



# Pediatric Cervical Spine Injuries

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## Abstract

**Objective** Pediatric cervical spine injuries are rare and account for 1 to 2% of all pediatric spine injuries. There is a paucity of data on pediatric cervical spine injuries in developing countries like India. The purpose of this study is to review and analyze our 5 years of experience with pediatric cervical spine injuries.

**Methods** All the available medical records over the 5 years were reviewed retrospectively. The data was analyzed to know the epidemiology, mechanism of injury, injury patterns, management, and outcome. The patients were divided into two groups: 0 to 9 years and 10 to 18 years.

**Results** Seventy-five eligible records were included in our study. The incidence of cervical spine injuries was significantly lower in younger children than the older ones ( $p < 0.042$ ). The most common mechanism of injury was fall from height: 33 (44%) patients followed by road traffic accidents: 27 (36%) patients. The involvement of the upper cervical spine was significantly higher in younger children ( $p < 0.001$ ). Fractures with subluxation were the most common pattern of injury, observed in 35 (47%) patients. However, fractures with subluxation were uncommon in younger children compared with older children ( $p < 0.04$ ). Spinal cord injury without radiographic abnormality (SCIWORA) was observed in 42% of younger children compared with 8% of older children ( $p < 0.02$ ). Thirty (40%) patients were managed surgically; anterior cervical corpectomy with fusion was the most commonly performed procedure in 19 (63%) patients. The overall mortality was 20%.

**Conclusion** The results of our study revealed predominant involvement of the upper cervical spine in children younger than 10 years of age. SCIWORA was documented in both the age groups with a significantly higher incidence in younger children. The instrumentation and fusion techniques in children are safe; however, developing pediatric spine needs special considerations.

## Keywords

- ▶ pediatric
- ▶ cervical spine injury
- ▶ SCIWORA

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## Introduction

Pediatric spine injuries are uncommon and account for only 1 to 10% of all spine injuries.<sup>1</sup> A similar incidence of 1 to 11% is also found in the Indian population.<sup>2</sup> The reported incidence of cervical spine injuries in children is 1 to 2% only.<sup>3</sup> However, the cervical spine is the most commonly involved region and accounts for 60 to 80% of all pediatric spine injuries.<sup>4–6</sup> The pattern of injuries and outcomes is different in pediatric patients in comparison to adults. This may be attributed to the different anatomy and biomechanics.<sup>7</sup> The upper cervical spine is more commonly involved in younger children compared with older children in whom involvement of the lower cervical spine is common.<sup>8,9</sup> There is a paucity of data on pediatric cervical spine injuries in the Indian population. Therefore, this study aims to analyze 5 years of data and describe the epidemiology and outcomes of pediatric cervical spine injuries admitted at our center.

## Materials and Methods

This is a retrospective observational study. A total of 75 records were found adequate after searching the patient database for cervical spine injury in children up to 18 years of age who were admitted from January 2015 to December 2019 in Neurotrauma ward, Trauma Centre at King George's Medical University, Lucknow, India. The incomplete datasets and patients with preexisting congenital cervical spine anomalies were excluded from the study. All the eligible medical records including plain radiographs, computerized tomography (CT), and magnetic resonance imaging (MRI) were reviewed. The neurological status was assessed according to the American Spinal Injury Association (ASIA) impairment scale.<sup>10</sup> Analysis of medical records was done in terms of age, gender, mechanism of injury, level of injury, type of injury, the severity of the injury, associated injuries, treatment received, and outcome at follow-ups. Patients were grouped in two age groups: 0 to 9 years and 10 to 18 years. Statistical analysis of categorical variables was done using the Pearson  $\chi^2$  test. Ethical approval for conducting this study was taken from the Institutional Ethics Committee.

**Table 1** Gender distribution in study patients (n = 75)

Gender	0–9 years	10–18 years	Total
Male	7 (9%)	53 (71%)	60 (80%)
Female	5 (7%)	10 (13%)	15 (20%)
Total	12 (16%)	15 (84%)	75 (100%)

## Results

After reviewing all the medical records over 5 years, a total of 75 records were included in our study. There were 12 (16%) patients in 0 to 9 years and 63 (84%) patients in (84%) 10 to 18 years age group. The mean age was  $11 \pm 1.5$  years (range: 3–18 years). The age-wise incidence of cervical spine injuries was statistically significant ( $p < 0.042$ ). The male-female ratio was 4:1. The boys (60; 80%) sustained cervical spine injuries more than girls (15; 20%). Gender distribution among the age groups is shown in **Table 1**.

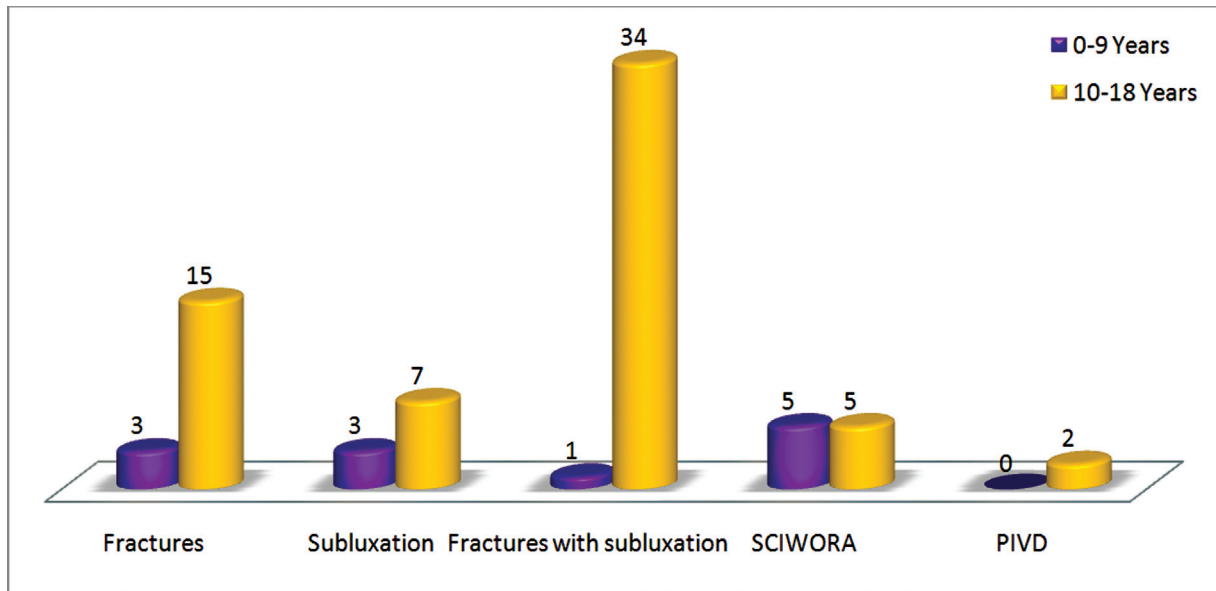
The two most common mechanisms of injury were fall from height (FFH): 44% followed by road traffic accidents (RTA): 36% (**Table 2**). Among the FFH-related injuries, 26 (79%) were boys and 7 (21%) were girls. The FFH was the most common mechanism of injury in the 0 to 9 years age group, but in the 10 to 18 years age group, both the mechanisms were almost equally common. The other uncommon mechanisms were machine injury, train accidents, diving into the river or swimming pool.

The upper cervical spine was involved in 16 (21%) patients, while the lower cervical spine was involved in 59 (79%) patients. The incidence of upper cervical spine injuries was higher in the 0 to 9 years age group, while 75% had upper cervical spine injuries ( $p < 0.001$ ). Similarly, lower cervical spine injuries were more common in older children ( $p < 0.001$ ). The most common pattern of injury was the fractures with subluxation that was found in 35 (47%) patients. However, fractures with subluxation were uncommon in younger children compared with older children ( $p < 0.04$ ). The other common patterns were isolated fractures: 18 (24%) patients and pure subluxation: 10 (13%)

**Table 2** Mechanism of injury in study patients (n = 75)

Mechanism	0–9 years	10–18 years	Total
FFH	7 (9%)	26 (35%)	33 (44%)
RTA	4 (5%)	23 (31%)	27 (36%)
Fall of objects	0	6 (8%)	6 (8%)
Fall from train	0	2	2 (3%)
Machine injury	1 (1%)	1 (1%)	2 (3%)
Diving	0	2 (3%)	2 (3%)
Fall into a pit	0	1 (1%)	1 (1%)
Firearm injury	0	1 (1%)	1 (1%)
Assault	0	1 (1%)	1 (1%)

Abbreviations: FFH, fall from height; RTA, road traffic accident.



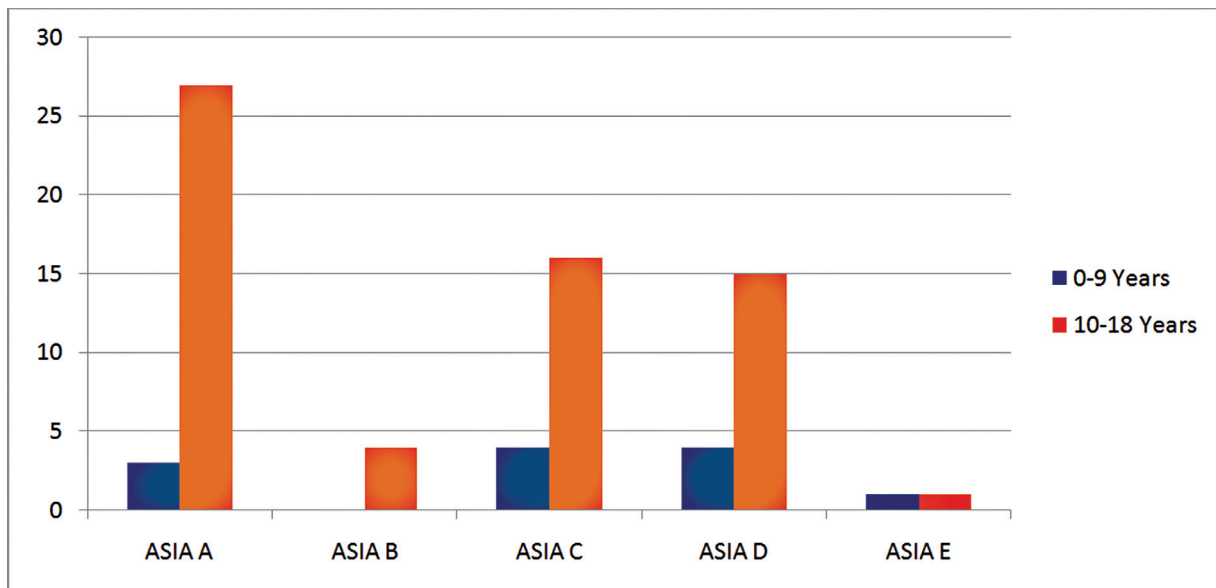
**Fig. 1** Pattern of injury (n = 75). PIVD, prolapsed intervertebral disc; SCIWORA, spinal cord injury without radiological abnormality.

patients (► **Fig. 1**). Spinal cord injury without radiographic abnormality (SCIWORA) was observed in 42% of younger children compared with 8% of older children ( $p < 0.02$ ). The most common associated injury was long bone fractures in eight (11%) patients, followed by head injury in two (3%) patients, brachial plexus injury in one (1%) patient, and facial injuries in one (1%) patient.

All the patients had spinal cord injuries. Thirty-one (41%) patients had complete and 44 (59%) patients had incomplete injuries. The most common neurological deficit was ASIA grade A in 30 (40%) patients followed by ASIA grade C and D (► **Fig. 2**). All the boys (7; 58%) in 0 to 9 years age group had incomplete injury, whereas complete injury was more common in older boys (21; 33%).

The 30 (40%) patients were managed surgically, whereas 45 (60%) patients were treated conservatively. Among the surgical arm, anterior cervical corpectomy with fusion (ACCF) was the most commonly performed procedure in 19 (63%) patients, followed by anterior cervical discectomy with fusion (ACDF) in 6 (20%) patients. The anterior odontoid screw placement was performed in two (7%) patients and one (3%) patient underwent anterior odontoid screw placement with ACCF. Posterior C1 to C2 fixation was done in 1(3%) patient and in another one (3%) patient, C1 to C2 laminectomy with foreign body removal was done.

The mean follow-up was 42 months (12–72 months). Out of 75 patients, follow-up was available for 20 patients. After admission, 13 (17%) patients went leave against medical



**Fig. 2** Severity of injury (n=75). ASIA, American Spinal Injury Association impairment scale.

**Table 3** Comparison of ASIA grading at admission and follow-up

Admission	ASIA A	ASIA B	Follow-up ASIA C	ASIA D	ASIA E
ASIA A	1		1		
ASIA B			1		
ASIA C			1	2	2
ASIA D				3	7
ASIA E					2

Abbreviation: ASIA, American Spinal Injury Association.

advice (LAMA) after knowing poor prognosis and financial constraints. Eleven (15%) patients were expired during the hospital stay and a further four (5%) patients succumbed to death after discharge in their follow-up period. Another 27 (36%) patients were lost to follow-up. Among 20 patients who were available for follow-up, 13 patients had improvement in at least 1 grade in ASIA grading, and the rest 7 patients were in the same neurological status (► **Table 3**).

## Discussion

The pediatric spinal column is more elastic and flexible to the external forces. This inherent hypermobility of the pediatric spine is both a boon and bane. On one hand, it permits significant movement between spinal segments without damage, but on another hand, it renders the spinal cord more prone to injuries. In a study by Leventhal, the spinal column could lengthen by 2 “without damage while the spinal cord by 0.25.”<sup>11</sup> Therefore, in very young children, spine trauma can inflict spinal cord damage much earlier than vertebral column injury. Several anatomical and physiological characteristics make the pediatric spine unique in comparison to the adult spine. The ligaments and joint capsules are elastic, facet joints are shallow and more horizontal, expansile intervertebral disc, anteriorly wedged vertebral bodies, and delicate neck muscles.<sup>12</sup> These features are responsible for different spine injury profiles in pediatric patients.<sup>13,14</sup>

The stratification of patients in two age groups allows for better comparison of the incidence of the mechanism of injury, injury patterns, and other variables. Birth to 9 years represents an immature spine. By 9 years of age, the tensile strength of ligaments and capsule increases, facets become more horizontal, and anterior wedging of vertebral bodies disappears. By the 18 years, it becomes closely similar to the adult spine.

Seventy-five children were included in the present study, the incidence of cervical spine injury was lower in the children of 0 to 9 years age group, only 12 (19%) children were aged 9 years or less compared with 63 (81%) in 10 to 18 years age group. A similar finding was noted in other studies too.<sup>5,15</sup> In the study by Hill et al among 122 children with neck injuries, 17% were below 9 years of age.<sup>13</sup> Another study reported by Apple et al also showed a lower occurrence of cervical spine injury in children younger than 8 years.<sup>16</sup> In this study, 17% of 29 children were below 8 years. This

relatively lower incidence of cervical spine injury in children below 8 to 9 years can be attributed to the hypermobility and elasticity of ligaments and joint capsule that can withstand more deformation before it fractures.

The most common mode of injury in both the age groups was FFH that accounts for 44% of injuries followed by RTA: 36%. In the Indian population and other developing countries, FFH is the most common mechanism of injury.<sup>17–19</sup> However, in developed countries most common etiology is motor vehicle accidents.<sup>20,21</sup> This reflects the socioeconomic differences between the developed and developing countries. Children are prone to injuries while playing. In one study by Finch et al, the most common cause of injury was sports or recreational activities, noted in 66% among 32 children.<sup>22</sup> However, in our study, only two (3%) children were injured during sports or recreational activities.

In the current study, nine (75%) children in the 0 to 9 years age group had upper cervical spine injuries, while older children had predominantly lower cervical spine involvement that was seen in 56 (89%) children. This finding was similar to several other studies.<sup>13,16,20,22,23</sup> This may be attributed to different biomechanical characteristics of the cervical spine in younger children compared with older children. Younger children have a relatively larger head and weaker neck muscles. The fulcrum of movements in younger children lies in the upper cervical spine. As the spine matures with age, neck muscles become stronger and head size becomes smaller. These changes shift the fulcrum to the lower cervical spine in older children similar to the adult spine.

The pattern of cervical spine injuries ranges from soft tissues injuries to bone fractures, subluxation, and SCIWORA. In our study, the most common radiological finding was fractures with subluxation. This was noted in 35 (47%) children. The term SCIWORA was first introduced and described by Pang and Wilberger in 1982 for the traumatic myelopathy in the absence of radiological findings on plain/flexion–extension radiographs or CT scans.<sup>24</sup> With the advent of clinical MRI in the early 1980s, those patients who were used to be diagnosed as SCIWORA started showing abnormalities on MRI. The MRI findings can be contusions in the spinal cord, disc injury, ligamentous and capsule injury.<sup>25,26</sup> The incidence of SCIWORA varies in the literature; however, it ranges between 3.3 and 34%.<sup>27,28</sup> In our series, the overall incidence of SCIWORA was 13%. However, a higher incidence was noted in children younger than 10 years, similar to the other

studies.<sup>29,30</sup> The greater elasticity and tenuous blood supply of the spinal cord can be accounted for a higher incidence of SCIWORA in younger children.

In the present study, all the children sustained neurological deficits. This is contrary to current literature that shows that neurological deficits are uncommon in children.<sup>3,4</sup> Also, incomplete injuries are more common in younger children.<sup>3,31</sup> In our series, 75% of children in the 0 to 9 years age group had incomplete injuries compared with 57% of children of the 10 to 18 years age group. This difference in the incidence of incomplete injury again can be due to differences in the anatomical and physiological characteristics of their spine.

The majority of pediatric cervical spine injuries can be managed conservatively with external immobilization. In this series, 30 (40%) patients were managed surgically and the ACCF was the most commonly performed procedure in 63% of patients. Most other series have documented a similar proportion of surgical intervention: 16–33%.<sup>31,32</sup> Patients who were managed conservatively had a short course of steroids, external orthosis, and limb physiotherapy.

The recovery of neurological functions is better in children compared with adults and incomplete injuries are associated with better prognosis. The follow-up was available for 20 patients. Thirteen patients had improvement in at least 1 grade in ASIA grading and 11 patients were ambulatory at their last follow-ups. Fifteen patients (20%) expired in our study that is comparable to other studies.<sup>20,33</sup> Twelve patients who expired belong to ASIA grade A and nine of them had respiratory involvement. The other three patients belong to ASIA grade B (1) and C (2) and all of them had polytrauma.

## Conclusion

Pediatric cervical spine injuries are associated with a high rate of neurological deficits and mortality rate as observed in our study. Even the children who survive the injuries have to live with deficits and psychosocial disturbances. Their family too suffers a lot from financial and emotional burdens. Therefore, the prevention of these fatal injuries is of paramount importance. Parental supervision is warranted during indoor and outdoor activities of young children. The use of seat belts and car seats may help in preventing cervical spine injury in younger children. Besides this, adolescents should be discouraged from unauthorized and unsafe driving. The practice of teaching traffic rules and safety measures for the prevention of spine injuries at the school level may have a positive impact on preventing these devastating cervical spine injuries.

### Conflict of interest

None declared.

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