

Pediatric Spine and Spinal Cord Injury in Istanbul

A Retrospective Analysis of 106 Patients

Belgin Erhan, Mustafa Onur Ulu,† Berrin Gunduz,* and Taner Tanriverdi†*

Abstract: This study provided a retrospective analysis of 106 pediatric patients 17 years of age or younger who incurred spinal cord injuries (SCIs) during the last decade in Istanbul. Data were retrieved from the medical records of the patients, who were admitted to Istanbul University's Cerrahpasa Medical Faculty and 70. Yil Physical Medicine and Rehabilitation Training Hospital from January 1992 to December 2002. The patients were evaluated with respect to demographic data, cause of injury, and level of injury as well as completeness of injury, radiologic findings, and mortality rate. The mean age of the patients was 12.67 ± 4.3 years, and the male-to-female ratio was 2:1. The most common cause of injury was motor vehicle accidents (41%), followed by falls from heights (33.6%), diving injuries (10.3%), and gunshot wounds (9.3%). The levels of injury, in descending order of frequency, were cervical (47.2%), thoracic (34.9%), and lumbar (12.3%). Complete and incomplete SCIs were seen in 55% and 45% of patients, respectively. SCIs without radiographic abnormalities were only seen in 1.9% of the patients in this series. The overall mortality rate was 9.4%. SCI caused by trauma is relatively uncommon in children, but the results may be catastrophic. This study aims to provide a statistical analysis of pediatric SCI cases admitted to our clinics and tries to estimate the situation in Turkey on the basis of the demographic features of Istanbul. The importance of preventive measures is also stressed.

Key Words: pediatric, spine, spinal cord injury, trauma

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Trauma to the spine and spinal cord in the pediatric age group is a relatively uncommon entity compared with that in the adult population. The incidence is estimated at 1% to 10% of all spinal cord injuries (SCIs), and the mortality rate seems to be higher than in adults.^{1–3} Because SCIs largely occur in young adults, it is not surprising that less attention has been paid to the pediatric age group. Currently, there is limited information available in the literature regarding SCIs in children, and this may lead to the fact that the actual incidence may be overestimated. It has been speculated that trauma to the spinal cord in children causes a different pattern of injury than

in adults because of the different biomechanical and anatomical features unique to a child's spine.^{4–6} Thus, receiving information about the incidence and causes in pediatric SCIs is of extreme importance for planning preventive measures and treatment modalities and for carrying out rehabilitation programs.

During the last decade, several studies from different centers have reported large series composed solely of pediatric age group patients and expanded our knowledge of the incidence, causes, and management of this devastating clinical entity. Although rarely encountered, the economic, social, and emotional consequences of these injuries are significant in children. Furthermore, irreversible neurologic deficits after SCI in a previously healthy child are disturbing to the child, his or her parents, and the physicians taking care of the child.

This retrospective study is the only study providing information about SCIs in the pediatric age group in Turkey, and the objective is to assess the causes, injury levels, and patterns of injury in Istanbul, the most crowded city in Turkey, during 1992 through 2002. The findings are discussed in light of the pertinent literature.

CLINICAL MATERIALS AND METHODS

This retrospective analysis includes 106 pediatric patients who were admitted with SCIs between January 1992 and December 2002. The data were acquired and reviewed from the records of Istanbul University's Cerrahpasa Medical Faculty Hospital and 70. Yil Physical Medicine and Rehabilitation Training Hospital, which are among the largest referral centers around Istanbul. The patients admitted were analyzed according to their age, gender, cause and level of injury, radiologic findings, and mortality. Birth injuries were excluded from the study. The patients were separated into 3 groups: those aged 0 to 5 years, those aged 6 to 11 years, and those aged 12 to 17 years. The purpose was to identify the age-dependent results and to be able to compare the different injury profiles. Injury severity was interpreted on the basis of the American Spinal Cord Injury Association (ASIA) impairment scale.⁴ Standard χ^2 statistical methods were used to evaluate the differences between the age groups. A probability value less than 0.05 was accepted as significant.

RESULTS

Age and Gender

The 106 patients reviewed included 70 boys (66%) and 36 girls (34%) aged 2 to 17 years, with a mean age of 12.67 ± 4.3 years. The overall ratio of boys to girls was 2:1. Most of the

From *70. Yil Physical and Rehabilitation Training Hospital, Istanbul, Turkey; and †Department of Neurosurgery, Cerrahpasa Medical School, Istanbul University, Istanbul, Turkey.

Reprints: Taner Tanriverdi, MD, PK 4, Cerrahpasa-Aksaray 34301, Istanbul, Turkey (e-mail: tanerato2000@yahoo.com).

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children who had incurred SCIs were 16 years old. Eleven patients (10.4%) were 5 years old or less, 22 (20.8%) were 6 to 11 years old, and 73 (68.9%) were 12 to 17 years old. These data imply that the incidence of spinal injury increases logarithmically with increasing age (Fig. 1).

Causes of Injury

Motor vehicle accidents and falls from heights were the most common causes of injury, accounting for 40.6% and 34% of SCIs, respectively. The falls were the main cause of SCIs in children between 0 and 5 years of age, whereas traffic accidents predominated in the remaining age groups ($P < 0.05$, $\chi^2 = 30.92$, $df = 12$; Table 1).

Level of Injury

The most commonly affected level of the spinal cord was the cervical region, which was affected in 50 patients (47.2%), followed by the thoracic level, which was affected in 37 patients (34.9%), and the lumbar level, which was affected in 13 patients (12.3%). Overall, the 12- to 17-year-old age group had more cervical injuries compared with the other 2 age groups, but the difference was statistically insignificant ($P = 0.05$). This finding is consistent with only 1 report in the literature.⁷ In 4 patients, more than 1 level of the vertebral column was involved. Injury to more than 1 spinal segment at the same level was noted in 17 patients (16.03%), and most of these injuries were to the cervical spine (Table 2).

Severity of Injury

Complete (ASIA A and B) and incomplete (ASIA C, D, and E) SCIs were seen in 56 (55%) and 45 (45%) patients, respectively. The relative number of victims with neurologic injury was higher in 12- to 17-year-old age group compared with the other age groups, but no statistically significant difference was found in the degree of completeness of neurologic injury between the different age groups ($P = 0.011$). Spinal cord injury without radiologic abnormality (SCIWORA) was noted only in 2 (1.9%) patients among the total 106 patients (Table 3).

Mortality

Ten (9.4%) of the 106 patients died, and in none of them was the cause exclusively attributed to spinal injury. Six of 10

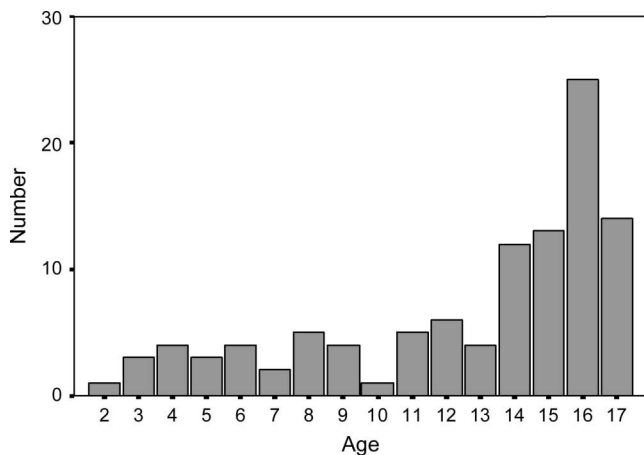


FIGURE 1. Age distribution of patients with spinal cord injury.

TABLE 1. Causes of SCI Related to Age Group

Cause	Age (y)		
	0-5	6-11	12-17
Gurshot		1	9
OA		2	
DI			11
Abuse	1		
MVA	4	12	27
Fall	6	5	25
Surgical complication		2	1

The difference in the causes between age groups was statistically significant ($P < 0.05$, $\chi^2 = 30.92$, $df = 12$).

DI indicates diving injury; MVA, motor vehicle accident; OA, occupational accident.

had complete (ASIA A) SCI, 3 had incomplete (ASIA C) SCI, and 1 had SCIWORA. Most deaths were seen in the 12- to 17-year-old age group, but no significant difference was found in deaths between the different age groups ($P = 0.7$). Six deaths occurred at the time of hospital admission as a result of associated injuries. Of the 10 patients who died, 9 had cervical spinal injuries and 1 had thoracic spinal injuries, but no significant difference was found between the level of spinal injury and death ($P = 0.07$; Table 4).

DISCUSSION

The estimated annual incidence of SCIs is 16 to 21 per million population in Turkey,^{8,9} but no previously established documentation was found that might provide the actual incidence of pediatric SCIs in Turkey. This study is the first trying to establish knowledge about pediatric SCIs in Istanbul, the most crowded city in Turkey because of immigration from all over the country. Thus, the large population of Istanbul, which we believe represents the Turkish population, may provide a unique opportunity to comment on pediatric spine injury. This study was designed at Istanbul University's Cerrahpasa Medical Faculty Hospital and the 70. Yil Physical Medicine and Rehabilitation Training Hospital, which are among the largest referral centers around Istanbul.

SCIs in the pediatric population account for 1% to 10% of all spinal injuries.^{1,2,3,5,10} The actual incidence of pediatric

TABLE 2. Level of Injury Related to Different Age Groups

Level of Injury	Age (y)		
	0-5	6-11	12-17
Cervical	6	11	33
Cervical and thoracic			1
Thoracic	3	10	24
TLJ		1	2
Lumbar			13
SCIWORA	2		

No statistical significant difference was found between the level of injury and the age groups ($P = 0.05$, $\chi^2 = 25.33$, $df = 10$).

TLJ indicates thoracolumbar junction.

TABLE 3. Completeness of Injury Related to Age Group

ASIA	Age (y)		
	0–5	6–11	12–17
A	1 (1%)	11 (10.9%)	32 (31.7%)
B	1 (1%)	1 (1%)	10 (9.9%)
C	2 (2%)	5 (5%)	16 (15.8%)
D		1 (1%)	5 (5.9%)
E	6 (5.9%)	4 (4%)	6 (5.9%)

There was no statistically significant difference in the degree of completeness of neurologic injury between the different age groups ($P > 0.05$, $\chi^2 = 19.85$, $df = 8$).

SCIs is not known, which is mainly a result of the differences in upper age limits reported in the literature and insufficient data in many countries. In this study, we also could not provide the actual incidence because of the lack of archived documentation related to SCIs in children. Because sufficient data related to pediatric SCIs were not available and the population aged from 1 to 25 years in our country is higher than that in most European countries, the actual incidence of SCIs in Istanbul and/or Turkey may be higher and underestimated.

Although SCIs are more rarely encountered in children than in adults, the mortality rate among children with spine injuries is unfortunately higher than that in adults and is estimated to be 25% to 32%.^{5,6,11} Limited reports, including large series, have determined that death is mostly a result of the concomitant head and other major organ trauma rather than the level of the spinal cord, particularly the cervical level, that is injured.^{1,2,5,10,12} In our series, the mortality rate was 9.4% and death ($n = 10$) was not solely attributed to the spine injury. Of the 10 patients who died in this series, 6 who died at the time of hospital admission had severe associated injuries. In addition, all the children who died, except 1 (thoracic injury), had severe cervical injury. In the present study, most of the victims with an immature (aged 0–9 years) or mature spine who experienced spinal injury, irrespective of the cause, had a higher incidence of injury to the cervical spine. Conversely, it has been suggested that children with an immature spine are more prone to the injury to the cervical level compared with older children.^{5,13,14} The reasons leading to differences in the incidence rate and injury profile in children with mature versus

TABLE 4. Mortality Related to Level of Injury

Level of Injury	Mortality	
	Death	Survival
Cervical	8	42
Cervical and thoracic		1
Thoracic	1	36
TLJ		3
Lumbar		13
SCIWORA	1	1
Total	10	96

No statistically significant difference was found in deaths related to the level of injury ($P > 0.05$, $\chi^2 = 10.1$, $df = 5$).

TLJ indicates thoracolumbar junction.

immature spines have been extensively discussed in the literature; it is beyond the scope of this report to elaborate on the complexity of these reasons. Suffice it to say that different biomechanical and anatomical features attributed to the surrounding structures and vertebrae in the mature spine and immature spine cause the unique findings after spinal trauma in young children. Our findings may seem to be inconsistent with those reported in the literature, but we think that the high incidence of injury to the cervical spine in children with a mature spine may be a result of the large number of children aged 9 to 17 years included in the study.

Two children had a diagnosis of SCIWORA, which represented 1.9% of all patients in the study. This finding is much lower than previously reported in large series in the literature.^{1,2,5,10,15} Regarding these two patients, one of them died as a result of concomitant trauma and the other patient improved well with physical therapy and rehabilitation. The incidence of SCIWORA has been estimated at 13% to 67%, and 25% of patients who develop SCIWORA have no neurologic deficits, but delayed neurologic deficits are also likely in this special clinical entity.^{2,16} Thus, the physician should be alert for SCIWORA, and a full radiologic examination should be performed.

Excluding the 5 patients with missing data related to completeness of injury, 101 patients were evaluated according to the ASIA impairment scale.⁴ Fifty-six (55%) and 45 (45%) patients in this review had complete (ASIA A and B) and incomplete (ASIA C, D, and E) SCIs, respectively, and in children with complete injuries, the affected levels were predominantly cervical and thoracic areas; these findings are in accordance with those reported in the earlier literature.^{1,2,5,10,12} In addition, as the age of the patient increases, the number of complete SCIs is also likely to increase. This may partly be explained by the enhanced plasticity or increased mobility of the spinal cord secondary to ligamentous laxity, underdeveloped neck and paraspinal muscles, horizontal orientation of facet joints, incompletely formed flattened uncinat process, incompletely ossified wedge-shaped vertebrae, and a larger head-to-torso ratio. Such features are believed to offer protection from injury in the younger children. The present study could not provide a statistically significant relation between patient outcome and completeness of injury because of the lack of sufficient data. Nevertheless, all the large series that include pediatric SCIs reported in the literature agree that children with complete SCIs have a poor prognosis compared with those with incomplete cord injury and that outcome is generally associated with the neurologic status at the time of hospital admission.^{1,2,3,5,10}

In agreement with previously published series in the literature, the current study demonstrated that the main cause of SCIs among children in Istanbul is traffic accidents (41%). Compared with European countries, Turkey has a relatively higher rate of traffic accidents, resulting in a large number of fatalities and injuries. Approximately 5000 people are killed every year, and approximately 100,000 people are injured in road traffic accidents in Turkey each year. These accidents also result in substantial cost to the Turkish economy.⁹ Most children with motor vehicle accident-related injuries are aged between 12 and 17 years, and the current study disclosed an

increased mortality rate in the same age range. To reduce the problem substantially, the National Traffic Safety Program has been developed within the Traffic Safety Project, which was financed partly by World Bank loans and partly by Turkish funds. The final report for the strategy component of the project has been called the National Traffic Safety Program for Turkey. The overall target of the National Traffic Safety Program is to reduce the number of fatalities and injuries in traffic accidents by at least 40% within a 10-year period.¹⁷ Despite the vigorous preventive measures, including laws and roads built suitable to standards, the number of injuries occurring as a result of traffic accidents has not decreased during the last decade in Istanbul. Therefore, it is important to note that most of the spinal injuries might be prevented through proper parent and child education, particularly in the case of motor vehicle accidents.

The second leading cause of SCIs in children in the current study was found to be falls from heights. In some published studies, the second leading cause of injury among surviving teenagers has been reported to be sports activities. Because there is no standard categorization, comparing the causes of SCIs is confusing. Falls during competition sports activities may injure children. Therefore, our findings are actually consistent with the findings reported in the literature. Sports should be taken into consideration as a cause of SCIs, and preventive measures may decrease the incidence.^{1,2,3,5}

CONCLUSION

SCIs in children are rare, but the effects on the victims may be permanent and catastrophic. Most of these injuries may be prevented through proper parent and child education, especially in the case of traffic accidents and sports activities. In addition, proper education of physicians and paramedical personnel who participate in provision of first aid is extremely important.

Despite the vigorous preventive measures, including laws and roads built suitable to standards, the number of injuries caused by traffic accidents has not decreased during the last decade in Istanbul. The findings of this study may

reflect the current situation in Turkey and may be helpful for future clinical studies regarding the SCIs in children.

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