly between both groups. Adult patients presented more often with a type C fracture, children with a type B fracture (Table 2).

Although average overall length of admission was equal between the two groups, children were admitted longer to the ICU. Most patients had concomitant injuries. In comparison with adults, children suffered more from head and extremity injuries. Adults had significantly more chest injuries compared with children (Table 3).

In the adult group 22 patients died, in 18 of these haemorrhage contributed significantly to the cause of death. Only one adult patient died solely due to the sequelae of haemorrhage from the pelvic fractures, in all other adult patients there was a combination of injuries. Mortality did not differ significantly between groups.

**Table 5.** Comparison of baseline characteristics in other studies

Author	Year of publication	Number of patients	Mean age (yrs; range)	Mortality	Operative treatment (n and %)
This study	2016	51	11.1 (3 to 16)	6%	11 (21)
Marmor <sup>4</sup>	2015	5325	< 13	10.2%	265 (5.0)
Leonard <sup>10</sup>	2011	39	8.6 (1 to 14)	3%	2 (5)
Banjaree <sup>2</sup>	2009	44	11.4 (1 to 16)	16%	1 (2)
Vitale <sup>21</sup>	2005	1190	11 (0 to 20)	7.2%	n.a.
Karunakar <sup>20</sup>	2004	148	< 16	n.a.	14 (9)
Chia <sup>6</sup>	2004	120	9 (1 to 16)	4%	7 (6)
Grisoni <sup>9</sup>	2002	57	9 (1.2 to 15)	4%	5 (9)
Rieger <sup>5</sup>	1997	54	10.9 (5 to 16)	6%	38 (70)

n.a., not applicable

## Discussion

In the period between January 1993 and December 2013, we treated 51 children with a pelvic fracture in our trauma centre. The baseline characteristics of our study group matched with the recent literature (Table 5). The mean age of our group (11.1 years) was high compared with other studies, which have reported a mean age ranging from 8.4 to 9.4 years.<sup>1,5,6,16</sup> The 28 children (55%) were aged 12 years or older. In the Netherlands, there are many cyclists. In 15 children (30%) they had an accident and fractured their pelvis whilst riding a bike; of these children, 13 were aged 12 years or older.

The aetiology of pelvic fractures in children differs from that in adults. Compared with adults, children suffer more from MVAs (Table 1) and are less involved in falls from heights or crush injuries. Adults are often the drivers of a car, while children are usually struck by a car from the side whereby they sustain lateral compression type injuries.<sup>10</sup> Also in bike trauma, severe crush injuries due to being run over by a car are often seen. This leads to open fractures with severe soft-tissue injury.

Considering the concomitant injuries, there are well-known differences in pathophysiological mechanisms in children as compared with adults. Rib cage fractures are rare in children but common in adults because of the elasticity of the ribs. In the Netherlands, until recently protective helmets for bicyclists were hardly ever in use for children. Combined with the fact that children have a relatively larger and heavier head, this might explain the high incidence of serious head injury. The origin of the different number of extremity trauma remains unclear. In this study, the majority of the MVAs (81%) is the result of being struck as a pedestrian/cyclist by a car or truck. The high incidence of type B2 fractures (lateral compression and internal rotation) supports this assertion. Only five children were car passengers.

According to the ATLS protocol, the gold standard for radiological examination of pelvic injuries in the emergency setting is the anteroposterior (AP) pelvic radiograph. In recent years, the CT scan had been increasingly used for the evaluation of paediatric trauma patients.<sup>2,15</sup> Consequently, we diagnosed additional pelvic fractures in children that

were initially missed on pelvic radiograph. CT scan occasionally resulted in changes in the classification of the pelvic fracture; however, there were no changes in treatment even though the classifications changed.

The use of CT scans in children is associated with increased cancer risk due to the higher doses of ionising radiation delivered by CT, especially CT scans of the abdomen and pelvis.<sup>18,21</sup> Therefore, we advise for general practice that a standard pelvic radiograph is performed and that additional CT is performed only for patients with highly complex fractures and for patients in which it is doubtful that their injuries can be managed non-operatively.

In the past, paediatric pelvic fractures were usually managed non-operatively because children possess greater ability of healing and remodelling after a fracture.<sup>1,10,15</sup>

In our hospital, all type A pelvic fractures and 79% of the type B fractures were treated conservatively, with adequate pain management and progressive mobilisation.<sup>15</sup> The conservative treatment of unstable and displaced pelvic fractures may result in pelvic asymmetry that can lead to serious disabilities and pain, similar to adult patients.<sup>1,5,17,20</sup> Several authors have observed that paediatric pelvic asymmetries do not remodel and deformities result in high morbidity.<sup>5,17,21</sup>

In the last few decades, surgical treatment of type B and C pelvic fractures in children has been promoted by several authors.<sup>1,3,15,19</sup> Unstable and displaced pelvic fractures (types B and C) should be reduced and stabilised.<sup>20</sup> External fixation is the preferred technique in the emergency setting because it can be applied rapidly, particularly in multi-traumatised patients.<sup>1,5</sup> In type C pelvic fractures, anterior external fixation may not be sufficient and placement of a C-Clamp is needed. In five patients, internal stabilisation of the SI joint was achieved with SI screws or plates over the SI joint, all of which were applied within 48 hours of the trauma. In the emergency setting, all of these patients were treated initially with an external fixator.

In this series, the percentage of severe pelvic fractures (types B and C) and mean ISS were high compared with those reported in the literature.<sup>1</sup> We treated 22% of the children operatively. In the literature, operative treatments are in the range of 0.6% to 30%.<sup>1,5,6</sup>

The high percentage of operative treatment in our clinic was the result of patient selection. Because our clinic is a level 1 trauma centre (and a national referral centre for pelvic and acetabular fractures), many severely injured patients are presented in our emergency room, which increased the number of unstable pelvic fractures and the ISS score.

The mean ISS of children differs from that of adults. It is questionable whether the method by which the ISS is calculated in adults can be applied to children.

A total of 50% of the paediatric patients had injuries in more than two regions close to the pelvic fracture. The incidence of associated injuries was similar to those of other series.<sup>1</sup> Intracranial injuries in particular have a substantial influence on prognosis and outcome.

In paediatric pelvic fractures, haematuria is a very common clinical finding and is usually present without significant injury of the urinary tract.<sup>5,6</sup> In this series, six patients (12%) were diagnosed with urogenital injuries. Others have reported associated genitourinary injury rates in the range of 6% of 24%.<sup>1,5,6,15</sup>

In contrast to adults, children have lower rates of exsanguinating haemorrhage. Blood transfusion requirements are approximately equal, but only two children had a large retroperitoneal hematoma. Perhaps this result is due to a more effective vasoconstriction response of less friable and non-atherosclerotic blood vessels.<sup>6</sup> All polytrauma patients, children and adults were resuscitated under supervision of one of the six trauma surgeons, in adherence to the hospital massive blood transfusion protocol. In case of haemodynamic instability, all patients (children and adults) are treated according to this protocol.

Mortality in our paediatric group was 6% which was comparable with other authors. However, the study by Marmor et al<sup>4</sup> reviewed the United States national databank and mortality was 10.2%. This might advocate treatment in specialised trauma centres with specific knowledge of treatment of the rare injuries.

This study was a retrospective analysis of collected data and thus may be subject to bias. Our conclusions regarding outcomes and effect on active daily life are based on data that were found on the medical chart. The follow-ups varied widely; therefore, no firm conclusions about the long-term results can be made.

Paediatric pelvic fractures are rare and differ from adults in aetiology, fracture type and associated injuries. They are observed in multi-trauma patients, with severe associated injuries. Treatment of these patients in specialised hospitals is likely to provide the best outcome because of the rarity of these fractures. Only a small percentage of the fractures need operative treatment. In a significant proportion of the operated patients, morbidity and mortality were not linked to the pelvic fractures, but to the associated injuries. Compared with adults, children die less often due to sequelae

of haemorrhage. Mortality does not differ between groups. Evaluation of functional outcome with the SF-36 and the Majeed questionnaire<sup>23</sup> is currently being studied in a prospective trial.

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### ETHICAL STATEMENT

This article does not contain any studies with human participants performed by any of the authors.

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