Spinal cord injury in pediatric age in Spain. Reality of a national reference center

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Introduction

Spinal cord injury (SCI) among children constitutes an unusu-al pathology, as it is less common at this age than during adulthood. At the same time, the death rate of young sufferers is double that of the adult population, equaling between 25 and 32 % [1, 2]. This type of injury is highly relevant due to its serious consequences, including long hospital stays among the survivors and its huge impact upon emotional, social, and economic domains that affect the whole family.

According to data published by the Spanish Society of Child Rehabilitation (SERI), the incidence and prevalence of children suffering from SCI in Spain are low (one per million inhabitants per year, 4 % in relation to adults) [1]. Regarding gender, there are no differences revealed between adults and children, although the disease is more frequent among males than females; this difference is less among children under the age of 8; however, it increases with age [2].

The most common etiology (cause of injury) of SCI both for adults and children is a motor vehicle crash (MVC). The second highest cause is dependent both on age and on the following factors: medical/surgical complications in children from 0 to 5 years, traumatic injuries in ages 6–12 years, sports in ages 13–15 years, and traumatic injuries again in ages from

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16 to 21 years. For sufferers over 21 years, falls are the second highest cause, followed by traumatic injuries [1, 3, 4]. Considering the entire group aged between 0 and 15 years, the three most common causes are MVC (44 %), followed by sports injuries (23 %) and traumatic injuries (21 %). Sports and traumatic injuries drop off dramatically as a cause of injury in older age groups while, in these subjects, falls become more common [5, 6].

Most of the problems in pediatric SCI are related to the fact that children are growing. An example of this is the existence of scoliosis, which occurs in virtually 100 % of children who suffer injuries prior to puberty. Bracing can help to improve sitting, balance, and function, but it does not reduce the extent of scoliosis, and children need to be monitored by orthopedic surgeons to determine if surgical fusion may be needed. Another specific issue is bladder capacity [6].

The aim of this study was to research the incidence and the main features of ambulant patients suffering from SCI in childhood. All patients were admitted to the Biomechanical and Technical Aids Unit of the National Spinal Cord Injury Hospital in Toledo (Spain), which is a pioneering medical institution for the study of SCI.

Materials and methods

A retrospective study was performed based on the following inclusion criteria: (1) all children (below the age of 18) with a diagnosis of SCI who were admitted to the Biomechanical and Technical Aids Unit of the National Spinal Cord Injury Hospital in Toledo (Spain) and were assessed between January 2006 and December 2013 and (2) patients who were able to walk independently with or without any aids for at least 10 m.

We analyzed the following variables included in the patient's medical histories: age, gender, etiology of the damage, and neurological level, as well as the use (or not) of walking aids. In addition, the following clinical evaluations were considered:

– The Walking Index for Spinal Cord Injury (WISCI) [7]: this measure assesses the amount of physical assistance needed, as well as the devices required for walking following paralysis as a result of spinal cord injury (SCI). This assessment is designed to be a more precise measure of improvement in walking ability (ability of a person to walk 10 m after a SCI from the most to the least severe impairment).
– The ASIA impairment scale [8]: this assessment establishes a classification according to five degrees as indicated by the absence or preservation of sensory and motor function, indicating the severity of the injury and its possible prognosis.
– The Functional Independence Measure (FIM) [9]: a functional scale aimed at providing an objective assessment of the degree of disability in activities of daily living that a patient has at a specific time and which measures the changes that occur with the rehabilitation treatment. The maximum score is 126 points, which indicates complete independence.
– The Barthel index [10]: this assessment measures the individual's ability to perform basic activities of daily living by assigning a score to each patient according to their degree of dependence, assessing each activity according to the time required for implementation and the need for assistance. It includes items such as eating, transfers (e.g. from chair to bed), bathing, using the toilet, moving (walking on a smooth surface or wheelchair), going up/down stairs, dressing/undressing, and continence. The overall score ranges between 0 (completely dependent) and 100 points (completely independent).
– The Motor Index of the upper and lower limbs: this assessment is used to measure strength in upper and lower extremities after injury. The weighted score based on the ordinal six-point scale of Medical Research Council is used to measure maximal isometric muscle strength.

this study was approved by the responsible of the Institute, and written informed consent was obtained by the participants' parents prior to commencing the study.

The Kolmogorov–Smirnov test was used to verify whether the clinical scores were normally distributed. The scores were normally distributed; therefore, we reported data as mean± standard deviation.

Results

Forty-eight patients were included in this study (25 males and 23 females), aged between 2 and 18 years (mean age, 12± 2.31 years).

For a large percentage of the patients (33.33 %), the etiology of the injury was congenital (diagnosed of myelomeningocele and lipomyelomeningocele), followed by traumatic (29.16), neoplastic (8.33 %), inflammatory (8.33 %), postsurgical (4.16 %), and vascular causes (4.16 %) with only one case of transverse myelitis (2.08 %) and infectious myelitis (2.08 %). An unknown etiology was reported in 8.33 % of patients. Among children with SCI due to traumatic causes, no information was available regarding the origin of the damage (traffic accident, dives, falls, etc.).

In terms of the level of SCI, in Table 1, we can observe that most patients (15 individuals, 31.25 %) showed some level of cervical injury (between C1 and C8), followed by lumbar level lesions (14 patients, 29.16 %), thoracic (8 patients, 16.66 %), and sacral lesions (one child, 2.08 %). In ten cases (20.83 %), the injury did not originate from SCI.

Table 1 Injury level

Spinal cord injury level	Percentage (%)	Frequency
Cervical (C1–C8)	31.25	15
Thoracic (T1–T12)	16.66	8
Lumbar (L1–L5)	29.16	14
Sacral	2.08	1
Non-spinal cause	20.83	10

Among the patients with incomplete SCI, its etiology was different, as represented in Table 2. However, the highest percentage was related to traumatic SCI.

In terms of the use of walking aids, we analyzed the WISCI assessment (Table 3), which revealed that more than half of the patients (29 patients, 60.41 %) did not usually use walking aids because they did not need them in order to move about (WISCI 20), followed by seven patients (14.58 %) who required two crutches and two ankle foot orthoses (AFOs) (WISCI 12). However, several different situations were observed: five patients (10.41 %) used walkers and two AFOs (WISCI 9) and two patients (4.16 %) had an estimated WISCI of 19 and 18. We found one patient (2.08 %) who required either two crutches in order to walk (WISCI 16), a walker (WISCI 13), or a cane/crutch with braces and was able to do so for 10 m without physical assistance (WISCI 15).

The Motor Index for the lower limbs showed a mean value of 36.75 (standard deviation, 11.31; range, 7–50) while the Motor Index for the upper limbs displayed a mean value of 46.02 (standard deviation, 7.39; range, 26–50).

The FIM presented a mean value of 111.42 (standard deviation, 17.93; range, 59–126). In particular, the mean value of the FIM locomotion score was 6.4 (standard deviation, 0.94; range, 3–7), and the FIM stairs was 5.38 (standard deviation, 1.70; range, 1–7).

Table 2 Etiology of incomplete spinal cord injuries

Type	Percentage (%)	Frequency
Traumatic SCI	52.08	25
Lipomyelomeningocele	2.08	1
Myelomeningocele	14.58	7
Achondroplasia	2.08	1
Conus medullaris	2.08	1
Anterior cord syndrome	2.08	1
Central cord syndrome	2.08	1
Cauda equina	6.25	3
Brown–Sequard	10.41	5
Myelitis	4.16	2
Meningitis	2.08	1

Table 3 Use of technical aids for ambulation (WISCI)

WISCI	Percentage (%)	Frequency
Level 20	60.41	29
Level 19	4.16	2
Level 18	4.16	2
Level 16	2.08	1
Level 15	2.08	1
Level 13	2.08	1
Level 12	14.58	7
Level 9	10.41	5

The Barthel Index showed an average of 82.61 (standard deviation, 17.00; range, 25–100). All these data are collected in Table 4.

Patients were generally evaluated in terms of walking ability once (mean value, 1.41; standard deviation, 0.72), with a range among the sessions from one to three sessions.

The patients who were analyzed just once represented 73 % of the total, and 14.3 % were analyzed twice and 12.6 % three times. None of the patients was analyzed more than three times.

Discussion

SCIs in childhood are not frequent and represent just 2–10 % of the total number of SCI cases [2, 11]. It is possible that the true incidence of SCI may be higher: some cases are not registered because the patient dies at the time of the accident or during the transfer to the hospital [2]. Compared to the literature [2, 12], our data showed a higher SCI incidence in males and adolescents, even if the proportion of males/females differed slightly.

The most frequent mechanism of injury is traumatism, with a predominance of traffic accidents (being more frequent among young people). Falls and SCI with a medical etiology are more usual in older people. It is important to highlight the high percentage of SCI with congenital origin (myelomeningocele), which represents the second mechanism of injury after traumatic SCI [13]. In general, most of the complete lesions observed in sufferers of SCI are due to traffic accidents, while medical causes are more often the case of the incomplete lesions [13–15]. However, the literature is sparse in terms of etiology and classification of SCI in pediatric age. Over the last 30 years, the percentage of injuries due to MVC has increased in the 0–15-year age group while causes due to trauma have decreased. Within sports, diving remains the top cause for damage, but the percentage of cases due to both diving and football has decreased, while those due to skiing have increased. In the 1970s, 6.4 % of all new cases occurred in children aged 0–15, but this has steadily declined to 2 % in the current decade [16].

Table 4 Motricity Index, FIM, and Barthel assessments

Scale	Mean (SD)	Range (maximum–minimum)
Lower limb Motricity Index	36.75 (±11.31)	50–7
Upper limb Motricity Index	46.02 (±7.39)	50–26
FIM	111.42 (±17.93)	126–59
FIM locomotion	6.4 (±0.94)	7–3
FIM stairs	5.38 (±1.70)	7–1
Barthel	82.61 (±17.00)	100–25

Regardless of the level of the damage, the ultimate objective of the rehabilitation treatment is to achieve a satisfactory integration of the person into their home and to offer them a good quality of life [17]. The comprehensive treatment for people affected by SCI (whether in adult age or in childhood) includes psychosocial rehabilitation in order to achieve the total integration of patients into their community (family, work, school).

There is a higher incidence of paraplegia than tetraplegia (65 vs. 35 %) in children under 12 years, which reverses to the typical adult ratio (45 vs. 54 %) in teenage years. Children aged 0–5 have about 67 % complete injuries, while from 6 to 12 years, this decreases to around 62 %. These percentages decline in the typical adult ratio (about 56 % complete and 44 % incomplete) in older groups. The higher occurrence of complete injuries in younger children reflects the relatively less stable vertebral column, compared to the large size of a child's head [16, 18]. The bones are not yet completely ossified (hardened), and the ligaments and spinal muscles are not as strong as those in adults, resulting in more damage to the spinal cord with trauma.

Children do not develop a normal adult-size bladder until about the age of 10. If, for example, a 4-year-old child is injured, the bladder may not grow sufficiently to achieve adult capacity, resulting in incontinence or other problems when the child reaches adulthood. Providentially, bladder augmentation resolves this problem; many young patients have benefitted from this procedure [15, 18].

Children display a lower incidence of heterotopic ossification (abnormal outgrowths of bone) and a higher incidence of hip misalignment than adults. Adolescents are especially inclined to immobilization hypercalcemia, which is an elevated level of calcium in the blood that can cause nausea, fatigue, depression, or kidney stones if left untreated.

A large number of patients with high tetraplegia who use ventilators have opted for the placement of phrenic nerve pacers (surgically implanted devices that stimulate the nerve innervating the diaphragm), a less cumbersome and more appealing alternative to ventilator tubing. Children still have backup ventilators for nighttime use, periods of illness, or in case of pacer failure [18, 19].

Literature on walking ability in pediatric SCI is very poor. Most studies are focused on children with cerebral palsy (CP), before and after rehabilitative programs [20, 21], rather than in children with SCI. Some studies have aimed to establish the natural walking history in children and adolescents affected by SCI [22–24], revealing that their gait pattern is dependent on factors such as neurological damage, age of the injury, and/or model of orthosis used to walk. Other studies have focused their attention on the strategy of the affected limbs in young patients with SCI [25, 26]. More information is available regarding the gait strategy of people with SCI of congenital origin and, in particular, of patients affected by myelomeningocele. DeGrootad et al. [27] evaluated the degree of energetic consumption in 14 children and adolescents affected by spina bifida. They found that these patients walked with higher energy expenditure than age-matched healthy individuals.

It is evident that the research literature is scant on this topic and the analyzed samples are small. Thus, future studies should be conducted to provide further scientific evidence using rigorous methods and larger samples. Improving the knowledge of the same is important in order to increase the awareness of all those involved in the treatment of children with SCI and thus provide them a better treatment and quality of life. Among the pediatric population, SCI is, in fact, a relatively uncommon occurrence but one that has a major impact on welfare, personal, social, and family domains.

This study represents a reference for the treatment of pediatric SCI in Spain, revealing data on the characteristics of these patients. In addition, few studies have been conducted on the treatment of children with SCI and their walking ability. For this reason, further studies on this subject are necessary in order to advance knowledge regarding the appropriate treatment and rehabilitation necessary for children suffering from SCI.

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