

Trends in pediatric cervical spine injuries in the United States in a 10-year period

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Abstract

Background: Cervical spine fractures (CSFs) are potentially devastating injuries in pediatric population. Fortunately, these injuries are uncommon in pediatric patients. The purpose of this study was to determine the epidemiology, the risk factors, mechanisms of injury and to identify possible strategies for prevention. In addition, the aim of the current study was to compare CSF sustained in 2003 to CSF sustained in 2008 and 2013 so as to recognize the trend of pediatric CSFs in the United States. **Methods:** The National Electronic Injury Surveillance System was queried for CSF sustained in pediatric population up to 16 years of age for years 2003, 2008, and 2013. Outcomes of interest were patient characteristics (age and sex), causes of CSF, and mechanism of injury. **Results:** Eighty pediatric patients with CSF were identified. The average age was 10.5 years. Boys sustained significantly more CSF than girls. Statistically significant more CSF were occurred in children of 10–16 years than in children up to 9 years. Sports or recreational activities and home-related accidents were the predominant causes of CSF. Mechanisms of injury were age-related, with younger children sustaining CSF as a result of home-related accidents while adolescents commonly injured during sporting or recreational activities. In contrast to current data in literature, motor vehicle accidents were not a major cause of CSF. Comparing the years 2003, 2008, and 2013, statistically significant differences in the incidence of CSF were not found. **Conclusions:** Our study confirms previous findings that adolescents who sustain CSF have higher incidence of sport or recreation-related accidents than younger patients who sustain commonly home-related accidents as a consequence of insufficient parental supervision. The perception that motor vehicle accidents comprise major cause of CSF appears not to be true.

Keywords

cervical spine fractures, home-related accidents, injury prevention, NEISS, pediatric, sports

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Introduction

Pediatric cervical spine injuries (PCSI) constitute approximately 1–2% of all pediatric trauma admissions.^{1–6} Although PCSIs are relatively uncommon, they have been reported to comprise 60–80% of all spine injuries, in contrast to 30–40% in adults.^{1,7–11} Younger children have a predilection for injuries of the upper cervical spine, whereas older children have a significant predilection for injuries at the lower cervical spine.^{11–14} PCSI is age-related, with approximately 80% of total cases occurring

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in older children.¹ However, as has been reported in the literature, the mortality rate tends to be higher among younger patients and often is related to concomitant head injuries.^{4,5,8,15} Fatal injuries can be explained by the ligamentous laxity and increased mobility of the immature spine that allows lethal distraction injuries during the trauma event associated with motor vehicle accidents.² The most frequent cause of PCSI is motor vehicle accidents, followed by sports or leisure-related accidents. Traffic accidents are more prevalent in younger children, whereas older children are more commonly injured in motor vehicle accidents and during sports or leisure activities.^{1,2,5-8,16,17}

Types of the cervical spine injury (CSI) include fractures, dislocations, discoligamentary injuries, and spinal cord injuries without radiographic findings of skeletal or discoligamentary injuries.^{5,7}

Patients <8-year old are more likely to have upper cervical fracture (UCF) than patients \geq 8-year old who have more possibilities to have lower cervical fractures (LCFs).^{14,18} It has been postulated that biomechanical and anatomical features unique to the immature pediatric spine may account for different injury patterns in children compared with those in adults. In young children, head size is large in proportion to body size, causing the upper cervical spine to be subject to greater force than the lower cervical spine, thus making the upper cervical spine more prone to injury.^{4,19} Patients with UCFs have a threefold higher rate of death than these with LCFs.¹⁴

A thorough understanding of cervical spine fractures (CSFs) is essential so that these injuries are not overlooked. The purpose of this study was to determine the epidemiology, risk factors, and mechanisms of CSI in children as well as to identify possible strategies for prevention. A second aim of the current study was to compare CSFs sustained in 2003 to cervical fractures sustained in 2008 and 2013 in the United States to identify the trend of pediatric cervical fractures during the last decade.

Materials and methods

After obtaining institutional review board approval, a cross-sectional descriptive epidemiological study was performed on incidence of cervical fractures treated in emergency department (ED) within the United States. The National Electronic Injury Surveillance System (NEISS) database was used. NEISS is an injury surveillance system operated by the US Consumer Product Safety Commission. NEISS gathers data from EDs of approximately 100 hospitals selected as a probability sample of all 6100 United States hospitals with a minimum of 6 beds and a 24-h ED.

Data analysis

Data were collected on the cervical fractures in children up to 16 years treated in the EDs during 2003, 2008, and 2013. Cervical fractures were further divided into age subgroups:

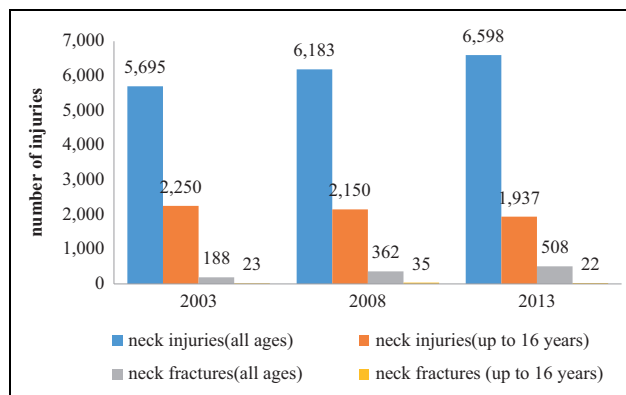


Figure 1. Neck injuries in all ages, neck injuries in children up to 16 years of age, neck fractures in all ages, and neck fractures in children up to 16 years of age as recorded in the emergency departments during 2003, 2008, and 2013.

up to 9 years and from 10 years to 16 years to investigate the differences between children and young adolescents. Age-related separation at that point was mainly based on skeletal maturation of the cervical spine, following existing literature that indicates a division of patients into group aged 9 years or less with predominantly upper CSFs and an older age group of patients with commonly lower CSFs.^{4,8,10,12-14}

Results

During 2003, 5695 neck injuries for all ages were reported to NEISS. A total of 2250 of these injuries (40%) were recorded in children up to 16 years of age. Neck fractures comprised 3.3% of all neck injuries in all ages. When neck fractures were calculated in children up to 16 years, 23 injuries were identified during the year 2003 (12% of all neck fractures).

During 2008, 6183 neck injuries for all ages were reported to NEISS. A total of 2150 of these injuries (35%) were recorded in children up to 16 years of age. Neck fractures in all ages increased by 93% from rates in 2003, when neck fractures in children up to 16 years increased by 52% (Figure 1).

During 2013, 6598 injuries of all ages were reported to NEISS. A total of 1937 of these injuries (29%) were recorded in children up to 16 years of age. When neck fractures were calculated in children up to 16 years, a 37% decrease compared to rates in 2008 was found.

Sex

Of the 80 children included in this study, 59 were male (74%) and 21 were female (26%). In 2003, of all neck fractures in children up to 16 years of age, 17 (74%) occurred in boys and 6 (26%) in girls (Figure 2). Similarly, in 2008 and 2013, 28 (80%) and 14 (64%) of total fractures were recorded in boys.

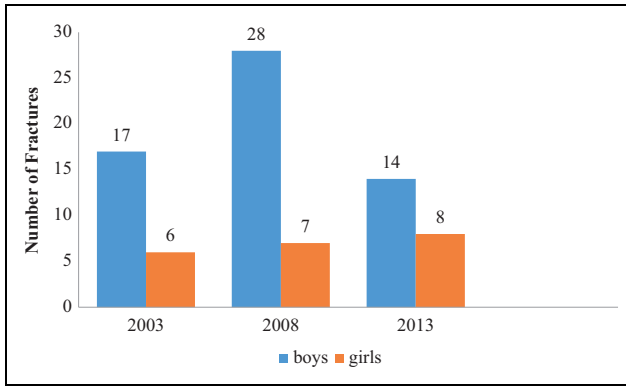


Figure 2. Neck fractures in boys and girls up to 16 years of age recorded in emergency departments during 2003, 2008, and 2013.

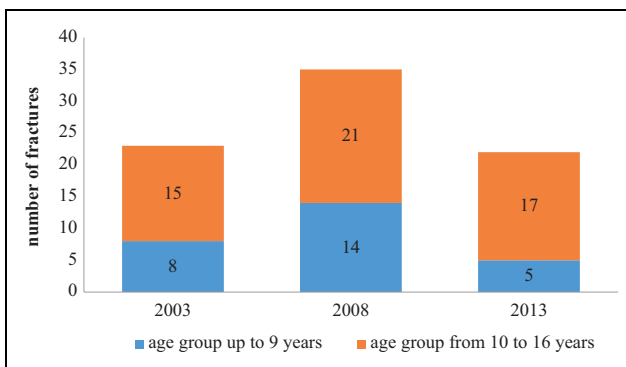


Figure 3. Neck fractures based on age group in 2003, 2008, and 2013.

Age group

The mean age at injury was 10.5 years (standard deviation (SD) 4.7). The mean age was 13.1 years for sports-related accidents, whereas the mean age for home-related accidents was 7.3 years.

Children between 10 years and 16 years sustained significantly more fractures than children up to 9 years ($p = 0.005$; Figure 3). The 10- to 16-year age group had significantly more sports-related fractures ($n = 33$) than home-related accidents ($n = 13$; $p = 0.042$), while football was the recreational activity most commonly associated with the injury. In this age group, the mean age was 13.8 years for sports-related accidents, whereas the mean age for home-related accidents was 12.5 years.

Children up to 9 years had significantly more home-related accidents ($n = 20$) than sports-related fractures ($n = 4$; $p = 0.009$). The mean age for sports-related fractures was 7.5 years, while the mean age for home-related fractures was 4 years.

There was no significant difference in motor vehicle-related accidents between the two age groups. In both groups, motor vehicle accidents comprised only a small percentage of total accidents.

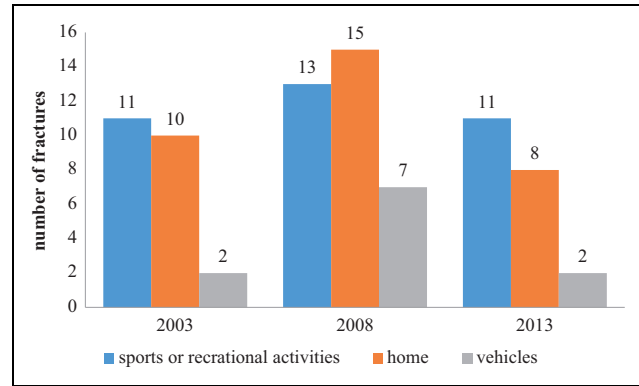


Figure 4. Neck fractures in children up to 16 years of age in relation to sports or recreational activities, home-related accidents, and motor vehicle-related accidents in 2003, 2008, and 2013.

During 2003, 35% of total neck fractures were occurred in the age group up to 9 years, whereas age group of 10–16 years sustained the 65% of total fractures. In 2008, the age group up to 9 years and the age group of 10–16 years showed an increase of 75% and 40%, respectively, in their percentages ($p = 0.152$ and 0.68 , respectively). In 2013, the percentage of CSFs in age group up to 9 years was decreased to 64% ($p = 0.642$), whereas the percentage in the other group was decreased to 19% ($p = 0.348$).

Mechanism of injury

During 2003, sports or recreational activities were the major cause of neck fractures in children (48%; Figure 4). In 2008 and 2013, 13 (37%) and 11 (50%) of total neck fractures were caused by sports or recreational activities. In 2003, cervical fractures caused by football accounted only for 27% of all sports-related fractures. During 2008, football was the sport most commonly associated with CSIs (54%). Likewise, in 2013, football led to more CSIs than any other recreational activity (50%).

Home-related accidents are considered as a major cause of cervical fractures. In 2003, 10 cervical fractures (43%) occurred in home. In 2008, home-related neck fractures remained to be 43%. During 2013, a 7% decrease was accounted in neck fractures occurred at home. No statistically significant difference was found between home- and sports-related accidents as a cause of CSFs in the pediatric population ($p = 0.638$).

Motor vehicle accidents caused less CSFs than expected. In 2003 and 2013, 5 and 8% of total neck fractures occurred in motor vehicle accidents. During 2008, seven children were involved in motor vehicle-related accidents (20%).

Discussion

CSFs in the pediatric population are uncommon and consist of a distinct type of spine injury when compared with the adults.^{20,21}

The pediatric patient is anatomically and biomechanically different from the adult. The child's spine is more flexible and mobile. 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.²² Our results confirmed age-related incidence of injury seen in earlier studies but also revealed findings that are significantly different from previously published work. We found, in contrast to the literature, a higher incidence of home-related accidents in younger children and a decreased incidence of motor vehicle accidents in all age groups.

According to NEISS, 80 children admitted to EDs in United States, during 2003, 2008, and 2013. Similar to previous studies, the mean age was 10.5 years (SD = 4.7).^{8,10} Dietrich et al.¹⁰ reviewed the medical records of children with CSFs who were admitted to the Children's Hospital, Columbus, OH, between 1985 and 1989. The average age of the 50 patients was 11 years and 62% were boys.¹⁰ Overall, in our survey, injured boys outnumbered girls as 2.8:1. This finding is consistent with those in other series in the literature, in which boys were reported to outnumber girls in cervical spine trauma.^{4,5,10,20} For home-related accidents, the male-to-female ratio was 1.75:1 and for sports-related accidents 3.6:1. For motor vehicle accidents, boys predominated as 9:1.

In our study, children of 10–16 years sustained significantly more fractures than children up to 9 years. This finding is supported by the survey of Jain et al.¹¹, who concluded that the most CSFs occurred in patients older than 8 years. Jain et al. used the Nationwide Inpatient Sample and identified 4418 patients (<18 years) who had CSFs with spinal cord injury from 2000 through 2010. Platzer et al.⁸ reviewed admission data and trauma registry of Vienna General Hospital, University of Vienna Medical School, and identified all pediatric trauma patients and all patients (pediatrics and adults) with skeletal or nonskeletal injuries of the spine who were admitted to this level-1 trauma center between 1980 and 2004. They reviewed 56 cases of CSIs in pediatric population and 46 of these patients had fractures or fractures with dislocation. Similar to our survey, they concluded that patients of the older age group B (9–16 years) were significantly more often injured during sports. In group B, patients had only skeletal injuries (fractures or fractures with dislocation). In contrast to our study, they concluded that skeletal injuries (fractures and fractures with dislocation) were found equally in both study groups (group A range from 1 years to 8 years) without any statistical significance. This is in contrast to current data in literature, reporting that CSFs occur predominately in adolescents.^{5,16,23} This conclusion

of Platzer and colleagues may reflect a selection bias and such findings may not be applicable to the entire population of the country. The limited number of the patients with CSFs included in this survey may led to this conclusion. Additionally, Saul and Dresing in a recent study²⁴ reported a tendency of younger patients to be injured in the cervical spine. According to the authors, this finding was attributed to the relative high weight of the head and it opposes the results of the present study.

The most common mechanisms of CSFs were sports or recreational activities and home-related accidents. The 10- to 16-year age group sustained significantly more sports-related fractures ($n = 33$) than home-related fractures ($n = 13$). On the contrary, younger children were more likely to sustain CSFs caused by home-related accidents. Lykissas et al.²⁵ reported an overall increase in sports-related injuries in children with increasing age. Similar to these findings, our study found that sports-related fractures occurred commonly in adolescents, whereas the incidence was lower in children up to 9 years. Football was the activity most frequently associated with the injury. This is consistent with the conclusions of Lykissas et al., who identified football as the predominant cause of sports-related musculoskeletal injuries in 2010, including fractures in children. Regarding the incidence of multilevel injury, it seems that multilevel injuries occur in older children.^{24,26} This can be attributed to the fact that the CSF in older children is due to sports injuries or motor vehicle injuries, whereas in younger patients, the cause of injury is mainly home-related activities.

In comparison to previous reports,^{5,8,12} a lower incidence of fractures caused by motor vehicle accidents was observed in our study. According to our survey, neck fractures caused by motor vehicle accidents comprise 14% of the total neck fractures in the pediatric population. In 2003 and 2013, 5 and 8% of total cervical fractures were occurred in motor vehicle accidents, respectively, whereas during 2008, the percentage was 20. However, Dietrich et al.¹⁰ evaluated that the predominant cause of CSFs is motor vehicle-related accidents (including pedestrians, bicyclists, and passengers), which accounted for the 54% of the CSFs. Brown et al.⁵ evaluated all children admitted to Children's Hospital Medical Center, Cincinnati, OH, an accredited level-1 trauma center, between January 1991 and August 2000 with CSI. Over this period, 103 children sustained CSI. CSFs accounted for 43% of all injuries and occurred commonly in the older children. According to this survey, most of the CSFs were caused by falls or motor vehicle accidents. These studies^{5,10} reported the causes of CSFs from 1980 to 2000. Brown et al.⁵ found that over 75% of younger children in their series were either totally unrestrained or not using an appropriate restraint device. Equally disturbing was the fact that 87% of older children and adolescents in these series were not restrained. However, since 2000, seat belt use has been on the rise. Laws, education, and technology have increased seat belt use

from 11% in 1981 to nearly 85% in 2010. According to US Department of Transportation, the estimated number of adults and children injured in motor vehicle accidents declined during the previous decade (2000–2009). Also, implementation of effective legislation, which mandates the use of helmets in bicyclists, has led to decreased bicycling-related injuries.^{27,28} All these findings are consistent with our results and make clear that the motor vehicle accidents have decreased and are not the predominant cause of CSFs in children.

The aim of the current study was to compare injuries sustained in 2003 to injuries sustained in 2008 and 2013 in order to recognize the trend of pediatric CSFs in the United States. Comparing these years, statistically significant differences regarding the causes of cervical fractures in all ages were not identified. The incidence of pediatric cervical fractures has not been changed significantly during these years. Despite the low incidence of CSFs in children and adolescents, further efforts at prevention of those injuries are demanded. Based on our data, CSFs mostly result from home-related accidents and sports or recreational activities. Youthful abandon during sports or at home is often responsible for pediatric cervical fractures. Prevention of these potentially devastating injuries should be directed toward each age group and parental supervision should be encouraged. The incidence of CSIs resulting from sports-related activities may be reduced by attention to physical conditioning and strengthening, especially of the neck muscles, by football players and other athletes. Proper tackling and checking techniques as well as avoidance of head-butting maneuvers should be stressed. In general, all head-first moves should be avoided, that is, spearing in football, sliding head first in baseball, or hitting the boards head first during hockey. Proper fit of football and hockey helmets so as not to extend below the nape of the neck may also reduce the likelihood of CSIs in children.

Limitations of our study are inherent to the NEISS database. The database may underestimate the actual number of injuries to this population, as only injuries treated in an ED were included and those treated in non-ED health-care facilities, such as private physician offices or urgent care centers, were excluded. The database lacks information related to the degree of athletic exposure, the skill being attempted at the time of injury, the type of supervision at the time of injury, the number of days of activity lost, and the ultimate outcome. The NEISS data reflect only the most severe injury at the time of presentation which may underestimate the number of minor injuries. The database does not provide estimates for overuse or repetitive injuries which are commonly seen in children.

Conclusion

The incidence of CSFs in pediatric patients remains low during the last decade. For children aged up to 9 years, home-related accidents comprise the major cause, whereas

sports or recreational activities cause the most fractures in adolescents. Since the implementation of strict laws and prevention programs, motor vehicle accidents have caused less injuries than in the past. The perception that motor vehicle-related accidents result in the most fractures in pediatric population appears not to be true. Despite the low incidence of CSFs in children, increased efforts at prevention are demanded because those injuries may lead to devastating consequences for the patients and the family.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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