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Pediatric spine injuries after trauma: a review of 43 cases

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Abstract

Objective: To evaluate and review our experience with pediatric spinal injuries and factors affecting outcome, the authors conducted a retrospective clinical study of 43 cases (32 boys, 11 girls) of pediatric spine injuries treated during four years (January 1999 to December 2003).

Methods: Forty-three children with spinal injuries were studied retrospectively over four years and were divided into two age groups: 0-9 years and 10-17 years. We reviewed the level(s) involved, types of bony injuries, presence of spinal cord injury, treatment received, length of hospital stay, discharge status, any associated injuries, and any complications during the hospital stay. Analysis of variance and chi-square were used to analyze differences between groups.

Results: Motor vehicle accidents were the most common cause in this series. There were twelve patients aged 0-9 years and thirty-one aged 10-17 years. Spine injury incidence increased with age. There was 14% cervical, 46.5% thoracic, 34.9% lumbar, and 4.6% multilevel involvement. Thirteen patients had spinal cord injury. Spinal cord injury was more common in the 0-9 age group. One patient with spinal cord injury without radiographic abnormality (SCIWORA) was in the 0-9 age group and had complete neurologic injuries. Young children with spinal injuries were more likely to die than older children. The associated injuries were 25.7%. Twenty-five point six percent underwent decompression, fusion, and instrumentation. The complication rate in surgical patients was higher than in patients treated non-surgically and in multiply injured patients. This may be related to the severity of the initial injury.

Conclusion: Our results suggest age-related patterns of injury that differ from previous work. Potential for neurological recovery is good. Young children have a higher risk for death than older children. There was no predominance of cervical injuries in the young child. The incidence of SCIWORA was low. Higher complication rates were seen in polytrauma and surgical patients.

Keywords: spinal injury, children, spinal cord injury.

Introduction

Spinal injury in the pediatric age group presents a unique challenge. The failure pattern of the growing spine in children- due to special biomechanics and anatomy- is different from that of adults.

Spinal injury in the pediatric patient is a concern as prevention of further neurologic damage and deformity and the potential for recovery make timely identification and appropriate

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Gender/age groups	0-9 y	10-17y	Total
Male	7	25	32
Female	5	6	11
Total	12	31	43

Table 1. Gender distribution among age groups.

Etiology	0-9 y	10-17 y
MVA	76.7%	71%
Fall	23.3%	20%
Sport accidents	o	9%

Table 2. Mechanism of Injury among age groups.

treatment of such injury critical.

The incidence and age distribution of spine fractures in children have been reported previously[1,5] with some variations in the experience among the different study populations.

Methods

This retrospective study presents forty-three children who sustained injuries to the spinal cord or vertebral column seen at Kamyab Hospital, a neurotrauma center in Mashhad, Iran, from January 1999 to December 2003. Kamyab Hospital acts as a referral center for all trauma cases in Mashhad and the surrounding region. Patients with pathologic fractures or sacral fractures or those with injuries associated with congenital vertebral column anomalies were excluded. Birth injuries were also excluded. The frequency of pediatric spinal injury is 3%.

Medical records for each patient were reviewed, level(s) involved, type of bony injury, presence of spinal cord injury, treatment received, length of hospital stay, discharge status, any associated injuries, and any complications during the hospital stay were recorded.

Children were divided into two age groups for analysis: 0-9 and 10-17 years. This categorization allowed for comparison of age with mechanism of injury, injury pattern and level, incidence of cord injury, treatment, and outcomes. Analysis of variance and chi-square were used to analyze differences between age groups. Mean follow up period for our patients was 4 years.

Results

Five-hundred and thirteen spinal trauma cases in all ages were seen at Kamyab Hospital from January 1999 to December 2003. Forty-three pediatric cases with spine injuries were identified. There were 12 patients aged 0-9 and 31 patients aged 10-17. Sixteen point seven of the injured children aged 0-9 years sustained a cervical spine injury and 12.9% in the 10-17 group. This difference in spine injury incidence among the age groups is statistically significant at $P < 0.001$. The age range for the spine-injured patients was from 2 years to 17 years (mean 11.86 years). There were 31 boys and 12 girls. The male/female ratio was 1.4 in the first group and 4.25 in the second group (Table 1).

Motor vehicle accidents were the most common cause of injury across all age groups followed by falls and sports injuries (Table 2).

In young children (0-9 years), cervical injury was 5% and thoracic and thoracolumbar injury was 17%, while in older children (10-17 years) cervical injuries were 9% and thoracic and thoracolumbar were 29.5% (Table 3).

Cervical spine injuries were seen in 14% of the 43 patients (5% upper cervical, 10% lower cervical)(Fig. 1). 46.5% had thoracic and thoracolumbar involvement (Fig. 2).

34.9% had lumbar involvement and 4.6% multilevel involvement. The thoracic and thoracolumbar spine was the most commonly involved in the 0- to 9-year-old group (17%) and the 10- to 17-year-old group (29.5%). The lumbar and thoracic spines were involved equally in the 10- to 17-year-old group. Patterns of vertebral column injury were divided into four types: Simple fracture (compression fracture)

Level / Age	Cervical	Thoracic and thoracolumbar
0-9 y	5%	17%
10-17 y	9%	29.5%
Total	14%	46.5%

Table 3. Level of involvement.

was seen in 16 of 43 injuries (37.2%); Burst fracture was seen in 16 of 43 injuries (37.2%); fracture with subluxation or dislocation only was seen in 6 of 43 injuries (14%); and spinal cord injury without radiographic abnormality (SCIWORA) was seen in 1 of 43 injuries (2.3%); upper cervical fracture was seen in 3 patients (7%) and sagittal slice fracture was seen in 1 patient (2.3%)(Table 4). Due to the small numbers in the latter two groups, statistical comparisons between the age groups were not performed (Fig. 3).

Compression fractures over one or several levels were seen in 16 (37.2%) patients. Seven were in the thoracic spine, eight in the lumbar, and one lower cervical area. Minor fractures (i.e. spinous process or transverse process fractures) were not seen in any patients. There was one Chance fracture (2.3%) and 16 burst fractures (37.2%).

One Chance fracture was in a 14 year old boy. Three of the sixteen burst fractures were in children aged under 10 years. Four patients with burst fractures sustained cord injuries; three were complete (Frankle A) and the other was incomplete.

Fourteen (33.6%) patients had spinal cord injury. Eleven (25.6%) of these were complete cord injuries, and three (7%) were incomplete injuries. No neurologic deterioration was noted during any patient's hospital stay (Table 5). All patients with incomplete cord injuries showed neurologic improvement. A greater proportion of the children aged 0-9 sustained cord injury compared with the 10 to 17 year olds (54.5% compared to 45.55%), and this was statistically significant at P = 0.01.

Patients with a dislocation or fracture dislo-

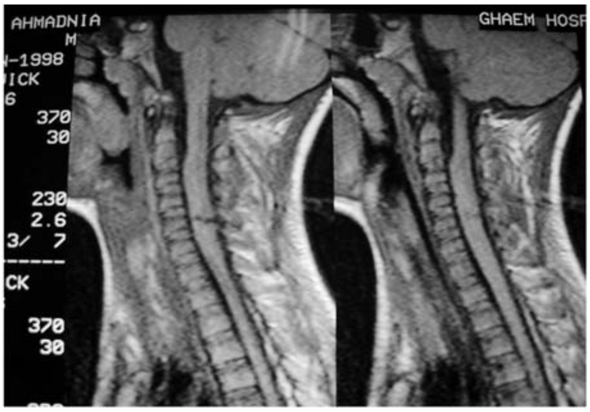

Fig.1. Spinal cord transsection at C6 level in an eight year old boy due to MVA.

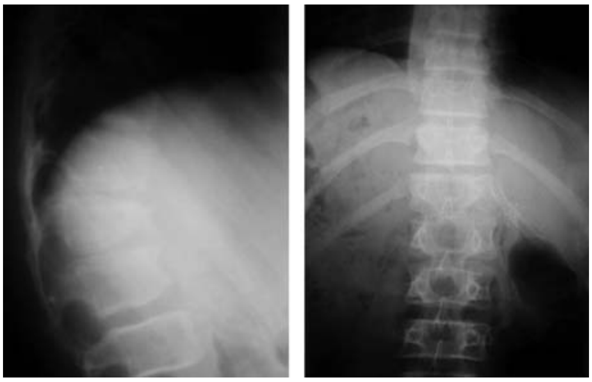

Fig. 2. T12 wedge fracture in a 12 year old boy due to a fall.

Fig. 3. T12-L1 fracture dislocation in a 17 year old boy due to motorcycle accident.

Age groups	Fracture						
	Burst Fx	Wedge Fx	Fx/dislocation	Upper cervical Fx	SCIWORA	Sagittal slice Fx	Total
0-9 y	4	4	3	0	1	0	12
10-17 y	12	12	3	3	0	1	31
Total	16	16	6	3	1	1	43

Table 4. Pattern of vertebral column injury among age groups.

Age groups	Neurological state					
	Frankle A	Frankle B	Frankle C	Frankle D	Frankle E	Total
0-9 y	6	0	0	0	6	12
10-17y	5	2	1	0	23	31
Total	11	2	1	0	29	43

Table 5. Type of neurologic injury among age groups.

cation were more likely (P < 0.001) to have injury to the spinal cord compared with pure fracture site (Table 6).

SCIWORA was seen in one patient that presented immediately after injury. There were two deaths (4.6%) due to respiratory insufficiency following high cervical injury and after one month supported with mechanical ventilation. Young children who sustain a cervical spine injury are more likely to die than older children.

Associated injuries excluding abrasions and minor lacerations were seen in 26.8% of patients. The most common extraspinal injury was mixed injury (multiply traumatized) including head trauma seen in 6 of 43 patients (14%) followed by isolated head injury in 3 (7%) and fractured limbs in 2 (4.7%). Head injuries were more commonly seen in patients with cervical spine injuries. Other extraspinal injuries were not related to the level of the spinal injury or to the patient's age.

Spinal surgery were performed in eleven patients (25.6%) during their hospital stay. Seven had unstable fractures and four had fracture dislocations. Ten patients underwent posterior stabilization, three of which had complete cord injuries, without improvement postoperatively, but four patients had sphincter problems which showed improvement 1-2 months postoperatively. One patient underwent anterior decompression and stabilization in the cervical region that had incomplete cord injuries while showing neurological improvement postoperatively.

One patient developed scoliosis on follow-up at 4 and 6 years who sustained complete cord injuries at the thoracic level.

Complication rate was 14% (6 patients). The most common complication was pneumonia followed by urinary tract infection and wound infection in one case. Two patients with respiratory insufficiency due to upper cervical injury died. Complication rates were comparable among the different age groups and the different fracture types.

Discussion

Children uncommonly develop spinal injury with reported frequencies of 1-10% [1,2,4], and is distinct from spine injury in adults. The pediatric patient is anatomically and biomechanically different, resulting in a unique injury profile compared with an adult patient. The child's spine is more flexible and mobile [5,6]. The neck muscles are underdeveloped, the vertebral bodies are wedge shaped, the facets are shallow and horizontal, and the interspinous ligaments are elastic and lax [6]. Our results confirmed

Type of neurological state	Level of injury				
	Cervical	Thoracic and thoracolumbar	Lumbar	Multilevel	Total
Frankle A	3	7	0	1	11
Frankle B	1	1	0	0	2
Frankle C	0	1	0	0	1
Frankle D	0	0	0	0	0
Frankle E	2	11	15	1	29
Total	6	20	15	2	43

Table 6. Type of neurologic Injury among different levels of vertebral column Injury.

age-related patterns of injury seen in earlier studies but also revealed findings that are significantly different from previously published work.

Categorization of the subjects by age was done to allow us to assess differences in injury patterns. The under 10 years old group represent the young immature spine and the over 10 years old group represent the mature adolescent spine (which closely resembles the adult spine). Maturation of cranial and cervical bony morphology after the age of 8 years leads to more adult-like patterns of cervical spinal injury after trauma. During the later stage of development, the facet joints become more vertically oriented and the decreasing ratio of head to torso size moves the center of cervical spine sagittal rotation down to the C5 to C6 level. By the time a child reaches 11 to 12 years of age, injuries to the cervical and thoracolumbar spine resemble those seen in the adult population [7,8].

Older children had a higher risk of sustaining spine injuries after trauma than younger children. This finding is similar to previous studies that report an increasing frequency of spinal injury with age [1,2,9]. This may be reflective of the protective effect of a flexible spine in the younger child.

The most common cause of injury was motor vehicle accidents in the present study. This is similar to other studies [9,10].

The second most common cause of injury was falls. There was no spine injury caused by documented child abuse. Previous studies have uniformly shown a predominance of cervical spine injuries in the younger population [9,11]. Biomechanical factors, specifically the relatively large-sized head compared with the torso in the young child, have been implicated in the high incidence of cervical spine injuries in the young child compared with their older counterparts [1,9]. However, our series showed that the different regions of the spine were affected in a similar manner among the various age groups. Only one other study has shown the lack of predominantly upper cervical spine injuries in the young child [12].

Multiple level spinal injuries were observed in two patients (4.6%). Previous studies reported an 11-16% incidence of multiple level spine involvement in children [11,12]. The dissipation of the energy of trauma through a smaller body may explain the high incidence of multilevel and noncontiguous level involvement [13].

Various minor and major spinal injuries were seen such as spinous process avulsion, fractures as well as severe fracture-dislocations. A large majority of our patients presented with the fracture-only injury pattern. Most of these were compression fractures comprising 37.2% of the study cases. Compression fractures of the thoracic spine are fairly common owing to the wedge shape of the immature vertebral body and the presence of a natural kyphosis. Support from the rib cage prevents excessive translations and dislocations [12,13]. Burst fractures were exclusively seen in the older child.

A higher incidence of neurological deficits was seen in children with a dislocation or fracture-dislocation than children with fracture alone. This is to be expected as dislocation causes larger degrees of displacement than pure fracture types, and the force required to produce such a displacement must be greater.

Observation of only one child with SCIWORA which represented 2.3% of this patient series is much lower than reported previous series [1,14]. This is lower than in any other series where the reported incidence of SCIWORA has been 13-67% [14]. The lower incidence may be reflective of the increasing sensitivity and use of newer imaging modalities [1,15].

Since the study was retrospective and institution based, children who sustained spine injuries and died on the scene were not identified and included in the study. Thus the mortality rate in our cases may not be accurate. This is a much lower rate than those of Kewalramani et al [16] (58%), which was a population-based study, and Hamilton and Myles [17] (45%), who looked at all pediatric autopsy cases in their region. All previous studies and the current study have shown that the more serious and fatal injuries occurred in younger children. The ligamentous laxity and increased mobility in the immature spine may be protective in relatively minor trauma but allow lethal distraction injuries during the force of trauma associated with motor vehicular accidents.

Head injury was the most common extraspinal injury. These were more commonly associated with cervical spine injuries. This is similar to previous studies published on pediatric cervical spine injuries [10,16].

Conservative management was the major treatment modality, with only 25.6% requiring surgery for unstable or irreducible spinal injuries and/or decompressing the spinal cord.

Only 1 of the 11 patients with complete spinal cord injuries developed scoliosis following paraplegia which is in marked contrast to previous reports of a 92% incidence of scoliosis after childhood paraplegia [18]. This may be due to incomplete follow up in our series.

A complication rate of 18.7% was comparable with other studies. The higher complication rate in patients who underwent surgery may be reflective of the severity of the initial injury and not a consequence of the surgery itself, as patients with polytrauma also had a higher complication rate compared with those with isolated spine injuries [13,18].

Conclusion

This study supports previous findings that young children who sustain spine injuries have a higher incidence of cord injury and are at greater risk of death than older children, the most common cause of spine injury is motor vehicle accidents, and young patients who sustain cord injury have a good chance for recovery or improvement. In contrast, we saw no preponderance of cervical spine injuries in the younger child. We report a low incidence of SCIWORA and a low incidence of deformity after paraplegia in childhood.

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