Research Article

Epidemiology of traumatic spinal cord injury in childhood and adolescence in Galicia, Spain: report of the last 26-years.

E. Canosa-Hermida [1,3], R. Mora-Boga [1,3], J.J. Cabrera- Sarmiento[1,3], M.E. Ferreiro-Velasco [1], S. Salvador-de la Barrera [1], A. Rodríguez-Sotillo[1], A. Montoto-Marqués [1,2]

[1]Unidad de Lesionados Medulares, Instituto de Investigación Biomédica de A Coruña (INIBIC). Complexo Hospitalario Universitario A Coruña (CHUAC), A Coruña, Spain, [2]Departamento de Medicina, Universidade da Coruña (UDC), A Coruña, Spain, [3]Servicio de Medicina Física y Rehabilitación, Complexo Hospitalario Universitario de A Coruña (CHUAC), A Coruña, Spain

Objective: To analyze the characteristics of traumatic spinal cord injury in children of Galicia (Spain).
Design: Descriptive and retrospective study.
Methods: Data extracted from the internal registry of the Spinal Cord Injury Unit and the patient's medical records, between March 1988 and December 2014. Inclusion criteria: patients aged ≤ 17 years with a traumatic spinal cord injury.
Outcome measures: Total patients, percentages, incidence, ASIA scale results and improvement.
Results: A total of 68 patients were included. The incidence was 5.6 cases/1,000,000 inhabitants/year. The mean age was 14.4 years (median: 16). Only 25% were younger than 15. Male patients accounted for 73.5% of the total.
The main cause were traffic accidents (60.3%; n = 41), being higher (77.8%) in children ≤ 10 years. Other etiologies included falls (19.1%), diving accidents (16.2%) and other causes (4.4%).
Eleven patients (16.2%) had injuries classified as SCIWORA, 8 (72.7%) of them aged ≤ 10 years. The mean age of the SCIWORA group was 7.5 years versus 15.7 years in the non-SCIWORA group ($P < 0.001$). Half (50%) of these patients had a complete spinal cord injury and, of these, 64.6% were paraplegic.
Conclusions: Traumatic spinal cord injuries are rare in children, and most cases occur between 15 and 17 years. Unlike in adults, SCIs in children mostly involve the thoracic spine. Most patients aged ≤ 10 years have SCIWORA. The most common etiology continues to be traffic accidents, although sports accidents prevail among adolescent patients.

Keywords: spinal cord injury, children, pediatric, SCIWORA, etiology

Introduction

Traumatic spinal cord injury (tSCI) is a rare entity in the pediatric population, with a very low incidence as compared to the adult population. Its prevalence has gradually dropped in recent years.[1] Nevertheless, SCI in the pediatric population continues to be a condition that must be taken into account, and which warrants the need for health professionals to demonstrate specific knowledge and apply special prevention strategies.

The characteristics of these injuries in pediatric patients differ from those of adult ones owing to the immaturity of virtually all their systems, which is of particular importance in the case of the osteoligamentous structures of the vertebral column. Thus, in SCI patients aged ≤ 10 years, the mobility of the first three vertebrae rotating around the C2-C3 axis is greater, the head is proportionally larger in size and the atlanto-occipital joint is less stable, as the occipital condyles are smaller and the C1-C2 joints more horizontal. As a result,

Correspondence to: Eva Canosa Hermida, Complexo Hospitalario Universitario A Coruña (CHUAC), Coruña, Spain, St. Xubias de Arriba, 84 -15006 – A Coruña. E-mail: eva.canosa.hermida@sergas.es

This article has been republished with minor changes. These changes do not impact the academic content of the article.

DOI 10.1080/10790268.2017.1389836

SCIs in this age group have certain peculiarities. For instance, spinal cord injuries without radiographic abnormalities (SCIWORA) are more common in the pediatric population due to the greater elasticity of the bone tissue, which reduces the likelihood of fractures, but, in turn, leaves the marrow more exposed to external aggressions. Another typical spinal condition is the upper cervical spinal cord injury (C1-C3) secondary to the greater mobility of the occipitovertebral joints and high vertebral joints.

The mechanical resistance of the tissues that support the spine increases gradually between the ages of 8 and 10. The vertebral, muscle-ligament and disc morphology becomes progressively more similar to that of adults, and the spinal injury patterns tend to lie somewhere between that of adults and that of small children.

In this study we examined the incidence of pediatric SCI in our region between 1988 and 2014. Furthermore, we analyzed the characteristics of the injury, its etiological and sociodemographic factors, and information on its evolution during the initial rehabilitation stages.

Methods

The study was carried out in the *Unidad de Lesionados Medulares of the Complexo Hospitalario Universitario de A Coruña*, a leading center for the treatment of spinal cord injuries in Galicia (northwestern Spain), which boasts a population of approximately 2,750,000 inhabitants.

A retrospective descriptive study was conducted from March 1988 to December 31, 2014. Relevant data were extracted both from the admissions registry of the SCIU and the patients' electronic health records. Our inclusion criteria were: 1) acute SCI and 2) age ≤ 17 years at the time of onset of the injury. We chose to study patients up to the age of 17 years owing to the great variability in terms of age that we observed in the different studies consulted, as this allowed us to analyze a greater number of cases, and, consequently, to achieve greater significance in each variable.

Patients with a SCI of medical etiology and without a neurological injury on their admission to the SCIU were excluded from our study.

Only events related to the patients' first admission to our unit were recorded, regardless of their duration. We also included patients who had initially been treated at other hospitals, as long as the primary transfer had been made to our hospital. In these cases, we also recorded any event that had taken place in the referring hospital.

The following variables were collected: age at the time of onset of the injury, sex, cause of the injury, date of the injury, level of the injury, ASIA (American Spinal Injury Association) grade, vertebral injury, associated injuries, treatment administered, clinical evolution according to the ASIA classification, high functionality, mean hospital stay, admission to the ICU and mortality.

Spinal cord injuries were assessed using the international standards for the neurological classification of SCIs according to the ASIA scale, revised in 2011 by Kirshblum *et al.*[2] Spinal cord injury levels were categorized into upper cervical (C1-C3), lower cervical (C4-C8), thoracic and lumbosacral.

To test other specific aspects, we decided to divide our patient sample into two groups: patients aged ≤ 10 years and patients aged > 10 years. This is due to the fact that, in general, an optimal osteoligamentous maturation ensuring greater stability of the spine is reached between the ages of 8 and 10, hence, the results of certain aspects related to the characteristics of each injury may differ considerably between both age groups.

All data obtained were organized and analyzed with the IBM SPSS Statistics software (version 19), and the incidence tables were created with the Libreoffice version of Excel. A descriptive study was carried out to analyze the study variables. Variables with a normal distribution were expressed as means with a standard deviation and the rest were represented as medians and percentiles.

Incidence rates were calculated annually using estimates of the Galician population on the first of January of each year, segregated by age, based on data extracted from the Statistics Institute of Galicia (*Instituto Galego de Estadística*).[3] According to its records, the mean annual population for the selected age group (≤ 17 years) dropped from 670,000 in 1988 to 390,000 on 1 January 2015. Hence, the demographic decline was important, this being the reason why our incidence analyses were carried out on an annual basis.

The data used were treated in accordance with the guidelines of the Hospital's Ethics Committee, complying with Spanish Organic Law 15/1999, dated December 13, on the Protection of Personal Data. The study was approved by the Autonomic Research Ethics Committee of Galicia (registration code 2015/155).

Results

Age and sex

A total of 68 patients met our inclusion criteria, 50 being male patients and 18 female patients (ratio 2.8:1), with a mean age of 14.4 ± 3.6 years and a median age of 16 years (age range: 0–17). Only 25% (n = 17) of the patients were younger than 15 years; which is considered to be a pediatric age by the Spanish Health System, and the remaining 75% (n = 51) were patients aged 15 to 17 years.

Incidence

The mean annual incidence of SCI was 5.27/1,000,000 inhabitants/year. However, after exclusively analyzing patients under the age of 15, this incidence rate dropped to 1.32/1,000,000 inhabitants/year.

Taking the figures obtained by Montoto-Marqués A *et al.*[4] as a reference, we observed that, since January 1995 (date in which his case series began), patients under the age of 17 have accounted for 3.5% of the total number of cases of SCI recorded in our region, and those under the age of 15 have only represented 0.9% of such total.

(Fig. 1) shows these annual figures, proving that the incidence of SCI in this population has dropped over the last few years. The annual percentage change (APC) was -2.93, which translates into a downward trend, although this value was not statistically significant.

As in the case of adults, most injuries (41.2%; n = 28) occurred during the summer months, particularly in August, when 25% of the injuries were recorded (n = 17). In contrast, fewer cases were recorded during the winter months (14.7%; n = 10). The most frequent day of onset of the SCI was Sunday (29.4%; n = 20), with fewer cases having been recorded mid-week; on a Tuesday, Wednesday or Thursday (8.8%; n = 6, each).

Etiology

The spinal cord injuries were categorized into 4 different groups based on their etiology (Fig. 2):

– The most common injuries were those resulting from traffic accidents, accounting for 60.3% (n = 41) of cases and being the most frequent type of etiology both by sex and by age group. After grouping the injuries into subcategories, we recorded 19 car accidents (all cases, except for one, were children aged > 10 years), 10 motorcycle accidents (all drivers over the age of 15, except for a younger child who travelled as a passenger), 7 bicycle accidents (children over the age of 10 in all cases) and 5 vehicle-pedestrian collisions (all patients aged ≤ 10 years).

– The second most common type of injuries were those resulting from falls, accounting for 19.1% of cases (n = 13). This group included 2 females aged 15 and 17 years, respectively, who had jumped from a height as an act of self-harm. All other cases resulted from accidental falls, with a sex ratio of 1:1.

– Diving accidents represented 16.2% of cases (n = 11), all of them being recorded in males between the ages of 14 and 17.

– The last group, classified as other traumatic causes, was comprised by 3 individual cases (4.4%).

Characteristics of the injury

An analysis of the levels of the spinal injury revealed that 36.7% of the patients had quadriplegia and 63.3% had paraplegia, which, in turn, could be subdivided into 44.1% of cases of thoracic injuries and 16.2% cases of lumbosacral ones.

The neurological level of the injuries could only be determined in 63 of the 68 cases. Most injuries involved C5 neurological level, with a total of 8 children (13.8%) over the age of 12 having such level affected. This level was followed in frequency by C4 (10.3%; n = 6), and by thoracic levels T10 and T12 (8.6%; n = 5, each).

The tSCI of 66 of the total of 68 patients could be classified on their admission to the hospital according

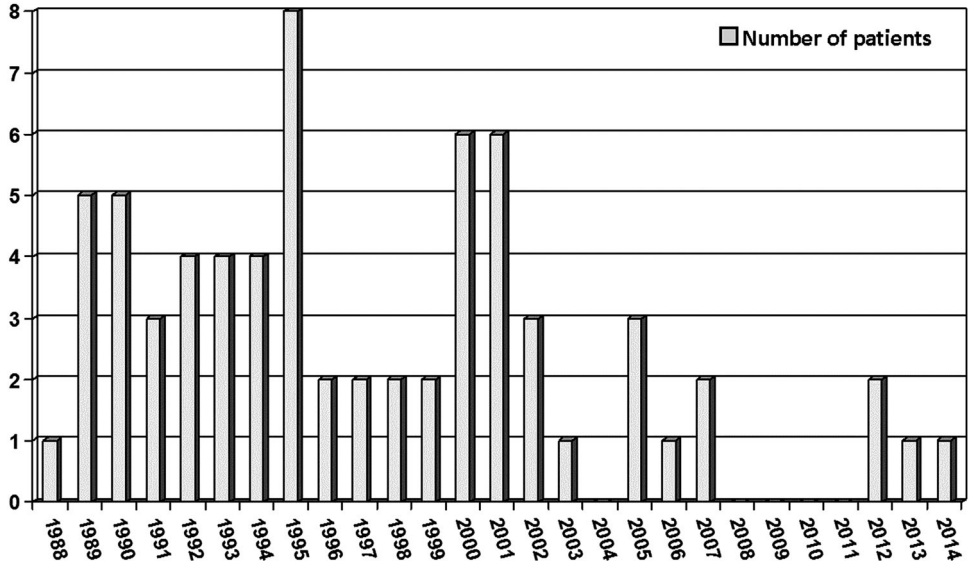

Figure 1. Annual distribution of traumatic spinal cord injury in the pediatric population.

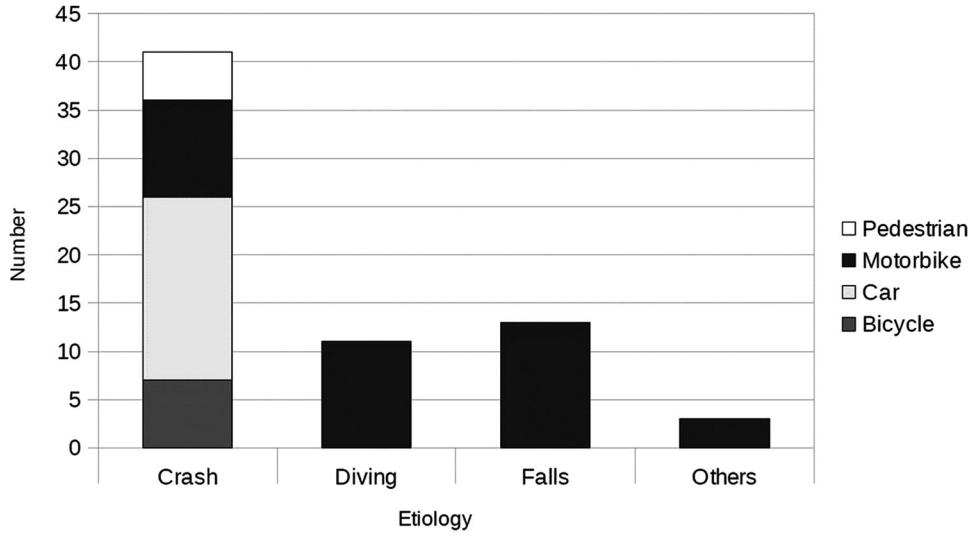

Figure 2. Distribution of traumatic spinal cord injury in the pediatric population by etiology

to the ASIA scale (Fig. 3), with 50% of cases corresponding to complete spinal cord injuries (ASIA A).

In addition, an age-structured analysis (Table 1) revealed that in the group of patients aged ≤ 10 years, made up of 9 patients, 77.8% (n = 6) of them had complete injuries and 33.3% (n = 3) had tetraplegia. Two of these 3 cases of tetraplegia involved upper cervical levels (C1-C3), with such type of lesion only having been recorded in this age group. In contrast, in the group of patients aged > 10 years, including a total of 59 cases, 44.1% (n = 26) of them had a complete SCI and 37.3% (n = 22) had tetraplegia.

A total of 11 cases of SCIWORA were recorded (16.7% of the total), 8 of them corresponding to the group of patients aged ≤ 10 years, with 7 cases being complete SCIs. Only 3 cases of SCIWORA were recorded in the group of patients aged > 10 years, all of them being incomplete SCIs (ASIA C and D).

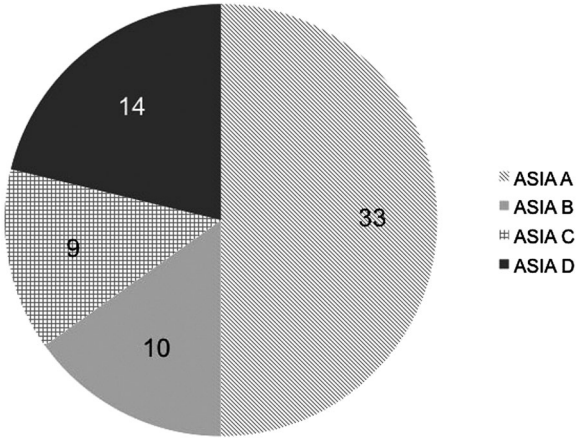

Figure 3. Distribution of ASIA impairment scales.

Classified according to the level of the injury, 7 of the SCIWORAs were thoracic, 3 were cervical and 1 was lumbosacral. Also, traffic accidents and falls were the most common etiologies.

Fifty-seven out of the total of 68 patients (83.8%), all over the age of 10, had vertebral bone injuries, of which 64.9% (n = 37) were treated with surgery.

Associated injuries were observed in 55.9% (n = 37) of the patients, with 56.7% of these cases involving several neurological levels. The most frequent associated injuries were chest injuries (n = 19), traumas to the limbs (n = 16) and head traumas (n = 14).

Clinical evolution and functionality

To assess the clinical evolution of our patients during their stay at the hospital, we analyzed their functional status according to the ASIA classification through periodic evaluations. As a result, we were able to record data from 58 of the total number of patients. A change of category was recorded in 43.1% (n = 25) of cases (Table 2).

At discharge, 23 patients needed a wheelchair, 29 were able to walk in a community setting with or without the need for orthotics and 13 were capable of walking around their house but needed a wheelchair when leaving it.

Mean hospital stay was 123.5 ± 89.9 days, with a median of 111 days (range: 2–418).

Also, 41.2% (n = 28) of the patients had to be admitted to the ICU at some point of their hospital stay.

Regarding the hospital mortality of tSCI in our study population, two patients of our sample passed away.

Discussion

Several studies on pediatric spinal cord injuries have been published in recent years. However, the variety in

Table 1. ASIA impairment scale by age group.

0–10 years	Paraplegias	ASIA A	ASIA B	ASIA C	ASIA D	Lost
(n = 9)	(n=6)	5	0	0	1	0
	Tetraplegias	ASIA A	ASIA B	ASIA C	ASIA D	Lost
	(n=3)	2	0	0	0	1
	Total	7	0	0	1	1
11–17 years	Paraplegias	ASIA A	ASIA B	ASIA C	ASIA D	Lost
(n = 59)	(n=36)	19	6	7	4	0
	Tetraplegias	ASIA A	ASIA B	ASIA C	ASIA D	Lost
	(n=22)	7	4	2	9	0
	Unknown	ASIA A	ASIA B	ASIA C	ASIA D	Lost
	(n=1)	0	0	0	0	1
	Total	26	10	9	13	0

terms of their inclusion and exclusion criteria makes it difficult to compare them and obtain well-founded conclusions. Even so, they all agree on the low incidence of this type of injury in the pediatric population as compared to the adult one. The most recent scientific papers (Table 3) report a significantly lower incidence of pediatric injuries as compared to adult ones, which, as demonstrated by the study published by Lee *et al.*[5] in 2011, is in no case lower than 10 patients/1,000,000 inhabitants/year, thus supporting the data obtained in our sample.

According to data from the Spanish Society for Children's Rehabilitation (*Sociedad Española de Rehabilitación Infantil* [SERI]), pediatric spinal cord injuries (0–15 years) only account for 4% of the total number of spinal cord injuries recorded in our country.[6] In our case series, the percentage recorded for this age group was lower than 1%, with a mean annual incidence of 5.27/1,000,000 inhabitants/year, of which only 1.32/1,000,000 inhabitants/year corresponded to patients under the age of 15. Furthermore, we observed that the incidence of pediatric tSCI has dropped in recent years, although the annual percentage of change is not statistically significant. This downward trend is probably related to the decline in the most frequent cause of these injuries; traffic accidents, which may also be responsible for the overall decrease in the number of cases of tSCI, as proved by recently published epidemiological data on tSCI in our region.[4] This decline seems to be related to the improvements in road safety and the awareness campaigns that have recently been implemented in our country.

After consulting the reference literature and the literature published to date, we observed that the highest percentages usually correspond to elderly age groups, although a smaller peak was also observed during the first few years of life.[7] Compared with other studies, our case series revealed an even higher incidence rate in the adolescent age group, with 75% of our study sample being comprised by teenage patients between the ages of 15 and 17.[8–10]

In terms of sex, male patients seemed to prevail over female ones both in our study and in those reviewed as references (Table 3). In fact, the percentage of male

Table 2. Evolution of the traumatic spinal cord injury in the pediatric patients during the hospitalization.

	ASIA A at admission	ASIA B at admission	ASIA C at admission	ASIA D at admission
ASIA A final	23	0	0	0
ASIA B final	5	6	0	0
ASIA C final	1	1	2	0
ASIA D final	0	1	5	2
ASIA E final	0	2	0	10
Total: 58	With neurologic recovery: 33		Without neurologic recovery: 25	

Table 3. Comparison of revised articles about traumatic spinal cord injury in children

	Augutis, Sweden [8]	Kim, USA [9]	De la Cruz, Spain [10]	Canosa-Hermida, Spain
Age	0–15	0–18	2–18	0–17
Number	37	275	48	68
Incidence (cases/ 1,000,000 children/year)	2,4	-	-	5'27
Sex ratio (M:F)	1.04:1	1.4:1	1.09:1	2.78:1
Cause			-	
Traffic	43.2%	53%		50%
Sport	32.4%	28%		26.5%
Falls	16.2%	13%		19.1%
ASIA A	17 (45.9%)	-	-	34 (50%)
Tetraplegia	16	88	15	26
Paraplegia	21	155 *	23 **	42

* Includes Bone injury without spinal cord injury
** Includes non traumatic spinal cord injury

patients in our sample was much higher than that reported by other authors. Nevertheless, our sex ratio was still lower than that observed in the adult population (2.8:1 in children vs. 3.2:1 in adults in our region,[4] and 3.8:1 in the US[11]). However, these percentages seemed to become increasingly similar at younger ages, in such a way that the sex ratio in patients aged > 10 years was 3.1:1 and in those aged ≤ 10 years it was 4:3, a trend that has also been reported in other reviews.[12,13] A possible explanation for this is the existence of certain risk behaviors that, in general, tend to be associated with males. Thus, for example, in our study we did not record any cases of females with a SCI resulting from a motorcycle or diving accident.

The etiology of our cases coincided with that described in the revised literature (Table 3). The most frequent causes of the injuries, both globally and by age and sex group, were traffic accidents, and, within this etiological group, car accidents. In our case series we also included bicycle accidents in this etiological group, unlike in the case of the reference studies, which established a specific category for sports accidents encompassing both bicycle accidents and diving ones. As a result, our figures regarding SCIs resulting from traffic accidents were slightly higher than those reported in other case series. If we would have created a group of injuries resulting from sports accidents with the same characteristics, it would have become the second most frequent etiological group, with an incidence of 26.5% (n = 18), nearing that of traffic accidents, whose percentage would have dropped to 50% (n = 34).

Half (50%) of our patients were diagnosed with a complete spinal cord injury during their initial physical exam, a similar percentage to that reported in adult case series. However, our figures differ from those reported in other studies involving the pediatric population (Table 3), in which the percentage of complete spinal cord injuries was higher.[9,10] Nevertheless, this value could have been influenced by the high mean age of our group of patients, in such a way that if we had only analyzed patients aged ≤ 10 years, this percentage would have increased to 77.8%, which is similar to the incidence reported in other case series of pediatric tSCI.

The percentages of quadriplegia and paraplegia obtained in our study are consistent with those reported in the available literature, with cases of paraplegia being much more frequent,[7] as opposed to the percentages obtained in adult samples, which seem to be much more even (53% quadriplegias and 47% paraplegias, in our health sector).[4] In our study, only 33.3% of the patients aged ≤ 10 years had quadriplegia, although this percentage increased to 37.3% in patients over the age of 10, thus proving the existence of a directly proportional relationship between the injury and the patients' age, as reported in other studies.[8–10]

We could not find a clear prevalence in the available literature in terms of the level of the injury. Although the incidence of lumbar injuries is always lower, the percentage of thoracic and cervical injuries varies significantly, one injury being more prevalent than the other depending on the case series analyzed. In our study, thoracic injuries prevailed over the rest, however, this runs counter to other reports, in which cervical injuries were more common (66.1%)[14].

Both older and recent articles report a certain tendency for underage patients to experience upper cervical spinal cord injuries (C1- C3).[15–19] In our sample, only two patients had this type of lesion, both of them age ≤ 10 (0 and 8). The biomechanical and anatomic features of the immature pediatric cervical spine may explain the prevalence of upper cervical spine injuries in younger children.

Also, in our study we recorded a total of 16.1% cases of SCIWORA, a figure which far exceeds that reported in other studies (6%)[9], with 72.7% of these cases corresponding to patients aged ≤ 10 years. In our study, 89% (8 out of 9) of the patients included in the SCIWORA group had this type of injury, a much higher percentage than that reported in the reference literature (60%)[7].

Out of all the studies consulted, only the one conducted by Kim *et al.*[9] provided information on the surgical treatment of the vertebral bone lesion (14%), although the results of this study were not comparable with ours, owing to the fact that this author also included patients with bone injuries not involving the spinal cord, which explains why our percentage is much higher. In our case, more than half of the patients (52.9%) underwent surgery.

Overall mortality resulting from pediatric tSCI is low in all cases, having been of only 2.94% in our case series, which falls within the normal range and is lower than in the case of adult patients.

Conclusions

– SCIs are rare in pediatric patients.
– The incidence of this entity has dropped in recent years, probably as a result of the decrease in the number of traffic accidents.
– There is a clear relationship between the age of the patient and the etiology of the injury, with diving and motorcycle accidents being the most common type of injury in teenagers. Likewise, the type of etiology also seems to be correlated with the patients' sex, with traffic and diving accidents being more frequent in

male patients and falls being the most common cause of the injury in the case of female ones.
– SCIWORAs are very frequent and mainly occur in younger patients ($\leq$ 10 years).
– There is a greater incidence of paraplegia and complete spinal cord injuries at younger ages.

Disclaimer statements

Contributors None.

Declaration of interest The authors report no declarations of interest.

Ethics approval None.

ORCID

E. Canosa-Hermida http://orcid.org/0000-0002-0678-5959
R. Mora-Boga http://orcid.org/0000-0002-6052-4434
M.E. Ferreiro-Velasco http://orcid.org/0000-0001-5079-146X
S. Salvador-de la Barrera http://orcid.org/0000-0002-9810-7548
A. Montoto-Marqués http://orcid.org/0000-0003-1773-365X

References

1 Saunders LL, Selassie A, Cao Y, Zebracki K, Vogel LC. Epidemiology of Pediatric Traumatic Spinal Cord Injury in a Population-Based Cohort, 1998–2012. Topics in Spinal Cord Injury Rehab 2015;21(4):325–32.
2 Kirshblum SC, Waring W, Biering-Sorensen F, *et al*. Reference for the 2011 revision of the international standards for neurological classification of spinal cord injury. J Spinal Cord Med. 2011;34 (6):547–54.
3 IGE Instituto Galego de Estadística Santiago de Compostela: Xunta de Galicia 2016. Available from http://www.ige.eu.
4 Montoto-Marqués A, Ferreiro-Velasco ME, Salvador-de la Barrera S, *et al*. Epidemiology of traumatic spinal cord injury in Galicia, Spain: trends over a 20-year period. Spinal Cord 2017; 55(6):588–94.
5 Lee BB, Cripps RA, Fitzharris M, Wing PC. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. Spinal Cord 2014; 52(2):110–6.
6 López-Dolado E, Talavera-Díaz F. Mielomeningocele y lesión medular infantil. In: Redondo-García MA, Conejero-Casares JA coords. Rehabilitación infantil SERI. Editorial Médica Panamericana 2014;165–72. ISBN 978-84-9835-344-0.
7 Vogel LC, Betz RR, Mulcahey MJ. Pediatric spinal cord disorders. In: Kirshblum S, Campagnolo DI, editors. Spinal Cord Medicine. 2nd ed. New York: Wolters Kluwer/Lippincott Williams & Wilkins 2011;533–64.
8 Augutis M, Levi R. Pediatric spinal cord injury in Sweden: incidence, etiology and outcome. Spinal Cord 2003;41:328–36.
9 Kim C, Vassilyadi M, Forbes JK, Moroz NWP, Camacho A, Moroz PJ. Traumatic spinal injuries in children at a single level 1 pediatric trauma centre: report of a 23-year experience. Can J Surg 2016;59(3):205–12.
10 Perez-de la Cruz S, Cimolin V, Gil-Agudo A. Spinal cord injury in pediatric age in Spain. Reality of a national reference center. Childs Nerv Syst 2015;31(6):917–21.
11 Wyndaele M, Wyndaele JJ. Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey? Spinal Cord 2006;44(9):523–9.
12 Vogel LC, DeVivo MJ. Etiology and demographics. In: Betz RR, Mulcahey MJ editors: The childs with a spinal cord injury. Rosemont (IL): American Acad Orthop Surg 1996;3–12.
13 Chien LC, Wu JC, Chen YC, Liu L, Huang WC, Chen TJ, *et al*. Age, sex, and socio-economic status affect the incidence of pediatric spinal cord injury: an eleven-year national cohort study. PloS ONE 2012;7(6):e39264.
14 Dhillon Jaspreet K, Shi J, Janezic A, Wheeler Krista K, Xiang H, Leonard Julie C. U.S. estimates of pediatric spinal cord injury: implications for clinical care and research planning. J Neurotrauma 2017;34(12):2019–26.
15 Kokoska ER, Keller MS, Rallo MC, Weber TR. Characteristics of pediatric cervical spine injuries. J Pediatr Surg 2001;36(1): 100–5.
16 Cirak B, Ziegfeld S, Knight VM, *et al*. Spinal injuries in children. J Pediatr Surg 2004;39(4): 607–12.
17 Ribeiro da Silva M, Linhares D, *et al*. Paediatric cervical spine injures. Nineteen years experience of a single centre. Intern Orthop 2016;40(6):1111–6.
18 Joseph H. Piatt Jr, MD. Pediatric spinal injury in the US: epidemiology and disparities. J Neurosurg: Pediatrics 2015;16(4): 463–71.
19 Goldstein HE, Anderson RC. Classification and Management of Pediatric Craniocervical Injuries. Neurosurg Clin N Am 2017;28 (1):73–90.