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Original Article

Effects of early rehabilitation on postoperative healing and complications in patients with spinal cord injuries

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Abstract: Objective: The aim of this study was to investigate the effects of early rehabilitation on functional recovery and complications in patients with spinal cord injuries. Methods: This study retrospectively analyzed 342 cases of spinal cord injuries. A total of 158 patients receiving rehabilitation 30 days after surgery were included as the control group. A total of 184 receiving rehabilitation within 30 days after surgery constituted the observation group. The two groups were compared regarding motor and sensory function (American Spinal Injury Association scores), activities of daily living (modified Barthel index), functional independence (functional independence rating), and complications (pressure sores, deep vein thrombosis, pain, lung infection, and urinary tract infections). Results: There were no significant differences in motor function scores, sensory function scores, activities of daily living, or functional independence scores between the two groups before treatment (P>0.05). Significant differences were seen after treatment. Incidence of complications was significantly lower in the observation group than the control group (P<0.05). Incidence of pressure sores, pain, lung infections, and urinary tract infections was lower in the observation group than the control group (P<0.05). Conclusion: Early rehabilitation is beneficial to the recovery of motor function and sensory function. It can improve the activities of daily living, increase functional independence, and reduce occurrence of complications.

Keywords: Early rehabilitation, spinal cord injury, activities of daily living, complications

Introduction

Spinal cord injury refers to a transverse injury of the spinal cord, resulting in impaired motor, sensory, sphincter, and autonomic function. It is highly lethal and disabling [1, 2]. The annual incidence of spinal cord injuries has been increasing, seriously affecting the living standards of patients and placing a significant burden on society [3, 4].

In recent years, various new drugs and treatments, such as neurotrophic factors and stem cell transplantation, have been introduced. Their curative effects, however, for spinal cord injuries have not been satisfactory. Therefore, active rehabilitation therapy shows prominent value for patients, families, and society [5, 6].

Rehabilitation therapy is often started after the end of clinical treatment, leading to longer bed-rest times and higher complication rates. Moreover, in the acute phase of spinal cord injuries, some patients do not receive appropriate and effective rehabilitation. Some even have negative experiences that further add negative effects to the recovery [7, 8]. Active rehabilitation is a very effective means of promoting the remodeling of spinal cord function [9], It can effectively alleviate progressive damage to spinal cord function, reducing occurrence of complications and enabling patients to better utilize the remaining functional abilities. This restores functional independence and improves quality of life [10]. In recent years, studies have reported that early rehabilitation can better stabilize patient conditions. However, some hospitals do not emphasize early rehabilitation and the timing of rehabilitation remains unclear.

This study retrospectively analyzed the medical records of 342 patients with spinal cord inju-

Table 1. General information

	Control group	Observation group	χ^2	*p*-valued
Number	158	184		
Sex			0.338	0.561
Male	101 (63.92)	112 (60.87)		
Female	57 (36.08)	72 (37.13)		
Age (years)	43.2 ± 7.6	44.1 ± 6.9	1.147	0.252
Education			1.036	0.309
High school and below	104 (65.82)	110 (59.78)		
High school	54 (34.18)	74 (40.22)		
Residence			1.345	0.246
Country	82 (51.90)	107 (58.15)		
City	76 (48.10)	77 (41.85)		
ASIA classification			2.459	0.483
A	40 (25.32)	46 (25.00)		
B	89 (56.33)	92 (50.00)		
C	23 (14.56)	35 (19.02)		
D	6 (3.80)	11 (5.98)		
Damaged locations			1.068	0.586
Cervical spinal cord injury	40 (25.32)	49 (26.63)		
Thoracic vertebra cord injury	75 (47.47)	79 (42.93)		
Lumbosacral spinal cord injury	43 (27.22)	56 (30.43)		

ries, exploring the application of early rehabilitation.

Materials and methods

Research subjects

This study retrospectively analyzed 342 cases of spinal cord injuries treated between April 2012 and May 2017. A total of 158 patients that started rehabilitation 30 days after surgery were included as the control group, while 184 that started rehabilitation within 30 days after surgery were selected as the observation group. All patients met the guidelines of the Spinal Cord Injury Association, 5th edition. Patients were aged 21-58 years and included 213 males and 129 females. Disease duration lasted no more than 3 months. None of the patients had undergone rehabilitation therapy before the study and the vital signs of patients were stable. The patients had no abnormalities of the heart, liver, or kidneys and had no severe abdominal injuries, abnormal bleeding or coagulation, or history of alcoholism. Patients with combined limb fractures, incomplete data, history of gastritis, postoperative spinal instability, severe bone and joint disease, or mental or learning impairment were excluded. This study was approved by the Ethics Committee and written informed consent was obtained for each patient.

Treatment methods

Both groups of patients received treatment for the primary disease, including the use of corticosteroids, neurotrophic factors and other drugs, spinal decompression, and vertebral fusion with plate fixation. At the same time, rehabilitation was performed. Rehabilitation treatment time in this study was not more than 3 months. Both groups received comprehensive rehabilitation and physiotherapy for 3 months. This mainly included instruction in correct posture changes, exercise therapy, vascular adjustment training, promotion of systemic and limb circulation, neuromuscular electrical stimulation, bladder function training, and rectal function training. A rehabilitation treatment plan was formulated for each patient.

Observation indicators

American Spinal Injury Association (ASIA) grades were used to assess the degree of spinal cord injuries [11]. The ASIA score was used to evaluate motor and sensory function, while the modified Barthel index score was used to evaluate the performance of daily living activities. The functional independence rating scale was applied. Complications, including pressure sores, deep vein thrombosis, pain, lung infections, and urinary tract infections, were assessed in all patients.

Statistical analysis

SPSS 19.0 (Asia Analytics Formerly SPSS China) was used for statistical analysis. Enumeration data are expressed as [n (%)]

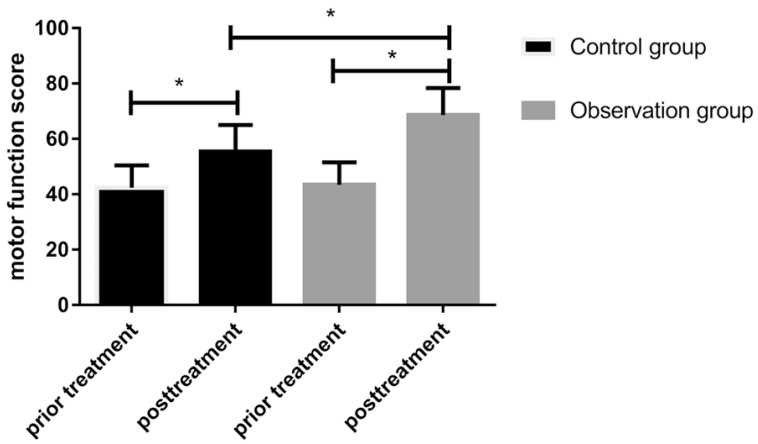

Figure 1. Evaluation of motor function, *indicates P<0.05.

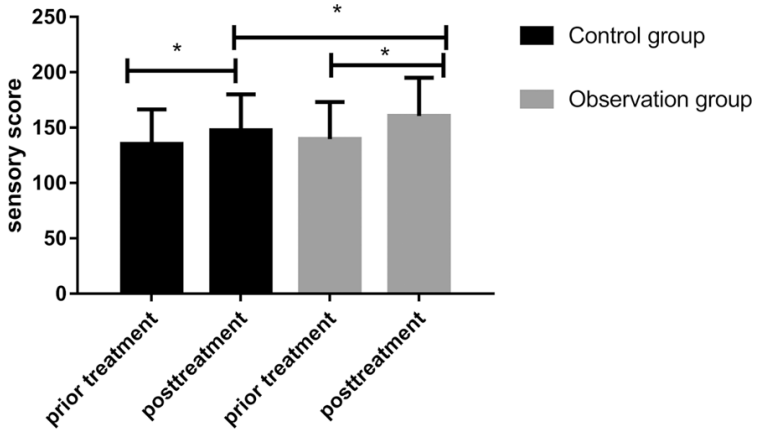

Figure 2. Evaluation of sensory function, *indicates P<0.05.

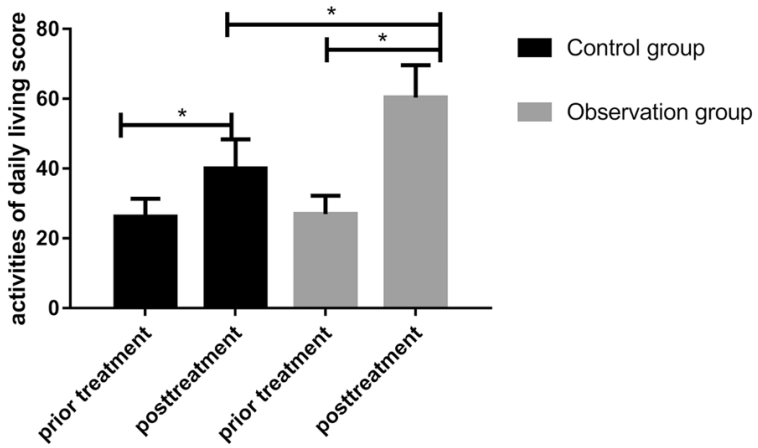

Figure 3. Evaluation of the ability to perform activities of daily living, *indicates P<0.05.

and the ratio was compared using the χ^2 test. Measurement data are expressed as mean ± standard deviation (Mean ± SD) and t-test was used for comparisons between the two groups. P<0.05 indicates statistical significance.

Results

General information

The control group comprised 158 patients, including 101 males and 57 females, with an average age of 43.2 ± 7.6 years. There were 184 patients in the observation group, including 112 males and 72 females, with an average age of 44.1 ± 6.9 years. There were no significant differences regarding sex, age, education level, place of residence, ASIA classification, and spinal cord injury levels between the two groups (P>0.05) (**Table 1**).

Patient motor ability evaluation

There were no significant differences in motor function scores between the two groups before treatment (P>0.05). After treatment, there were significant differences in motor function scores between the two groups (P<0.05). The motor function score in the observation group was significantly higher than that in the control group (P<0.05). Motor ability scores of the two groups after treatment were significantly higher than those before treatment (P<0.05) (**Figure 1**).

Patient sensory function scores

There were no significant differences in sensory function scores between the two groups before treatment (P>0.05). After treatment, there were significant differences in sensory function scores bet-

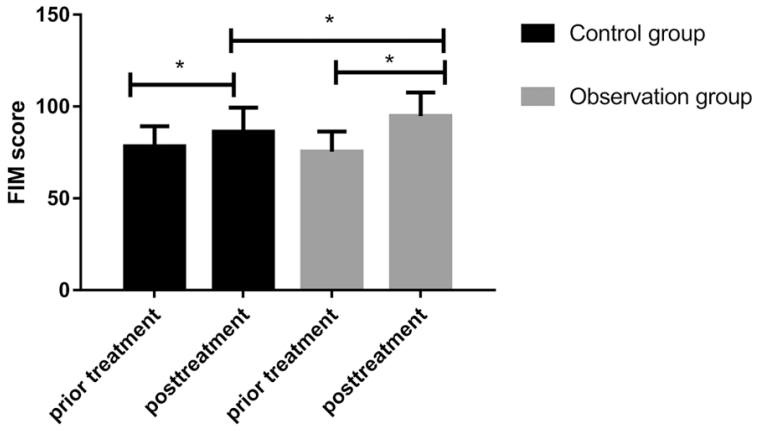

Figure 4. Evaluation of independent function, *indicates P<0.05.

Table 2. Statistical analysis of patient complications

	Control group	Observation group	χ^2	*p*-valued
Pressure sores			6.169	0.013
Yes	46 (29.11)	27 (14.67)		
No	138 (87.34)	157 (85.33)		
Deep venous thrombosis			0.017	0.896
Yes	17 (10.76)	19 (10.33)		
No	141 (89.24)	165 (89.67)		
Pain			8.159	0.004
Yes	44 (27.85)	28 (15.22)		
No	114 (72.15)	156 (84.78)		
Pulmonary infection			8.853	0.003
Yes	46 (29.11)	29 (15.76)		
No	112 (70.89)	155 (84.24)		
Urinary tract infection			22.010	<0.001
Yes	84 (53.16)	52 (28.26)		
No	74 (46.84)	132 (71.74)		
Total complication rate	97 (61.39)	68 (36.96)	20.328	<0.001

ween the two groups. Sensory function scores of patients in the observation group were significantly higher than those in the control group (P<0.05). Sensory function scores of the two groups after treatment were significantly higher than before treatment (P<0.05) (**Figure 2**).

Daily living activities evaluation

There were no statistical differences in scores between the two groups before treatment (P>0.05); After treatment, there were significant differences in scores between the two groups. Scores in the observation group were significantly higher than those in the control group (P<0.05). Activities of daily living scores in the two groups after treatment were significantly higher than before treatment (P<0.05) (**Figure 3**).

Functional independence evaluation

There were no statistical differences in functional independence scores between the two groups before treatment (P>0.05). After treatment, there were significant differences in functional independence scores between the two groups (P<0.05). Functional independence scores in the observation group were significantly higher than those in the control group (P<0.05). Functional independence scores in the two groups after treatment were significantly higher than before treatment (P<0.05) (**Figure 4**).

Statistical analysis of patient complications

The total complication rate was 61.39% (97 cases) in the control group and 36.96% (68 cases) in the observation group. There were statistically significant differences in total complication rates between the two groups (P<0.05). Incidence of complications in the observation group was significantly lower than that in the control group (P<0.05). There were also statistically significant differences in incidence of pressure sores, pain, lung infections, and urinary tract infections between the two groups. Incidence rates in the observation group were all lower than those in the control group (P<0.05), but the incidence rate of deep vein thrombosis was not statistically different (P>0.05) (**Table 2**).

Discussion

Spinal cord injuries cause impaired sensation, movement, and autonomic function, adversely

affecting physical and psychological conditions [12]. Early rehabilitation can improve motor function, prevent complications, and improve the ability to perform activities of daily living [13]. This retrospective study examined the importance of early rehabilitation in 342 cases of spinal cord injuries.

Medical records of 342 patients with spinal cord injuries that underwent rehabilitation were included in the present analysis. There were no statistically significant differences in sex, age, education, place of residence, ASIA classification, and injury location between the two groups. Therefore, they were comparable. After rehabilitation, scores of motor and sensory functioning in the two groups were higher than before treatment. Results indicated that active rehabilitation was beneficial to the recovery of motor and sensory function in spinal cord injuries. The present study also found that recovery of motor and sensory function with early rehabilitation was significantly higher than that without early rehabilitation, indicating that early rehabilitation can more effectively restore motor and sensory function in patients with spinal cord injuries. Rehabilitation and clinical treatment are equally important for patients with spinal cord injuries. A patient that does not receive timely rehabilitation will have inadequate clinical results, especially in cases of complete spinal cord injuries [14]. Although the recovery of motor and sensory function in patients with spinal cord injuries is the main goal of rehabilitation therapy, it also brings positive outcomes for restoration of activities of daily living and functional independence [15]. After rehabilitation, activities of daily living and functional independence scores in the two groups were higher than those before treatment. Therefore, rehabilitation can effectively restore activities of daily living and functional independence in patients with spinal cord injuries, indicating its curative value. Activities of daily living and functional independence scores with early rehabilitation were also significantly higher than those without early rehabilitation, suggesting timely early rehabilitation's importance, in accord with previous reports [16, 17]. Moreover, incidence rates of complications in patients receiving early rehabilitation were significantly lower than in patients without early rehabilitation, in accord with previous reports [18, 19]. Patients undergoing early rehabilitation can change positions more often and have a shorter bedrest time, making the blood vessels more adaptable to pressure and reducing occurrence of pressure sores. The underlying mechanisms remain unclear, but pain can seriously affect psychological status, with adverse effects on treatment. Pulmonary infections are among the most serious complications in spinal cord injuries, mainly due to the interrupted connection between the spinal cord and central nervous system. Early rehabilitation can also reduce indwelling catheter time and decrease incidence of urinary tract infections [20, 21]. However, the present study did not find a difference in the incidence rates of deep vein thrombosis between the two groups, possibly because of the shorter study duration. Therefore, this study should promote further research on early rehabilitation for spinal cord injuries.

In summary, early rehabilitation is more conducive to recovery of motor and sensory function. It can improve activities of daily living, increase functional independence, and reduce occurrence of complications. Therefore, early rehabilitation may have a positive impact on the early return of patients with spinal cord injuries to society.

Disclosure of conflict of interest

None.

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References

[1] Athanasou JA. Spinal Cord Injury. In: editors. Encountering Personal Injury. Springer; 2016. p. 157-164.

[2] Alizadeh M, Fisher J, Saksena S, Sultan Y, Conklin CJ, Middleton DM, Finsterbusch J, Krisa L, Flanders AE, Faro SH, Mulcahey MJ and Mohamed FB. Reduced field of view diffusion tensor imaging and fiber tractography of the pediatric cervical and thoracic spinal cord injury. J Neurotrauma 2018; 35: 452-460.

[3] Scott WH, Ogonowska-Slodownik A, Gorman PH, Slodownik R and Geigle PR. Reliability & validity of aquatic deep water peak vo2 testing for individuals with spinal cord injury: 3028 board# 8 June 2 3. Medicine & Science in Sports & Exercise 2017; 49: 858.

[4] Lee BB, Cripps RA, Fitzharris M and Wing PC. The global map for traumatic spinal cord injury epidemiology: update 2011, global incidence rate. Spinal Cord 2014; 52: 110-116.
[5] Kumru H, Murillo N, Benito-Penalva J, Tormos JM and Vidal J. Transcranial direct current stimulation is not effective in the motor strength and gait recovery following motor incomplete spinal cord injury during Lokomat ((R)) gait training. Neurosci Lett 2016; 620: 143-147.
[6] Zbogar D, Eng JJ, Miller WC, Krassioukov AV and Verrier MC. Movement repetitions in physical and occupational therapy during spinal cord injury rehabilitation. Spinal Cord 2017; 55: 172-179.
[7] Shinozaki M, Iwanami A, Fujiyoshi K, Tashiro S, Kitamura K, Shibata S, Fujita H, Nakamura M and Okano H. Combined treatment with chondroitinase ABC and treadmill rehabilitation for chronic severe spinal cord injury in adult rats. Neurosci Res 2016; 113: 37-47.
[8] Wilson JR, Voth J, Singh A, Middleton J, Jaglal SB, Singh JM, Mainprize TG, Yee A and Fehlings MG. Defining the pathway to definitive care and surgical decompression after traumatic spinal cord injury: results of a canadian population-based cohort study. J Neurotrauma 2016; 33: 963-971.
[9] Dobkin B, Barbeau H, Deforge D, Ditunno J, Elashoff R, Apple D, Basso M, Behrman A, Fugate L and Harkema S. The evolution of walking-related outcomes over the first 12 weeks of rehabilitation for incomplete traumatic spinal cord injury: the multicenter randomized spinal cord injury locomotor trial. Neurorehabil Neural Repair 2007; 21: 25-35.
[10] Ma VY, Chan L and Carruthers KJ. Incidence, prevalence, costs, and impact on disability of common conditions requiring rehabilitation in the United States: stroke, spinal cord injury, traumatic brain injury, multiple sclerosis, osteoarthritis, rheumatoid arthritis, limb loss, and back pain. Arch Phys Med Rehabil 2014; 95: 986-995 e981.
[11] Wang JJ, Zeng ZL, Zhu R, Huang RZ, Yu Y, Di RJ, Ma B, Xie N, Hu X, Xu W, Ren YL, Wu ZR, Zhu RR, Zhu YJ and Cheng LM. Clinical efficacy of anterior decompression and stability reconstruction in patients with cervical hyperextension injury. Zhonghua Yi Xue Za Zhi 2018; 98: 3858-3863.
[12] Nas K, Yazmalar L, Şah V, Aydın A and Öneş K. Rehabilitation of spinal cord injuries. World journal of orthopedics 2015; 6: 8.
[13] Sandrow-Feinberg HR and Houle JD. Exercise after spinal cord injury as an agent for neuroprotection, regeneration and rehabilitation. Brain Res 2015; 1619: 12-21.
[14] Mackelprang JL, Hoffman JM, Garbaccio C and Bombardier CH. Outcomes and lessons learned from a randomized controlled trial to reduce health care utilization during the first year after spinal cord injury rehabilitation: telephone counseling versus usual care. Arch Phys Med Rehabil 2016; 97: 1793-1796, e1791.
[15] Hearn JH, Finlay KA, Fine PA and Cotter I. Neuropathic pain in a rehabilitation setting after spinal cord injury: an interpretative phenomenological analysis of inpatients' experiences. Spinal Cord Series and Cases 2017; 3: 17083.
[16] Soekadar S, Witkowski M, Gómez C, Opisso E, Medina J, Cortese M, Cempini M, Carrozza M, Cohen L and Birbaumer N. Hybrid EEG/EOG-based brain/neural hand exoskeleton restores fully independent daily living activities after quadriplegia. Science Robotics 2016; 1: eaag3296.
[17] Wirz M, Dietz V; European Multicenter Study of Spinal Cord Injury (EMSCI) Network. Recovery of sensorimotor function and activities of daily living after cervical spinal cord injury: the influence of age. J Neurotrauma 2015; 32: 194-199.
[18] Sezer N, Akkus S and Ugurlu FG. Chronic complications of spinal cord injury. World J Orthop 2015; 6: 24-33.
[19] Loh E, Guy SD, Mehta S, Moulin DE, Bryce TN, Middleton JW, Siddall PJ, Hitzig SL, Widerstrom-Noga E, Finnerup NB, Kras-Dupuis A, Casalino A, Craven BC, Lau B, Cote I, Harvey D, O'Connell C, Orenczuk S, Parrent AG, Potter P, Short C, Teasell R, Townson A, Truchon C, Bradbury CL and Wolfe D. The canpain sci clinical practice guidelines for rehabilitation management of neuropathic pain after spinal cord: introduction, methodology and recommendation overview. Spinal Cord 2016; 54 Suppl 1: S1-6.
[20] Cogan AM, Blanchard J, Garber SL, Vigen CL, Carlson M and Clark FA. Systematic review of behavioral and educational interventions to prevent pressure ulcers in adults with spinal cord injury. Clin Rehabil 2017; 31: 871-880.
[21] Brommer B, Engel O, Kopp MA, Watzlawick R, Muller S, Pruss H, Chen Y, DeVivo MJ, Finkenstaedt FW, Dirnagl U, Liebscher T, Meisel A and Schwab JM. Spinal cord injury-induced immune deficiency syndrome enhances infection susceptibility dependent on lesion level. Brain 2016; 139: 692-707.