Pediatric spinal injury: review of 61 deaths

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Injury to the spinal column and spinal cord occurs relatively infrequently in the pediatric population. The authors present a unique review of 61 pediatric deaths associated with spinal injury. This group represented 28% of the total pediatric spine-injured population and 45% of the total pediatric spinal cord-injured group studied. The ratio of pediatric to adult spinal injury mortality was 2.5:1. Of the 61 children, 54 (89%) died at the accident scene. Thirty patients underwent a complete autopsy, 19 of whom had an Abbreviated Injury Scale Grade 6 injury (maximum score, untreatable). Spinal cord injury was found to be the cause of death in only eight children and associated with injury to the high cervical cord and cardiopulmonary arrest. These children typically sustained severe multiple trauma. In this population, there appears to be little room for improved outcome through changes in treatment strategy.

Key Words: pediatric spine • spinal fracture • spinal cord injury • death • children

Injury to the spinal column and spinal cord occurs relatively infrequently in the pediatric population,10-13,16,18 and information concerning the role of spinal injury in the traumatic death of children is extremely limited.3,6,10 To explore this issue, we reviewed spinal injury and traumatic death occurring in 61 pediatric patients in southern Alberta over a 13-year period.

Clinical Material and Methods

This series of deaths occurring over a 13-year period (between January, 1975, and December, 1987) was compiled retrospectively. The records of the Chief Medical Examiner’s Office in Alberta were examined to see if a traumatic death that had occurred in a pediatric patient (aged 1 day to 17 years) was associated with a spinal injury. The medical records of the three University of Calgary hospitals (Alberta Children’s Hospital, Calgary General Hospital, and Foothills Hospital) which provide neurosurgical care for all southern Alberta (estimated population 1.25 million in 198820) were also examined using similar criteria.12 Specific details were documented concerning the age and sex of the victim, the etiology of the injury and associated factors such as seat-belt use, alcohol use, presenting neurological examination and treatment details (if applicable), and the autopsy specifics of spinal and all other injuries.

Results

This review identified 61 pediatric patients who sustained spinal injury in association with their traumatic death. An additional 156 children were admitted to hospitals with spinal injury during this 13-year period.12 Also in this period, the Medical Examiner’s Office identified 366 deaths in adults associated with spinal injury, and there were 2971 adult spinal-injury hospital admissions.12 The mortality rate of children with spinal injury was significantly higher than that for adults: 28% of children with spinal injury compared with 11% of adults (ratio 2.5:1).

Overview

There were 35 boys and 26 girls in this group. The average age was 11.3 years (range 3 months to 17 years). There were 21 children aged 9 years or less, 14 children aged 10 to 14 years, and 26 children aged 15 to 17 years.

Trauma was associated with a motor vehicle in 56 patients (Table 1). However, since motor-vehicle accidents were the cause of trauma in only 30 of the 61 patients, the question of proper seat restraint (seat belt, car seat) was applicable only to this group. Seat restraint was definitely used by only one patient, 26 victims were not restrained, and in three this information could not be determined from the records. Alcohol was considered a significant factor in the etiology of 22 (36%) of
the 61 accidents but was not a significant factor in 31 accidents; this information could not be determined from the records of eight patients.

Injury Profile

Of the 61 children, 31 (50.8%) did not have a complete autopsy. These included 19 boys and 12 girls. Sixteen children were aged 9 years or less, seven were aged 10 to 14 years, and eight were aged 15 to 17 years. Spinal x-ray films were completed in nine of the 31 children. Spinal injury was identified in the remaining 22 children by marked hypermobility of the affected spinal level. The cervical spine was the site of injury in 30 children (96.8%) and the thoracic spine in one child. All nine children with spinal x-ray films sustained cervical spine trauma and two had noncontiguous, two-level involvement. Of these, atlanto-occipital dislocation occurred in two cases, the C1-2 level was affected in two cases, and the C3-7 level was involved in seven. Six children had external evidence of severe head injury, while another six had no other significant external evidence of injury. Thirty children (96.8%) died at the accident scene. One child was resuscitated from a complete cardiorespiratory arrest at the accident scene but was brain-dead; life support was discontinued the next day.

In the group of 30 children who did undergo a complete autopsy there were 16 boys and 14 girls. Five children were aged 9 years or less, seven were aged 10 to 14 years, and 18 were aged 15 to 17 years. The cervical spine was the site of injury in 23 children (76.7%). Seven children had two noncontiguous spinal levels affected by trauma; three with two cervical levels involved, three with cervical and thoracic levels, and one with cervical and lumbar levels. There were eight fractures, 25 fractures with subluxations, three subluxations, and one spinal cord injury with no bony or ligamentous abnormality. Twenty-five children displayed evidence of spinal cord injury at autopsy and four had complete transection of the spinal cord. Five children showed no evidence of cord injury. Twenty-four children (80%) died at the accident scene. Two children died in a hospital emergency department, one from overwhelming head and brain-stem trauma and another secondary to massive hemorrhage. One child died secondary to severe head injury 1 day after trauma, another from a cardiac arrest of unknown cause 2 days following a minor head and spinal column injury, another because of severe head injury 4 days after trauma, and another from a massive pulmonary embolus 85 days after an incomplete spinal cord injury.

The Abbreviated Injury Scale and Injury Severity Scale were developed as descriptors of injury severity, 1.4.5.7.8.14.15 to aid in the determination of patient prognosis after trauma. These scales were applied to the group of children who had a complete autopsy to help characterize their injury profile. There were two children with an Abbreviated Injury Scale Grade 4 injury (serious, life-threatening, survival probable), nine children with a Grade 5 injury (critical, survival uncertain), and 19 children with a Grade 6 injury (maximum, currently untreatable). Atlanto-occipital dislocation with cervical medullary disruption, brain-stem disruption associated with head injury, cervical cord injury occurring at C-3 or above, and aortic transection were all assigned an Abbreviated Injury Scale Grade 6. Severe head injury, without brain-stem disruption was assigned Grade 5. An Injury Severity Scale score of 40, representing severe multiple trauma, is associated with a 50% mortality rate.4 The 11 patients with Abbreviated Injury Scale Grade 4 or 5 injuries had Injury Severity Scale scores ranging from 17 to 75 (mean 44). By definition, Injury Severity Scale scores should not be computed for patients with injuries of Abbreviated Injury Scale Grade 6.4 Only three children had scores less than 40: one child sustained an isolated C-2 level cord injury (Injury Severity Scale score 37) and died as a consequence of cardiorespiratory arrest; the second child sustained both an Abbreviated Injury Scale Grade 5 head injury and a Grade 5 spinal injury, but because of the method of calculation (which groups head and neck together as one category) he had an Injury Severity Scale score of 25 rather than 50; the third child will be discussed later.

Among the 30 children who underwent autopsy, there were three injuries potentially compatible with survival. One child died while undergoing an emergency thoracotomy for intrathoracic hemorrhage, another after suffering a cardiac arrest of undetermined etiology following a minor head and spinal injury (Injury Severity Scale score 17), and another from a massive pulmonary embolus 85 days after his accident in which he sustained an incomplete cervical cord injury.

The cause of death was attributed to spinal cord injury, with resultant cardiorespiratory arrest, in only eight (26.7%) of the 30 children who underwent autopsy: six of these eight patients sustained atlanto-occipital dislocation and two had a C1-2 fracture with subluxation. The remaining 22 children died as a consequence of massive hemorrhage (10 cases, 33.3%), severe head injury (seven cases, 23.3%), or multiple, severe trauma (five cases, 16.7%).
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Discussion

Incidence of Pediatric Spinal Injury Deaths

Spinal injury occurs infrequently in the pediatric population.\(^2\) Determination of an actual incidence of pediatric spinal injury, which includes both vertebral column and spinal cord injury, is difficult because the small number of clinical series reported are primarily hospital-based and typically include only patients actually admitted to the hospital with spinal cord injuries.\(^9\) Most patient series conclude that spinal injuries in the pediatric patient represent 1% to 10% of all spinal injuries. The 174 pediatric spinal injury admissions over a 14-year period at our institutions accounted for 5.4% of the total spinal injury admissions.\(^1\) Kewalramani, et al.,\(^1\) reported the incidence of acute spinal cord injury in children to be 182 cases/million population/year. The pediatric spinal cord injury incidence in their series represented 9.5% of spinal cord injuries and 4.8% of all admissions to hospitals for spinal cord injury. A dramatic finding of this study was the very high mortality rate in the pediatric population, representing a case fatality rate of 59%, with 65% of deaths occurring within 1 hour of trauma, typically at the accident scene, and a further 21% of deaths occurring within 24 hours of trauma. This mortality rate is significantly higher than in the adult population. Unfortunately, Kewalramani, et al., did not characterize this important subpopulation and, until now, there have been no other reports that have substantiated their mortality figures.

Highlighted in our review is a large group of 61 pediatric deaths associated with spinal injury, representing 28% of the total pediatric spine-injured population composed of patients with vertebral column injuries both with and without spinal cord damage. This compares poorly with an 11% mortality rate for adults during this time period. Furthermore, if one examines just those children with spinal cord injury, the 56 deaths represent 45% of a total of 124 pediatric patients in that category (56 children who died plus 68 who survived and were admitted to the hospital). This 45% mortality rate is of similar severity to the 59% mortality figure of Kewalramani, et al.\(^1\) While it has been suggested that the mortality rate after head injury in the pediatric patient is significantly less than for adults,\(^1\) the opposite appears to be true for spinal injury.

Injury Profile

The injury profile of the 30 patients who underwent autopsy is quite revealing. While there are some limitations to using Abbreviated Injury Scale or Injury Severity Scale scores to assess trauma severity,\(^3\) the Abbreviated Injury Scale scores effectively demonstrate that the majority of the children had injuries of such severity that either successful treatment is currently not available (63.3%) or survival is uncertain (30%). The mean Injury Severity Scale scores of the 11 patients with Abbreviated Injury Scale Grade 4 or 5 injuries was 44, exceeding a value of 40 which is associated with a 50% mortality rate.\(^4\)

What was the role of spinal injury in the death of these patients? Of the autopsied patients, 83% showed evidence of spinal cord injury while only 49% of our series of hospitalized patients\(^2\) experienced neurological injury. However, spinal injury was the predominant cause of death in only eight (26.7%) of 30 patients undergoing autopsy and was always associated with high cervical injury. Cord injury in the upper cervical region is more likely to result in cardiorespiratory arrest.\(^6\) Of the 30 patients who underwent autopsy, 12 (40%) had either atlanto-ocipital dislocation (27%) or fracture-dislocation at C1–2 (13%). The upper cervical spine was involved in only 15 (8.9%) of our 168 surviving hospitalized patients and none of these sustained atlanto-occipital dislocation.\(^1\)

Unfortunately, this review is limited in its analysis of the injury profile of the 31 children who did not have a complete autopsy. Important points about this group, however, include the fact that, of the 31 patients without a complete autopsy, 30 sustained cervical injury, 30 died at the accident scene, and six had external evidence of gross severe head injury. These details are generally in keeping with the profile outlined for the 30 children who had autopsies.

Outcome

Motor vehicles were involved in 92% of the accidents in this series, compared with only 62% (98) of 158 accidents involving surviving hospitalized patients.\(^12\) With such severe trauma forces, it is not surprising that the majority of patients undergoing autopsy died at the accident scene with evidence of multiple trauma. There appears to have been little room for improvement in outcome for these 61 patients through changes in treatment strategy. The outcome in only two of the 30 children undergoing autopsy might have been altered by a change in treatment strategy: namely, by the addition of deep-vein thrombosis prophylaxis or earlier, more aggressive management of intrathoracic hemorrhage.

It may seem obvious to many that efforts aimed at prevention of injuries would appear to represent the most effective means of improving survival;\(^22\) however, it is important to discuss this issue. Seat restraints were rarely used (one of 29 accidents) and alcohol was a factor in nearly 37% of the accidents. A seat-restraint law was in effect in Alberta for infants in mid-1985 and for motor-vehicle occupants of all ages in mid-1987. All deaths caused by motor-vehicle accidents in this review occurred prior to implementation of these laws. The incidence of spinal injury is definitely lowered with the use of proper seat restraints,\(^14\) and public education and enforcement of seat-restraint laws are essential. It is expected that, with aggressive enforcement of alcohol-related driving laws, this too will become less of a factor. A final observation concerns the 20 deaths that oc-
occurred as a result of pedestrian/motor-vehicle accidents. In this review it was not always possible to assess the less tangible roles that negligent parental supervision or driver speeding had on these injuries, but both features probably had a significant impact on accident frequency. We conclude that efforts aimed at the prevention of accidents in this population will be much more rewarding than focusing efforts purely on the treatment of what are often untreatable injuries. The neurosurgeon can play a positive role in developing awareness of these issues in the community and in government.

References


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