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Spinal Injury in Indian Children: Review of 204 Cases

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Abstract

Study design: Retrospective study.

Objective: The purpose of the study was to analyze the epidemiological parameters and associated factors after spinal cord injury (SCI) in children, in the last 14 years admitted at a tertiary care center (Indian Spinal Injury Centre [ISIC], New Delhi, India).

Method: The demographic and injury-related data was analyzed descriptively. The incidence, type, and level of injury were compared across the age groups using a χ^2 test. Wherever appropriate, Fisher exact test was used.

Results: There were 1660 pediatric trauma cases admitted at ISIC from 2002 to 2015, where 204 cases presented with spine injuries. The average age of children sustaining spine injury was 15.69 years (3-18 years of range). There were 15 patients in the age group 0 to 9 years, 27 patients in the age group 10 to 14 years, and 162 patients in the age group 15 to 18 years. This difference in spine injury incidence among the age groups was statistically significant. Fall from height was a common mode of injury. In our sample, boys were 3 times more likely to be injured than girls. Burst fractures were common among the type of injuries.

Conclusion: Our study confirms the predominance of cervical spine injury and the high incidence of multilevel contiguous with a lesser percentage of noncontiguous multilevel spinal involvement. SCIWORA (spinal cord injury without radiological abnormality) incidences were in a similar context to the literature available. There was a very low incidence of death. Neurological improvement was seen in 8 operated cases and 4 conservatively treated cases.

Keywords

pediatric, children, spinal cord injury, SCIWORA, trauma

Introduction

Spinal injury includes injury to the vertebral column and the spinal cord. In children, it accounts for 1% to 10% of total spinal injuries, and it is rarer in children below 5 years of age.[1-7] Although not particularly common in children, spinal injuries may result in more serious complications in physical, social, and mental health when compared with adults. This is exacerbated by the extended years' post-injury, thus creating an increased potential for severe limitations.[8] In fact, spinal injury in children could occur without any evidence of bone or soft tissue injuries.[9] Primary differentiating factors in children include injury mechanism, level of injury, and gender distribution.[7] Pediatric spinal injuries are classified according to morphology into bony injuries, ligamentous injuries, bony and ligamentous involvement, and spinal cord injuries without bony or ligamentous abnormality (SCIWORA).[10] Arresting further neurological deterioration and deformity improves chances of a good recovery in pediatric cases but timely identification and treatment of spinal injury are critical to the process.[11] Pediatric patients with traumatic spinal cord injury (SCI) exhibit a more robust neurological recovery potential compared with adults owing to their unique mechanisms of injury. Uncovering further characteristics of SCI in children,

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which are not evident in the adult population, will lead to an enhanced understanding of pediatric SCI cases and improved patient outcomes. Therefore, the study was designed to analyze the epidemiological parameters and associated factors in children with SCI admitted at the Indian Spinal Injuries Center (ISIC) in the last 14 years.

Materials and Method

A retrospective data analysis of pediatric cases (up to 18 years) with an SCI diagnosis was conducted for patients admitted at ISIC between 2002 and 2015. Children with birth injuries and other pathological anomalies were excluded.

Data including demographics and other details such as cause of spinal injury, neurological findings at admission, and discharge using the International Standards for Neurological Classification of Spinal Cord Injury—American Spinal Injury Association Impairment Scale (ISNCSCI-AIS), associated injuries, radiological findings, management received, steroids given, complications during hospital stay, and outcomes of the management were collected from medical records. The study was approved by the Institutional Ethics Committee of Indian Spinal Injuries Centre, New Delhi, India.

The subjects were divided into 3 age groups: I, II, and III, 0 to 9 years, 10 to 14 years, and 15 to 18 years,[11] respectively, for a better understanding of prevalence and mechanism of various injury patterns and other factors with respect to age. The demographic and injury-related datasets were analyzed descriptively. The incidence, type, and level of injury were compared across the age groups using a χ^2 test. Injury to the vertebral column was categorized into 4 types: fracture without subluxation or dislocation, fracture with subluxation or dislocation, SCIWORA, and dislocation or subluxation only. Wherever appropriate, Fisher exact test was used. The P value of <.05 was considered statistically significant. SPSS version 10 was used.

Results

There were 1660 pediatric trauma cases admitted at ISIC between 2002 and 2015, of which 438 were in group I, 435 in group II, and 787 in group III. We identified 204 cases with spine injuries from the medical records. The average age of children with spine injury was 15.69 years, ranging from 3 to 18 years. There were 15 patients (3%) in group I, 27 patients (6%) in group II, and 162 patients (21%) in group III. This difference in spine injury incidence among the age groups was statistically significant ($\chi^2 = 97.1$, degrees of freedom = 2, $P < .0001$). Among the spinal injured, boys (77%) were more vulnerable to injury than girls (23%). Group-wise distribution of boys was 11, 22, and 124 and girls was 4, 5, and 38 in groups I, II, and III, respectively.

Table 1 describes the mode, level, and type of injury across the age groups. Fall from height (FFH) was the most common cause of spinal injury, followed by road traffic accidents (RTA). The cervical spine was the highest involved region followed by the thoracic and lumbar regions. Among cervical-level injuries, 9% of subjects had upper cervical and 91% had subaxial involvement. The occurrence of upper cervical injuries (occiput to C2) was the same across all age groups (3 cases each in groups I and III and 2 cases in group II). Group III showed a predominance of all regional-level injuries. The proportion of subjects with thoracic level involvement was same in both groups I and II. There was only one sacral injury in group III. Twenty (9.5%) children had junctional level injuries that are cervicothoracic and thoracolumbar injuries. The fracture was the most evident type of injury, with 57%, followed by a fracture with dislocation or subluxation and pure dislocation or subluxation injury, with 25% and 11% correspondingly.

Table 1. Description of Mode, Level, and Type of Injury Across Age Groups.

	0-9 Years	10-14 Years	15-18 Years	Total (N = 204)
Mode of injury				
FFH	5	13	85	103 (50.4%)
RTA	8	8	63	79 (39%)
Sports	0	5	10	15 (7.2%)
Others	2	1	4	7 (3.4)
Level of injury				
Cervical	6	13	61	80 (40%)
Thoracic	7	7	44	58 (31%)
Lumbar	2	5	36	43 (19%)
Cervicothoracic	0	0	2	2 (1.5%)
Thoracolumbar	0	1	17	18 (8%)
Sacral	0	0	1	1 (0.5%)
Type of injury				
Dislocation	1	2	19	22 (11%)
Fracture	6	20	92	118 (57%)
Fracture dislocation	2	3	46	51 (25%)
SCIWORA	6	2	5	13 (6%)

Abbreviations: FFH, fall from height; RTA, road traffic accident; SCIWORA, spinal cord injury without radiological association.

The manifestation of single-level, multilevel contiguous, and noncontiguous injuries among the age groups were not different ($\chi^2 = 8.52$, degrees of freedom = 4, $P = .07$; Table 2). Figure 1 shows a group-wise injury-level involvement in the multilevel contiguous pattern.

Compression-type fractures were mainly in group III (n = 9) and prevalent in the thoracic region (5 out of 9). There were 30 burst fractures in the lumbar region (90%), 7 in the cervical region, mainly in group III but none in group I. Group II had 1 cervical and 2 thoracic burst fractures. There was a case of chance fracture at L1 in group III. This case was admitted with a history of RTA and exhibited (ISNCSCI) AIS A neurological findings with an associated abdominal injury. Fracture with subluxation or dislocation cases were 90% in group III, predominantly comprising the cervical spine and mostly resulted due to FFH. Dislocation/subluxation was in 11% of cases, mainly in the cervical region either due to RTA in 7 cases or FFH in 6 cases (Table 3).

SCIWORA was found in 13 children of the total population (6%) with an average age of 11 years, and group I documented

46% of these cases. Most of the SCIWORA incidents were in the thoracic spine (10 of 13) and were the result of either FFH (7 of 13) or RTA (4 of 13). Nineteen children sustaining junctional-level injuries had mostly fractures (15), mainly in group III (Table 1), and in most of the instances, 63%, were due to FFH (Table 3).

There were 41 children with associated injuries, which accounted for 20% of SCI patients; most of them were in group III. Extra spinal involvement consisted of head injury, abdominal injury, chest injury, and limb injuries, which were very small in number and could not be compared statistically. Children having complications during hospital stay were 16%, of which 14% were in group II and 2% in group III. Pressure sores (7.3%) and urinary tract infection (2.4%) were more common. The complication rate in patients who had surgery (16.8%, 22/131) was higher than for those who were not operated (13.7%, 10/73). Mostly these complications were noticed in AIS A (13.7%) and AIS B (1.4%) patients.

Table 2. The Number of Levels Involved and Type of Management Done Across Age Groups.

	0-9 Years	10-14 Years	15-18 Years	Total
Levels involved				
Single level	5	20	77	102 (50%)
Multiple levels	1	1	7	9 (4%)
Multiple contiguous levels	9	6	78	93 (46%)
Type of management				
Not operated	12	12	49	73 (36%)
Operated	3	15	113	131 (64%)

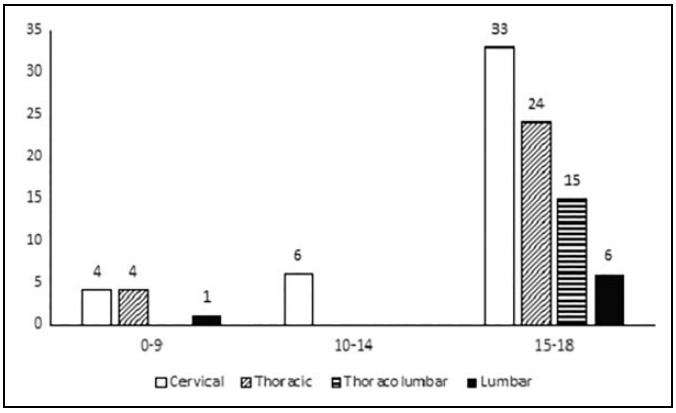


Figure 1. Level of injuries involved group-wise in the multilevel contiguous pattern.

The neurological finding was assessed at admission and discharge using the ISNCSCI-AIS scale. Figure 2 shows the comparison of AIS grades within different age groups. The association of mode of injury and level of injury with the type of injury is shown in Figure 3. Group III recorded highest number (84%) of AIS I cases; most of them were fracture cases and either resulted from FFH or RTA but they were almost equal in number in the cervical and thoracic regions. Seventy percent (92/131) of operated cases had complete injuries (AIS A). Children managed surgically and conservatively were 131 (64%) and 73 (36%), respectively (Table 2). Eight operated cases (1A → B, 1D → E, 3A → C, and 3B → C) and 4 conservatively treated cases (1A → C and 1B → C and 2D → E) improved in AIS grades, while one case in each category deteriorated. The outcome was assessed on the basis of children's neurological status at the time of discharge. Improvement in neurology observed is depicted in Table 4.

Children were categorized into fully dependent, partially dependent, and independent based on their neurological status at the time of discharge. Therefore, we found 62% dependent (poor outcome), 25% partially dependent (fair outcome), and 13% independent (good outcome) cases as the outcome of the injury. There were 2 deaths documented due to head injury and multiorgan failure.

Discussion

Children spinal anatomy and biomechanics are distinctive due to their immature neck muscles, wedge-shaped vertebral bodies, shallow and horizontally oriented facets, and elastic and lax

Table 3. Incidence of Level of Injuries Across Mode and Type of Injury.

	Cervical	Thoracic	Lumbar	Cervicothoracic	Thoracolumbar	Sacral	Total
Level of injury with MOI							
RTA	34	28	11	0	7	0	80 (39.2%)
FFH	30	27	31	2	10	1	101 (50%)
Sport	13	0	1	0	0	0	14 (6.8%)
Others	4	3	1	0	1	0	9 (4%)
Level of injury with TOI							
Dislocation	17	4	1	0	0	0	22 (11%)
Fracture	48	26	37	0	6	1	118 (58%)
Fracture dislocation	12	20	5	2	12	0	51 (25%)
SCIWORA	4	8	1	0	0	0	13 (6%)

Abbreviations: MOI, mode of injury; RTA, road traffic accident; FFH, fall from height; TOI, type of injury; SCIWORA, spinal cord injury without radiological association.

interspinous ligaments.[12] This makes the children's spines more flexible and mobile. These unique features offer great protection from trauma and lead to a unique injury profile compared with adults.[13,14]

Spinal injury in children is not common and the reported incidence is merely 1% to 10%. Children exhibit varying age-related injury patterns observed through age-based grouping. Children under 9 years signify the young immature spine, and on the other end of the spectrum, those over 15 years symbolize a developed youthful spine much closer to the fully formed adult spine. Our study concurs with previous studies concluding that older children are more prone to sustaining an injury after trauma compared with younger children.[1,2,5,6,15] This recurring conclusion reestablishes the flexibility of a young spine that offers children protection from injuries.[12]

In our study, falls were the most common mode of injury followed by RTAs.[1,4,7,15] This observation is completely different from Western statistics where RTA is found to be more common than falls. Adolescent children sustain spinal injuries primarily due to falls from roof, tree, or tractors. Children inflict traumatic injuries as they tend to climb up trees to pluck fruits, jump from one terrace to another, or slip from roof while flying kites. Sports-related injury contributed to 6% of total injuries and was mainly found in the adolescent group. This observation was in line with published literature (7%).[11] Other causes included gunshot injuries, fall of a heavy object, and being trapped in a machine.

The prevalence of cervical spine injuries in children was in agreement with the literature.[1,5-7,16] Overall, cervical spine injuries were common in the adolescent age group. A possible explanation for the predominance of cervical spine injuries in children is biomechanical aspects like the relatively large size of the head in comparison to torso.[1] The incidence of thoracic-level involvement was also evident and both cervical and thoracic injuries were nearly the same in groups I and II.

Injuries involving the junctional region cervicothoracic and thoracolumbar levels are highly unstable since most of them are fractures with dislocations. The majority of these injuries were complete (AIS A) and none of these patients showed improvements until discharge. The current study shows that half of all children had multiple spinal injury level involvement. We found only 4% of the injuries at the multilevel non-contiguous level, which is in contrast to the incidence (7% to 16%) reported.[2,7] The authors reported on this issue to the hyperflexibility of young spinal column.[2,15] However, this cannot be the sole explanation since children in the adolescent age group with less flexible spines also have injuries at multiple levels. The impact of trauma passing through a small body may explain the high degree of multilevel involvement.[12]

The fractures were predominant in the adolescent age group. Most of these fractures were at the cervical level. This is different from the available literature wherein thoracic-level fractures have been reported more commonly.[12] Burst fracture was the main type of fracture followed by a compression fracture type. These burst fractures were mainly in group III and also at the lumbar level. The high incidence of neurological involvement was evident in patients with a fracture or fracture-

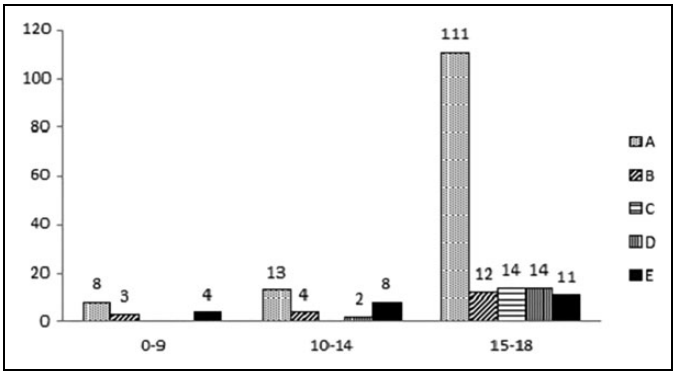
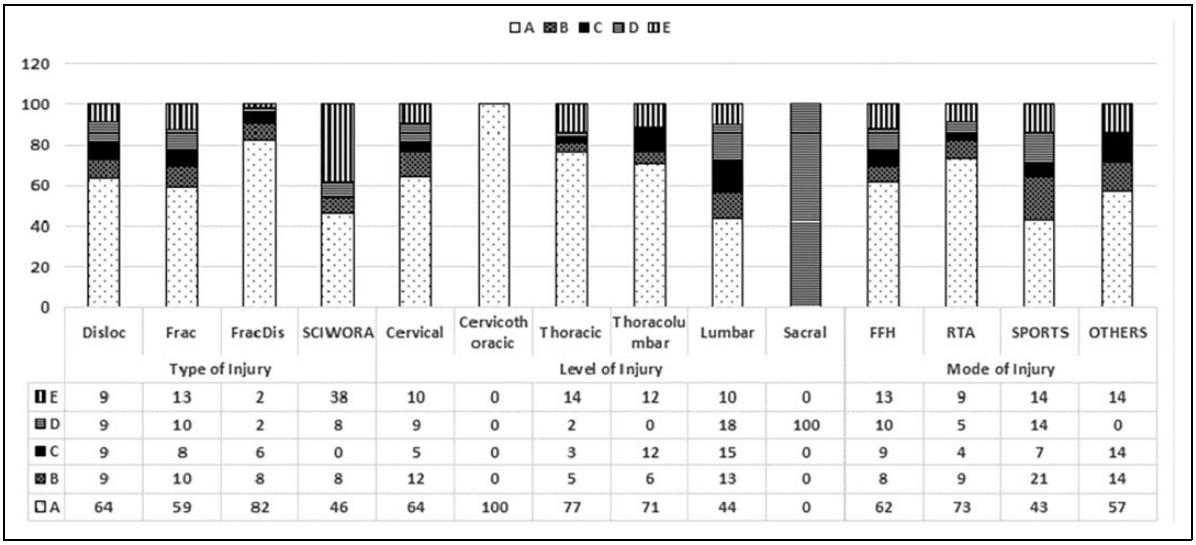


Figure 2. Comparison of AIS grades within different age groups.



	Disloc	Frac	FracDis	SCIWORA	Cervical	Cervicothoracic	Thoracic	Thoracolumbar	Lumbar	Sacral	FFH	RTA	SPORTS	OTHERS
	Type of Injury				Level of Injury						Mode of Injury			
E	9	13	2	38	10	0	14	12	10	0	13	9	14	14
D	9	10	2	8	9	0	2	0	18	100	10	5	14	0
C	9	8	6	0	5	0	3	12	15	0	9	4	7	14
B	9	10	8	8	12	0	5	6	13	0	8	9	21	14
A	64	59	82	46	64	100	77	71	44	0	62	73	43	57

Figure 3. Association of AIS with the mode of injury, type of injury, and level of injury.

Table 4. Comparison of AIS Grade at Admission and at Discharge.

AIS Grade	At Admission	At Discharge
A	132	127
B	19	16
C	14	22
D	16	13
E	23	26
Total	204	204

Abbreviation: AIS, American Spinal Injury Association Impairment Scale.

dislocation, in contrast to patients with fracture only. It is self-explanatory as fractures and fracture-dislocations require large forces and cause a great degree of dislodgment.

SCIWORA can be described as a condition when SCI can be established on magnetic resonance imaging, where plain radiographs fail to recognize any injury.[17] SCIWORA was observed in 6% (13) of the cases in our study, which is far less than the published reports suggesting incidence ranged between 13% and 67%.[7,16] This low incidence can be attributed to highly sensitive imaging modalities.[12] The average age of SCIWORA children in this study was 11 years, which remains in the range of existing literature (7.1 to 12 years), but still higher compared to the age reported by Walsh et al.[18] A possible explanation for such injuries is hyperelasticity and hyperflexibility of a young spine, which results in the spinal column stretching more than the spinal cord.[19] This phenomenon leads to a damaged spinal cord without obvious damage to the spinal column. The distribution and severity of SCIWORA injuries in our study are in line with the described pattern of published literature.[2,14]

In the study, 65% of patients had a complete injury, 24% had an incomplete injury, and 11% were intact at the time of admission. Mostly complete injuries were of high velocity observed in the cervical, thoracic, and junctional regions. Children managed surgically were mainly in group III who had unstable injuries. It is well known that the motive of surgeries has been to stabilize the vertebral joints columns, facilitate rehabilitation, and prevent further complications. Overall, 8 of the operated and 4 nonoperated cases recovered at least one AIS grade and none of the cases deteriorated. We also found that the higher incidence of complications was related to operated cases as reported by Carreon et al.[11] Some children had associated injuries but that did not cause any delay in rehabilitation. In our retrospective data, there were only 2 deaths, which accounts for less than 1% of the total included patients, and is far less than other published studies; others have noted 45%[7] to 58%[4] mortality in children.

Our study reaffirmed the prior studies' inferences that younger children are more prone to serious spinal injuries compared with older children. The ligamentous slackness and hypermobility of undeveloped spine could be protective of minor trauma but do not guard it against fatal distraction and forceful high-velocity trauma.[12]

The outcome was classified as good, fair, and poor based on the dependency level of the child at time of discharge. Hence, there were 37% good or fair and 63% poor outcomes. Six percent of the cases improved at least one grade at the end. Three patients improved to grade E from AIS D. Four patients improved from AIS A to C and AIS B to C.

Though it was beyond the scope of our study, it is reasonable to say that any level of functional incapacitation in a child might be detrimental to the socioeconomic growth of the individual and the society as a whole. Wang et al[20] concluded in their study that injury was common and frequent among children and could seriously affect their healthy development and growth. Health education, safety promotion, and removing hidden danger for injury are the major measures to prevent injury, and the government and the whole society should pay great attention to injury issues in children and young adults.

Conclusion

Our study identified fall from height as the most common mode of injury contrary to earlier observations of RTAs. Spinal injury was 3 times more prevalent in boys than girls. In this study, junctional-level injuries were mainly complete (AIS-A) injuries while fractures were the dominant type of injury. There were also a higher number of burst fractures than any other study. We affirm earlier studies' observation of predominance of cervical spine injury and high incidence of multilevel contiguous with a lesser percentage of noncontiguous multilevel spinal involvement. SCIWORA incidences are in line with published literature. The incidence of death was low in this study with the only 2 instances occurring in hospital due to head injury and multiorgan failure. Neurological improvement was seen in 8 operated cases and 4 conservatively treated cases. We propose to study the functional and psychological outcomes of these patients as well as reintegration in the community. Also, a multicentric study can show better implications of the management and outcomes of pediatric spinal injury.

Declaration of Conflicting Interests

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