Traumatic spinal injuries in children at a single level 1 pediatric trauma centre: report of a 23-year experience

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Accepted for publication Feb. 22, 2016

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DOI: 10.1503/cjs.014515

Background: With a reported incidence of up to 10% compared to all spinal trauma, spinal injuries in children are less common than in adults. Children can have spine fractures with or without myelopathy, or spinal cord injuries without radiological abnormalities (SCIWORA).

Methods: We retrospectively reviewed the cases of children with spinal injuries treated at a level 1 pediatric trauma centre between 1990 and 2013.

Results: A total of 275 children were treated during the study period. The mean age at admission was 12 ± 4.5 years, and the male:female ratio was 1.4:1. Spinal injuries were more common in children of ages 12–16 years, with most injuries among ages 15–16 years. The top 3 mechanisms of spinal injury were motor vehicle–related trauma (53%), sports (28%) and falls (13%). Myelopathy occurred in 12% and SCIWORA occurred in 6%. The most common spine levels injured were L2–sacrum, followed by O–C2. Associated injuries, including head injuries (29%), and fractures/dislocations (27%) occurred in 55% of children. Overall mortality was 3%. Surgical intervention was required in 14%.

Conclusion: The creation of a pediatric spinal injury database using this 23-year retrospective review helped identify important clinical concepts; we found that active adolescent boys had the highest risk of spine injury, that noncontiguous spine injuries occured at a rate higher than reported previously and that nonaccidental spine injuries in children are underreported. Our findings also emphasize the importance of maintaining a higher index of suspicion with trauma patients with multiple injuries and of conducting detailed clinical and radiographic examinations of the entire spine in children with a known spinal injury.

Contexte : Les traumatismes médullaires sont moins fréquents chez l'enfant que chez l'adulte, avec une incidence d'au plus 10 % de tous les cas déclarés. Les enfants peuvent subir des fractures de la colonne vertébrale avec ou sans myélopathie, ou un traumatisme médullaire sans anomalie radiologique visible (SCIWORA).

Méthodes : Nous avons effectué une analyse rétrospective des cas d'enfants atteints d'un traumatisme médullaire admis dans un centre de traumatologie spécialisé en pédiatrie de niveau 1 entre 1990 et 2013.

Résultats : Au total, 275 enfants ont été traités durant la période de l'étude. L'âge moyen au moment de l'hospitalisation était de 12 ± 4,5 ans, et le ratio garçons:filles était de 1,4:1. Les adolescents de 12 à 16 ans formaient le groupe le plus représenté, et l'incidence de traumatisme la plus élevée a été observée chez les jeunes de 15 et 16 ans. Les 3 mécanismes lésionnels les plus fréquents étaient les accidents de la route (53 %), la pratique d'un sport (28 %) et les chutes (13 %). Le taux d'incidence de la myélopathie était de 12 %, et celui du SCIWORA, de 6 %. La section du rachis touchée le plus fréquemment s'étendait de L2 au sacrum, les vertèbres entre l'occiput et C2 arrivant au deuxième rang. Des lésions concomitantes, dont des blessures à la tête (29 %) et des fractures et luxations (27 %), ont été observées chez 55 % des enfants. Le taux global de mortalité était de 3 %. L'intervention chirurgicale a été nécessaire chez 14%.

Conclusion : La création à partir de cette étude rétrospective d'une base de données sur les traumatismes médullaires chez l'enfant a mis en évidence quelques constatations cliniques dignes d'intérêt : les garçons adolescents actifs présentent le risque le plus élevé de traumatisme médullaire; les lésions médullaires non contiguës surviennent plus fréquemment que ce qui avait été rapporté précédemment; les traumatismes médullaires non accidentels chez l'enfant sont sous-déclarés. Nos conclusions viennent aussi souligner l'importance de maintenir un indice de suspicion élevé dans le cas de patients atteints de lésions multiples et d'effectuer un examen clinique et radiographique détaillé de la totalité de la colonne vertébrale des enfants ayant une lésion médullaire connue.

Although traumatic spinal injuries in pediatric patients are relatively rare, accounting for only 1%–10% of all reported spinal injuries, these injuries may contribute to substantial morbidity and mortality in children.[1] The overall incidence of spinal injuries among children in the United States is 7.41 per 100 000.[2] Another study reported that the incidence of spinal cord injury in the pediatric population within the United States is 18.1 injuries per 1 million children, representing approximately 1300 new cases per year.[3] The true incidence may be underestimated, because spinal injuries can be masked by other features of trauma. Therefore, a thorough understanding of spinal injuries is essential so that they are not overlooked. Different specialists involved in the care of children with spinal injuries should be aware of these findings. The aim of this study was to review spinal injuries in children admitted to a level 1 pediatric trauma centre by both the orthopedic and neurosurgery services at the Children's Hospital of Eastern Ontario (CHEO) in Ottawa, Ont. We investigated the epidemiology, mechanisms of injury, levels of the spinal injuries and types of injury as well as the morbidity and mortality associated with spinal injuries. Population-based, disease-specific surveillance data on injury are the hallmark of the public health approach to all burden of disease, including surgical trauma, and are required for the development of treatment and prevention strategies for traumatic spinal injuries.

Methods

Retrospective chart review

This study was approved by the research ethics board at CHEO. We performed a retrospective chart review of consecutive patients admitted to hospital with spinal injury using a 3-pronged approach to identify all spinal injuries over the defined study period of 1990–2013. First, we used ICD-10 codes (Appendix 1, available at canjsurg.ca) to identify hospital charts through the medical records department for the study period. Second, a hospital-based trauma registry was developed in 2000, and this was also used as a source to identify study patients. Finally, a fracture database maintained independently by the Division of Pediatric Orthopedics for research purposes was also used.

Spinal injuries included all spinal fractures, subluxations or dislocations with or without myelopathy, and spinal cord injury without radiologic abnormality (SCIWORA). Minor spinal fractures, such as spinous process and transverse process fractures, were considered spinal injuries and were also included in this study as they were referred to the surgical service (either orthopedic or neurosurgery). Data collection included patient demographics, mechanism of injury, levels of injury, extent of neurologic injury and recovery, associated injuries, treatment and follow-up. Children were grouped by age in our analyses: infants (0–1 yr), toddlers (2–4 yr), school age (5–13 yr) and adolescents (14–18 yr).

Results

Study sample

A total of 275 children were admitted to CHEO with spine injuries during the 23-year study period (1990–2013). The mean age was 12 ± 4.5 years (range 2 mo to 18 yr). Spinal injuries were most common in older children and teens aged 12–16 years, with the highest incidence in the 15–16 year age group; among younger children, injuries were most common in 4- and 6-year-olds (Fig. 1). The overall male:female ratio was 1.4:1. For injuries related to sports and falls, boys outnumbered girls 2.9:1 and 1.9:1, respectively. For fractures of the spine related to nonaccidental injuries in children, all 6 cases in our series involved boys, and for spine fractures related to other etiologies the ratio was equal. For motor vehicle–related injuries, the male:female ratio was 1:1.2.

Etiology of injury

Among all age groups, the predominant etiology of spinal injury was motor vehicle–related (53%). Of these, 38% were motor vehicle crashes (MVC), 5% involved motor vehicles and either bicycles or pedestrians, 4% involved recreational vehicles (e.g., dirt bike, snowmobile, all-terrain vehicle [ATV]), and 1% involved motor vehicles and motorcycles. Sports injuries accounted for 28% of all injuries, followed by falls (13%), other etiologies (4%) and child abuse (2%; Table 1).

The mean age of children with motor vehicle–related spinal injuries was 11.6 ± 4.7 years (range 10 mo to 18 yr). Of the 146 motor vehicle–related injuries, 72 (49%) involved adolescents, 54 (37%) involved school age children, 18 (12%) involved toddlers and 2 (1%) involved infants. The mean age of children with sports-related spinal injuries was 14.0 ± 2.3 years (range 4–18 yr). Of the 78 sports–related injuries, 51 (65%) involved adolescents, 26 (33%) involved school age children and 1 (1%) involved a toddler; no infants had sports-related injuries. More than one-fifth (22%) of sports-related injuries occurred while playing hockey (n = 17). Snowboarding (n = 10), diving (n = 8), biking (n = 7), football (n = 6) and skiing (n = 6) were the next most frequent sports-related mechanisms of injury, followed by tobogganing (n = 5), horseback riding (n = 5), trampoline (n = 3), gymnastics (n = 2) and wrestling (n = 2). Only 1 child in each of the following sports experienced a spinal injury: soccer, track and field, cheerleading, parkour, basketball, rugby and skating.

The mean age of children whose spinal injuries were due to falls was 10.3 ± 4.6 years (range 6 mo to 17 yr). More than half of these injuries (51%) occurred in school age children, 34% occurred in adolescents, 11% occurred in toddlers and 3% occurred in infants. About one-third (31%) of these children fell out of a tree, 14% fell out of a window, 9% fell off playground equipment and the remainder fell from other surfaces (e.g., from a balcony, ladder, roof, cliff, urinal, farming equipment, stairs).

The mean age of children with spinal injuries due to other etiologies was 13 ± 2.6 years (range 9–16 yr). Half of these injuries occurred in school age children and the other half occurred in adolescents; 30% occurred while play-fighting and the rest occurred in other circumstances (e.g., jumping off a railing, jumping out of a window, being pushed into lockers, running into a post, receiving a gunshot wound, falling on ice and falling off a deck).

The mean age of children with spinal injuries due to child abuse was 6.6 ± 3.8 months (range 2–10 mo).

Level of injury

The most commonly injured region of the vertebral column or spinal cord in all age groups was L2–sacrum (*n* = 72), followed by O–C2 (*n* = 46), T11–L1 (*n* = 44), C3–C7 (*n* = 42), T1–T10 (*n* = 39) and noncontiguous spinal levels (*n* = 32; Table 2). Of the 32 (12%) children with noncontiguous spinal injuries (NCSI), the mean age was 11.3 ± 4.9 years (range 10 mo to 17 yr), and overall male:female ratio was 1.1:1.

Myelopathy/clinical spinal cord injury

Spinal injury with myelopathy accounted for 12% of all injuries in this study. The mean age of children with myelopathy was 12.2 ± 4.1 years (range 2–17 yr). Myelopathy occurred most commonly in older children; approximately 74% of children with myelopathy were aged 12 years or older. The overall male:female ratio of these children was 1.6:1; the ratio in children younger than 12 years was 1.3:1, and that in children aged 12 years and older was 1.8:1. Spinal cord injuries in children most often occurred as a result of motor vehicle–related trauma (*n* = 16), sports-related injuries (*n* = 15), falls (*n* = 2) and a gunshot wound (*n* = 1; Table 3). In children younger than 12 years, the most common causes were motor vehicle–related trauma, followed by a fall and gunshot wound. In older children, the most common causes were sports-related injuries, followed by motor vehicle–related traumas and a fall.

All children with myelopathy (*n* = 34) presented with a range of neurologic deficits extending from transient paresthesias or paresis to permanent hemiplegia or paraplegia. Of these children, 19 presented with transient and 15 with permanent neurologic deficits. Eight had sensory deficits only, 7 had motor deficits only, and 19 had both sensory and motor symptoms. There were 2 SCIWORAs, 23 spinal cord injuries with fractures and 9 SCIWORAs other than fractures. Of the 15 children with permanent neurologic deficits, 10 were paraplegic (7 owing to MVCs, 2 owing to sports-related injuries and 1 owing to a gunshot wound), 2 were quadriplegic (both owing to sports-related injuries), 2 were hemiplegic (both owing to MVCs) and 1 had

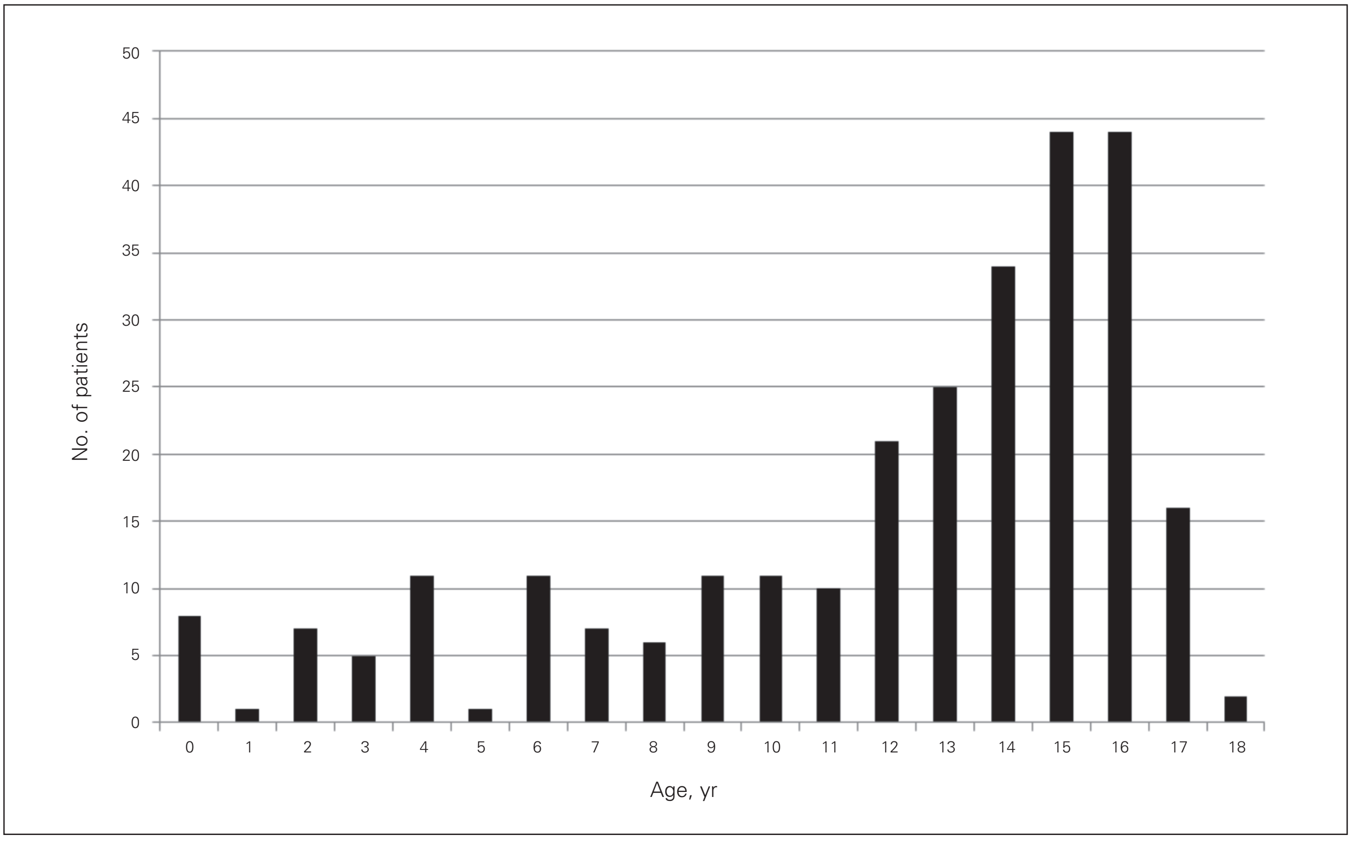

Fig. 1. Age distribution of children with spine injuries at all levels.

sensory deficits only (owing to an MVC). Numerous long-term complications were observed during follow-up for the patients with permanent neurologic deficits. Among the 10 paraplegic patients, all 10 had lower extremity weakness, 9 had neurogenic bladders, 2 had scoliosis, 1 was kyphotic and 1 had chronic autonomic dysreflexia. The quadriplegic patients had decreased sensation and motor function of the upper and lower extremities and no fine motor movement. The children with hemiplegia had upper and lower extremity weakness.

The most commonly injured regions in children with myelopathy were C3–C7 and NCSI, followed by O–C2, L2–S, T1–T10 and T11–L1 regions (Table 2). There were no deaths attributable to myelopathy (Table 3).

SCIWORA

In total, SCIWORA occurred in 2 (6%) patients with myelopathy, whose mean age was 13.5 ± 2.1 years. Both patients were boys, and the mechanisms of injury were

Table 1. Eitology of injury

	Age group; no. of patients				
Mechanisms of injury	Infant (0–1 yr)	Toddler (2–4 yr)	School age (5–13 yr)	Adolescent (14–18 yr)	Total
Motor vehicle crash	2	18	54	72	146 (53%)
Accident	2	16	38	47	103
Pedestrian	0	2	7	6	15
Bicycle	0	0	7	6	13
Recreational*	0	0	2	10	12
Motorcycle	0	0	0	3	3
Sports-related	0	1	26	51	78 (28%)
Hockey	0	0	4	13	17
Snowboarding	0	0	0	10	10
Diving	0	0	5	3	8
Biking	0	0	4	3	7
Football	0	0	2	4	6
Skiing	0	0	2	4	6
Tobogganing	0	0	3	2	5
Horseback riding	0	0	3	2	5
Trampoline	0	0	0	3	3
Gymnastics	0	0	1	1	2
Wrestling	0	0	0	2	2
Soccer	0	0	0	1	1
Track and Field	0	0	1	0	1
Cheerleading	0	0	1	0	1
Parkour	0	0	0	1	1
Basketball	0	0	0	1	1
Rugby	0	0	0	1	1
Skating	0	1	0	0	1
Falls	1	4	18	12	35 (13%)
Other	0	4	5	5	10 (4%)
Nonaccidental Injury	6	0	0	0	6 (2%)
Total	9	23	103	140	275

*Includes dirt bike (n = 1), snowmobile (n = 5) and all-terrain vehicle (n = 6).

Table 2. Levels of injury in all age groups

	Level of injury to vertebral column or spinal cord						
Age group	O–C2	C3–C7	T1–T10	T11–L1	L2–S	NCSI	Total
Infant	2	1	0	4	1	1	9
Toddler	11	1	0	1	5	5	23
School age	17	13	28	9	25	11	103
Adolescent	16	27	11	30	41	15	140
Total	46	42	39	44	72	32	275

C = cervical; O = occipital; L = lumbar; NCSI = noncontiguous spinal injuries; S = sacral; T = thoracic.

MVCs and sports. The school age patient (12 yr) sustained injury in the T1–T10 region, specifically at the T1–T3 level. The specific mechanism of injury in this patient was an unbelted MVC. The patient presented with both sensory and motor deficits, and initial magnetic resonance imaging (MRI) revealed a contusion or hematoma of the spinal cord at the T1–T3 level; the thoracic spine radiograph was normal. The patient was treated with methylprednisolone and a neck and thoracic brace. He had a complete spinal cord injury with complete loss of motor function below the middle thoracic region. He was paraplegic with a neurogenic bladder. The second patient with a SCIWORA was an adolescent (15 yr) who sustained an injury in the subaxial cervical region (C4–C5). The etiology was identified as a football injury. The patient presented with temporary lower extremity sensory deficits that lasted for 2 days. Positive MRI findings showed a focal central disc herniation, and the cervical spine radiograph was normal. The patient was treated with methylprednisolone, bed rest and a soft cervical collar. He made a complete neurologic recovery.

Associated Injuries

In total, 45% of children had isolated spinal injuries. Of the 151 (55%) children who had other associated injuries, the most commonly associated injuries were head (29%), orthopedic (27%), visceral (13%) and other body systems injuries (Table 4). Children with NCSI had associated injuries in 56% of cases, those with myelopathy had associated injuries in 65% of cases, and patients who died had associated injuries in 89% of cases.

Table 3. Patient and injury characteristics in all spinal injury patients and subgroups

Characteristic	Subgroup; no. of patients*				
	All spinal injuries (*n* = 275)	Myelopathy (*n* = 34)	Permanent neurological injuries (*n* = 15)	Mortality (*n* = 9)	SCIWORA (*n* = 2)
Age, mean ± SD, yr	12 ± 4.5	12.2 ± 4.1	11.1 ± 5.0	9.3 ± 5.3	13.5 ± 2.1
Sex					
Male	158	21	10	7	2
Female	117	13	5	2	0
Mechanism of injury					
Motor vehicle–related	146	16	10	9	1
Sports-related	78	15	4	0	1
Falls	35	2	0	0	0
Other	10	1	1	0	0
Child abuse	6	0	0	0	0
Injury level					
O–C2	46	5	1	6	0
C3–C7	42	8	2	0	1
T1–T10	39	4	2	0	1
T11–L1	44	4	2	0	0
L2–S	72	5	3	1	0
NCSI	32	8	5	2	0
SCIWORA	2	2	1	0	2
Associated injury					
None	124	12	4	1	1
Head injury	81	11	5	8	1
Orthopedic injury	73	10	5	2	1
Visceral injury	35	7	6	3	0
Chest injury	28	3	2	3	0
Genitourinary injury	14	2	0	0	0
Maxillofacial injury	23	3	2	0	0
Treatment					
Conservative	150	9	6	7	0
Collar or brace	67	10	0	2	2
Halo Vest	19	1	0	0	0
Surgery	39	14	9	0	0
Death	9	0	0	9	0

C = cervical; O = occipital; L = lumbar; NCSI = noncontiguous spinal injuries; S = sacral; SCIWORA = spinal cord injuries without radiological abnormalities; SD = standard deviation; T = thoracic.

*Unless indicated otherwise.

Mortality

Overall, 9 (3%) children with spinal injuries died. The mean age of these children was 9.3 ± 5.3 years (range 2–16 yr); 7 were boys. All deaths were motor vehicle–related, 1 of which involved a snowmobile. Six children died with O–C2 spine injuries, 2 with NCSI and 1 with an L2–S injury following a motor vehicle–pedestrian collision. Both of the children who died with NCSI had a section of their cervical spine involved. Eight of the 9 deceased children had closed head injuries (CHI); however, only 3 children died exclusively from CHI. Another 3 of the children with CHI had associated injuries: 1 had multiple traumatic injuries on autopsy, including fracture/dislocation and transection of the spinal cord at the C6–C7 and L1–L2 levels, and severe abdominal and cardiothoracic injuries; 1 had distraction at the C6–C7 level; and 1 had distraction at the C1–C2 level. Of the other 3 children who died, 1 had a complete C1 dislocation, 1 had a complex fracture of C3 and distraction at the C2–C3 level, and 1 died of a second MVC after recovering from the first one, but this child had no follow up at CHEO.

Treatment

Thirty-nine of 275 (14%) children with spinal injuries required operative treatment. Of these, 33 patients underwent posterior spinal fusion and 6 had open reduction and internal fixation. Fourteen of 34 children with myelopathy required operative intervention (Table 4).

Use of injury prevention devices

Of the 103 children injured in MVCs, 80 (78%) were reported to be appropriately restrained, whereas 23 (22%) were unrestrained. Of the 9 children who died after MVCs, 5 were appropriately restrained and 4 were unrestrained.

Discussion

Pediatric spine injuries are relatively rare events; however, their clinical outcomes can be devastating.[1] The actual incidence of pediatric spine trauma may be under-reported. Aufdermaur[4] found evidence of fractures of the spine at autopsy in 12 of 100 children over an 8-year period; however, only 1 of the 12 children was thought to have a spine fracture before autopsy. As such, a high index of suspicion is always warranted, especially in light of distracting injuries (i.e., associated injuries, such as abdominal, chest or head injuries seen in seriously traumatized children and adolescents).

Pediatric series on spine fractures have typically been small because of the nature of pediatric centres with small numbers. Few large, multicentre series exist. At many centres the care of spinal injuries may be shared between the orthopedic service and the neurosurgical service, further diluting reported series, which may not be multidisciplinary.[5] Our series reports the combined pediatric spinal injury referrals of 275 children to the orthopedic and neurosurgical services at a single level 1 pediatric trauma centre over a 23-year period. The Trauma Association of Canada (TAC), a multidisciplinary association of health care professionals committed to promoting injury control and excellence in trauma care throughout Canada, mandate provincial and regional injury surveillance and reporting via a trauma registry or database from participating trauma centres.[6] Recently, the Canadian Pediatric Spine Society (CPSS) discussed the further development of a pediatric module for a national Canadian Spine Society registry to promote an evidence-based approach to clinical care, patient safety and quality assurance. Presently, there is no Canadian pediatric spine trauma registry.[7]

The demographic characteristics of our patient population were similar to those of other studies with pediatric patients sustaining only cervical spine injuries. Similar to Brown and colleagues[8] and Orenstein and colleagues,[9] we found a bimodal age distribution, with the highest number of injuries in occurring in children aged 12–16 years and a smaller increase around the ages of 4 and 6 years. There were no differences in the age distribution between our study, which included injuries to all regions of the spinal cord, and studies investigating only cervical spine injuries. Like most other series in the literature, our study shows that spinal injury occurs more commonly in adolescents than in children aged 8 years or younger.[8,10] Likewise, we found that boys were more commonly injured than girls, with an overall male:female ratio of 1.4:1.[8]

Similar to other studies, we found that the most frequent etiology of spinal injury in children overall was MVCs. Hamilton and colleagues, Martin and colleagues, Mann and colleagues and Osenbach and colleagues reported that nearly half of all their patients with spinal injuries were caused by MVCs (50%, 46%, 52% and 50% of all injuries, respectively).[5,10–12] In our study, more than half (53%) of all spinal injuries were motor vehicle–related. More specifically, studies have reported that the most common mechanisms of injury in young children are MVCs, pedestrian–motor vehicle collisions or falls and in older children are sports-related injuries, diving accidents and gunshot injuries.[2,3,8] In our series, the most common mechanism of injury in young children was MVCs, followed by an even distribution of sports-related injuries and falls. In our older children, the most frequent

Table 4. Associated injury distribution in spinal trauma patients

Associated injury	No. (%) of patients
None	124 (45)
Head injury	81 (29)
Orthopedic injury	73 (27)
Visceral injury	35 (13)
Chest injury	28 (10)
Maxillofacial injury	23 (8)
Genitourinary injury	14 (5)

mechanism of injury was sports-related injuries. Sports-related injuries accounted for 28% of all injuries in our study. In a retrospective study of 103 consecutive cervical spine injuries treated in a single level 1 pediatric trauma centre, Brown and colleagues[8] reported that sports-related injuries accounted for 27%; of these, 29% were associated with football.[8] In our study, 22% of sports-related injuries occurred while playing hockey, and these were the leading cause of sports-related injuries in our adolescent group. We believe this reflects the popularity of ice hockey in Canada.

The thoracolumbar injury classification and severity score (TLICS) was established to facilitate communication among surgeons and serve as a guideline for treating thoracolumbar injuries. The classification system is based on 3 major categories: morphology of the injury, integrity of the posterior ligamentous complex and neurologic status of the patient. The 4 major morphologic subcategories are compression injuries, burst injuries, translational/rotational injuries and distraction injuries.[13] Among the 155 children in our series who sustained thoracolumbar injuries, 93 had compression injuries, 14 had burst injuries, 1 had a translational/rotational injury, 23 had distraction injuries and 24 had injuries that did not fit into 1 of the 4 TLICS morphologic subcategories (minor spinal fractures, spinous process fractures, transverse process fractures, SCIWORA). Consistent with several studies[1,10] there was a marked association between flexion–distraction injuries and abdominal injury. In our study, 23 children sustained distraction injuries, and 15 of them had abdominal visceral injuries.

Intentional injury in infants is an increasingly recognized cause of injury to the spine.[14] Avulsion fractures of the spinous process, fractures of the pars or pedicles or compression fractures of multiple vertebral bodies are the most common patterns of injury and may result from severe shaking or battering.[14] All of the infants in this series had compression fractures of vertebral bodies in the thoracic, lumbar or multiple regions of the thoracic and lumbar spine. These injuries were often associated with other common signs of intentional injury to children, including head injury and fractures of the skull, ribs or long bones.

Like other studies of pediatric spinal trauma, we reported that spine fracture without spinal cord injury was more common than fracture with spinal cord injury.[1,8,10] In addition, young children seem to sustain more cervical spine injuries, whereas adolescents tend to sustain more thoracic and lumbar injuries.[15,16] In our study, the most common spine levels injured were the L2–sacrum followed by the O–C2 regions. An O–C2 spine injury was the leading cause of death in our study. We believe that this reflects the anatomic features of these segments and that thoracic and lumbar spine injuries increase proportionally with the age of the child.[17]

Pang and Wilberger[18] originally defined SCIWORA as spinal cord injury without evidence of radiographic abnormality. We defined SCIWORA as an acute spinal cord injury associated with a sensory or motor deficit or both,[8] with a symptom duration of at least 24 hours and without evidence of injury on plain radiographs or computed tomography scans.[19] We identified 2 (6%) cases of SCIWORA in the patients with myelopathic changes (n = 34), which is within the wide range of published estimates of SCIWORA in the pediatric population with reported ranges of 1.3%–38%.[5,8,11,20] The positive MRI results of these 2 patients assisted in the identification and prognosis of their injuries.

The location of injury in patients with SCIWORA commonly involves the cervical cord,[20,21] but may also occur in the thoracic spine in association with high-energy trauma,[22,23] such as MVCs. Trigylidas and colleagues[20] found that 10% of myelopathic patients presented with associated head injuries and that 50% of these head injuries occurred in patients with SCIWORA.

Spine trauma in children and adolescents is frequently accompanied by associated injuries. In this series, we report a prevalence of associated injuries of 55%, which is similar to reported ranges in other series (42%–65%). Rush and colleagues[24] found associated injury frequency to be the highest among children aged 13–19 years (64%), but not much lower than in those aged 0–3 years (57%) or 4–12 years (52%).[24] They also reported spine injuries to be the most frequent in the older age group, similar to our results.

The incidence of NCSI reported in the literature over the last decade has been in the range of 6%–7%,[25,26] although a large pediatric series recently reported an incidence of 17%.[24] Our results also reflected a higher rate, with NCSI in 32 (12%) children; we defined NSCI as 1 intact vertebral segment between separate spinal injury levels. A significant rate of NCSI in children is an important finding that requires dissemination especially to front-line emergency workers who must maintain a high index of clinical suspicion when evaluating and imaging traumatized children. Our findings of a higher incidence than that reported a decade ago but in agreement with more recent and larger pediatric series may indicate a previous under-reporting of pediatric NCSI.

Rush and colleagues[24] found that 74% of NCSI in pediatric patients occurred in a different radiographic spinal region than the index fracture, with the most common divergence being between the cervical and thoracic regions. The implication here is that the emergency physicians would need to image a separate spine region in order to make the second fracture diagnosis. Firth and colleagues[27] found thoracic–thoracic NCSI to be the most frequent, with a median vertebrae divergence of 4 vertebral segments. With an average of 4 vertebral segments between NCSI, we support the idea of full radiographs of the hypermobile pediatric spine to clear NCSI, especially in children with high-impact injuries in which the distance between NSCI fractures can increase.[27] This would be especially true in unconscious children in the presence of associated injuries, which we believe can distract from clinical examination of the injured spine.

We found NSCI primarily in the mean age-group of 11.3 ± 4.9 years. Rush and colleagues[24] found the rate of

NCSI was highest in children aged 13–19 years, likely owing to the higher kinetic energies from MVCs and high-impact sports seen in the older age groups.

Conclusion

This study has added to the limited literature on children and adolescents with traumatic injuries that involve the spine, and it is important in that it represents the complete experience of a level 1 pediatric trauma centre over a prolonged period of time and includes children seen by the orthopedics and neurosurgery services. The population-based surveillance of the burden of surgical disease at referral centres such as ours has contributed literature on important clinical subgroups, such as children with NCSI[27] and how the rates of such subgroups may have been previously underestimated. Moreover, our data underline another important and under-reported problem, that of spine injury in child abuse.

Our data also underscore how trauma patients with multiple injuries present a diagnostic and therapeutic problem. Physicians should perform detailed clinical and radiographic examinations of the entire spine, and we recommend that if 1 spine injury is found then the entire spine should be imaged to rule out a second clinically important spinal injury distant from the first. Use of MRI should be considered in patients presenting with neurologic deficits after spine trauma, with or without plain radiograph findings of a boney spinal injury.

In a recent systematic review of pediatric spinal cord injuries, Parent and colleagues[28] concluded that traumatic spinal cord injuries should be highly suspected in the presence of abnormal neck or neurologic examinations, a high-risk etiology of injury or a distracting injury, even without radiological abnormality.[28] Finally, future efforts should continue to educate children, especially teenagers, about injury prevention.

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Funding: Funding for this study was provided by the Children's Hospital of Eastern Ontario, Department of Surgery.

Competing interests: None declared.

Contributors: M. Vassilyadi and P. Moroz designed the study. All authors acquired and analyzed the data. C. Kim, M. Vassilyadi, N. Moroz and P. Moroz wrote the article, which all authors reviewed and approved for publication.

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