

Treatment Characteristics and Outcomes in 58 Children with Spinal Cord Injury

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Abstract

Background: Spinal cord injury (SCI) can change an individual's life significantly and usually irreversibly. Recently, the incidence of spinal SCI in children has shown an upward trend. Many of them arise from back bends in dances. SCI can cause great suffering and dysfunction to children because they are still in the physical development stage and the degree of injury and prognosis are different from adults. This study aimed to analyze the characteristics of children with SCI and their prognosis, to study the causes of these injuries, and to explore rehabilitation strategies for children with SCI.

Methods: The clinical data of children with SCI, including general conditions, cause and degree of injury, and effects of rehabilitation were analyzed and evaluated.

Results: Out of the 58 patients, 22 (37.93%) had SCI at and above T6, 34 (58.62%) at T7-T12, and 2 (3.45%) at and below L1. The injuries were caused by a back bend in 35 cases (60.34%) and by traffic accidents in eight cases (13.79%). Upon discharge, seven patients (12.07%) achieved independent walking ability, 33 (56.90%) realized wheelchair independence, and 46 (79.31%) attained basic or complete self-care ability. Fifty-six (96.55%) of these children with SCI experienced bladder dysfunction, 55 (94.83%) experienced rectal dysfunction, and 20 (34.48%) had scoliosis.

Conclusions: Children with incomplete SCI are able to gain a great degree of functional recovery while children with complete SCI can achieve better independent living ability through active comprehensive rehabilitation training.

Background

Spinal cord injury (SCI) is rare, and cases in children account for 2–5% of all SCI occurrences[1–6]. In recent years, the incidences of SCI in children has had an upward trend. Thirty patients have been admitted and treated in our hospital. SCI differs in children and adults in terms of incidence, type and site of injury, and prognosis. This paper reviewed 58 children with SCI admitted, treated, and investigated in the past few years to analyze therapeutic characteristics and efficacy.

Methods

Subjects

Fifty-eight children with SCI, 6 males and 52 females, were included in this study. Their ages ranged from 1 to 14 years, with an average of 6.4 years. Thirty-five cases (60.34%) were caused by a **back bend**, eight cases (13.79%) by traffic accidents, five cases (8.62%) by myelitis, four cases (6.90%) by fall accidents, three cases (5.17%) by falling over, two cases (3.45%) by spinal vascular malformation, and one case (1.72%) by impact injury. Two cases (3.45%) had SCI at and above C8 level, 20 cases (34.48%) at T1-T6 level, 34 cases (58.62%) at T7-T12 level, and two cases (3.45%) at L1 level and below. Forty-seven cases (81.03%) had complete SCI, while 11 cases (18.97%) had incomplete SCI.

Case sources

The patients were divided into admittance and treatment group (n = 30) and investigation group (n = 28). Clinical data, including sex, age, cause of injury, injury level, degree of injury, and rehabilitation of the children with SCI admitted and treated in our hospital from January 2004 to January 2017 were reviewed.

Clinical evaluation

The level and degree of SCI were determined according to the International Standards for Neurological Classification of Spinal Cord Injury formulated by the American Spinal Injury Association (ASIA) in 1982 [6]. Patients were divided into three groups based on the site of injury: T6 and above, T7-T12, and L1 and below.

Rehabilitation evaluation

Rehabilitation evaluation must be carried out prior to rehabilitation treatment. Discharge evaluation included walking capacity (including walking by wearing a brace), wheelchair capacity, and self-care ability. Wheelchair capacity was further divided into wheelchair independence and wheelchair dependence. Patients were considered to have basic wheelchair independence if they are able to push their wheelchair for 50 meters on flat ground and perform bed to wheelchair transfer on their own. Self-care ability was evaluated using a modified Barthel Index, where a score >60 points is considered complete self-care; 40–60 points, partial self-care; and <40 points, living dependence.

Rehabilitation treatment

Physical therapy included passive movements, static stretching, position changing, early sitting-up, electric tilting table training, cardiopulmonary endurance training by upper extremities cycling, upper and lower extremities and abdominal and back muscles strengthening exercises, sensation facilitation training, sitting balance training, standing training, gait training, functional electrical stimulation, and other electrotherapies. Occupational therapy included activities of daily living (ADL) training, transfer training, and wheelchair skill training. Assistive devices used include suitable leg braces, walkers, canes, and braces for correcting scoliosis. Psychological therapy included early psychological counseling and support for patients and their family members to help them optimistically embrace life and integrate better into society.

Rehabilitation nursing

Patients and family members received training on turning over and positioning, pressure sore management, bladder management including clean intermittent catheterization and drinking/urination planning, and rectum management including dietary structural adjustment and anus stretching.

Results

The SCI levels of the 58 patients were mostly in the thoracic region, with 22 cases (37.93%) at T6 level and above and 34 cases (58.62%) at T7-T12 level. This is contrary to injuries in adults, which commonly occur in the thoracolumbar region [7,8]. Forty-seven cases (81.03%) had complete injury (Table 1). The primary cause of injury was back bend in 35 cases (60.34%) and traffic accidents in eight cases (13.79%) (Table 2).

Table 1. SCI level and degree of injury.

| <i>ASIA</i> | <i>T6 and above</i> | <i>T7-T12</i> | <i>L1 and below</i> | <i>TOTAL</i> |
|--------------|---------------------|------------------|---------------------|------------------|
| A | 18 | 29 | - | 47 81.03% |
| B | 2 | 1 | - | 3 5.17% |
| C | 1 | 2 | - | 3 5.17% |
| D | 1 | 2 | 2 | 5 8.62% |
| E | - | - | - | - |
| TOTAL | 22 37.93% | 34 58.62% | 2 3.45% | 58 |

Table 2. Causes of SCI injury.

| | <i>T6 and above</i> | <i>T7-T12</i> | <i>L1 and below</i> | <i>TOTAL</i> |
|-----------------------|---------------------|---------------|---------------------|------------------|
| back bend | 11 | 24 | - | 35 60.34% |
| falling accident | 2 | 1 | 1 | 4 6.90% |
| vascular malformation | 1 | 1 | - | 2 3.45% |
| traffic accident | 5 | 3 | - | 8 13.79% |
| myelitis | 1 | 3 | 1 | 5 8.62% |
| falling over <1 m | 1 | 2 | - | 3 5.17% |
| impact injury | 1 | - | - | 1 1.72% |

Among the 58 patients, seven (12.07%) achieved independent walking ability (including wearing braces) upon discharge, while 51 were discharged with wheelchairs. Of the 51 discharged with wheelchairs, 33 (56.90%) were wheelchair-independent and 18 (31.03%) were wheelchair-dependent. Forty-six patients (79.31%) were able to perform basic or complete self-care, 11 (18.97%) had incomplete self-care ability, and 35 (60.34%) had complete self-care ability. Twelve patients (20.69%) were dependent on others (living dependence); six of these patients with living dependence had SCI at T6 level and above while the other six had SCI at T7-T12 level (Table 3).

Table 3. Conditions of the 58 children with SCI upon discharge.

| | <i>T6 and above</i> | <i>T7-T12</i> | <i>L1 and below</i> | <i>TOTAL</i> |
|---------------------------|---------------------|---------------|---------------------|--------------|
| brace/independent walking | 2 | 3 | 2 | 7 [12.07%] |
| wheelchair independence | 12 | 21 | - | 33 [56.90%] |
| wheelchair dependence | 8 | 10 | - | 18 [31.03%] |
| basic self-care ability | 6 | 20 | 2 | 28 [48.28%] |
| partial self-care ability | 10 | 8 | - | 18 [31.03%] |
| living dependence | 6 | 6 | - | 12 [20.69%] |

Consistent with SCI in adults, incidences of complications, such as bladder and rectal dysfunction, were also high in children. In our patients, 56 (96.55%) had bladder dysfunction and 55 (94.83%) had rectal dysfunction. Incidence of scoliosis was also high because of the growth and development of children. Among our patients, 20 (34.48%) had scoliosis (Table 4). This is consistent with the high incidence of traumatic scoliosis reported in children with complete SCI in previous reports [5,10]

Table 4. Complications.

| | <i>T6 and above</i> | <i>T7-T12</i> | <i>L1 and below</i> | <i>TOTAL</i> |
|---------------------|---------------------|---------------|---------------------|--------------|
| bladder dysfunction | 21 | 34 | 1 | 56 [96.55%] |
| rectal dysfunction | 20 | 34 | 1 | 55 [94.83%] |
| urinary infection | 11 | 18 | - | 29 [50.00%] |
| pressure sore | 1 | 2 | - | 3 [23.08%] |
| scoliosis | 6 | 13 | 1 | 20 [34.48%] |

Discussion

Analysis of injury

In our patients, over 60% of the injuries were caused by a back bend, which must be noted by those active in sports and medical circles. Such result may also be attributed to the small sample size. Nonetheless, sports injuries related to the anatomical and physiological characteristics of children's spinal cords have shown an increasing trend in recent years [11]. (1) Joint capsules and ligaments of children's spines have good elasticity. Typically, the spine of newborns can be stretched for 5 cm along the longitudinal axis, but the spinal cord can only be stretched for 0.6 cm. (2) The articular surfaces of the spine are shallow. (3) The front part of the vertebral body is wedge-shaped, prompting ventral sliding of the intervertebral space.

(4) The immature vertebral endplate is vulnerable. (5) Infants have relatively large heads but relatively weak neck muscles, making them susceptible to cervical hyperextension or hyperflexion injuries. (6) Cervical spines of children have several biomechanical characteristics, such as the vertebral arch of the atlas is small while the occipital foramen is large, the atlantooccipital ligament and occipital condyle joint capsules are loose, and the occipital condyle articular surfaces are flat. (7) Little blood supply is available in the thoracolumbar junction of the spinal cord. (8) The thoracic spinal and thoracolumbar spinal canals are narrow. Based on these eight anatomical and physiological characteristics, children are subject to SCI without radiographic abnormalities (SCIWORA) in carrying out lower back activities. SCIWORA was first proposed by Pang in 1982 [9]. Its incidence in children is markedly higher than in adults, and most are complete injuries with poor recovery [5]. Therefore, sufficient preparations should be carried out prior to lower back dancing movements in children. Lower back training should be performed step by step, rather than in a rush for quick results.

Prognosis

The prognosis is mainly related to the degree of primary SCI after trauma. Early rehabilitation intervention should be carried out once patients are stable enough to obtain satisfying curative effects and prognosis. Most scholars believe that patients with mild or moderate injury could recover back to the level before injury. However, patients with severe SCI or complete injury are frequently deprived of spinal cord functional recovery [5,10]. Among our 58 patients, those with degrees of injury at grade A and B have no obvious recovery. Three patients with degree of injury at grade C improved to grade D, while five patients with degree of injury at grade D improved to grade E. Nonetheless, active and comprehensive rehabilitation treatment allows patients to achieve better self-care ability, even for those with severe injuries. Among our patients, 12 have living dependence which can be attributed mainly to their young age, making them unable to drive a wheelchair, to take a bath, or to go to the toilet. Moreover, high injury level, loss of hand function, and poor sitting balance are also important causes of living dependence.

Bladder management

Bladder dysfunction frequently induces urinary infection, urinary stones, and hydronephrosis. In severe cases, it can result in renal failure. For SCI patients with bladder dysfunction, reconstruction of the bladder function can remarkably improve quality of life [11]. Comprehensive treatments have been employed to treat SCI patients with bladder impairments, including bladder function improving agents, clean intermittent catheterization techniques, pelvic floor muscle strengthening exercises, and electromyographic biofeedback [13]. Eleven patients can complete automatic urination or self-catheterization, while 42 patients can only complete catheterization with the assistance of a family member due to their young age. With the recovery of spinal cord function, responsive changes can be seen in urine storage and urination function of the bladder, and the rehabilitation treatment plan should be adjusted accordingly.

Children are at the rapid growth and development phase; thus, malformation should be prevented during their rehabilitation treatment for SCI to ensure their growth and development. In our 58 SCI patients,

34.48% have scoliosis. According to Hong Yi et al., incidence of scoliosis, kyphosis, or lordosis is as high as 55–91% in children with SCI ages 6 months and older [14]. Among these, scoliosis is the most common malformation, causing patients to be unable to sit due to severe malformation. In severe cases, scoliosis can affect the pulmonary ventilation and gas exchange function. In the functional training and daily life of the patients, paying close attention to correct prone, sitting, and standing positions is necessary. If possible, patients should do standing training for a certain period daily to promote the normal development of the acetabulum and to prevent the occurrence of hip joint dislocation or subluxation. Furthermore, symmetric training on the upper and lower abdominal and back muscles should be strengthened to maintain the normal mechanical characteristics and physiological curves of the spine.

Conclusions

Children with incomplete SCI are able to gain a great degree of functional recovery while children with complete SCI can achieve better independent living ability through active comprehensive rehabilitation training.

Abbreviations

ADL: Activities of daily living

ASIA: American Spinal Injury Association

SCI: Spinal Cord Injury

SCIROWA: Spinal Cord Injury without radiographic abnormalities

Declarations

Ethic approval and consent to participate

The Medical Ethical Commission of the First Affiliated Hospital of Nanjing Medical University approved this study and the study was conducted in accordance with the Declaration of Helsinki. The study was retrospective and did not involve human or animal experiments, so the informed consent was exempted from ethical approval. These patients were contacted by telephone to obtain verbal informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on a validated request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

YL contributed to the study conception, data analysis, and editing of the manuscript. He found the patients in his clinical work. He decided to conduct the study based on a careful understanding of the patient's medical history. PG was responsible for the data collection for all the patients and completed the first draft of the paper by consulting relevant literatures. YH completed the revision of the article, passed the ethical review, and submitted the article. In addition, PG and YH also participated in the treatment of some patients. YW was in charge of translating the article. Professor JL provided technical guidance.

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