

Original Article

Improvement of pulmonary function and life quality on high paraplegia patients through pulmonary rehabilitation

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Abstract: Background: Spinal cord injury is often accompanied by paraplegia with respiratory failure, brings about patients suffering. The purpose of this study was to investigate the effects of pulmonary rehabilitation on pulmonary function and life quality in patients with advanced high paraplegia. Methods: Total of 98 patients with spinal cord injury were randomly divided into experimental group (49 cases) and control group (49 cases). All patients received conventional rehabilitation therapy, experimental group received another 12 months pulmonary rehabilitation therapy. The pulmonary function and life quality were used to analyze the effects of pulmonary rehabilitation. Results: The experimental group with pulmonary rehabilitation had significant improvements. The pulmonary function indicators such as forced expiratory volume in 1 second (FEV₁), maximal ventilation volume (MVV), forced vital capacity (FVC) and FEV₁/FVC had been greatly improved ($P < 0.01$). The indicators of life quality such as physical function, social function, role emotional, mental health and body pain had been greatly improved ($P < 0.01$). Conclusion: The pulmonary rehabilitation had great improvements on the pulmonary function and life quality in patients with advanced high paraplegia.

Keywords: High paraplegia, life quality, pulmonary function, pulmonary rehabilitation

Introduction

Spinal cord injury (SCI) often causes permanent changes in strength and sensation functions below the injury site [1], the complications of SCI include paraplegia, tetraplegia, respiratory failure, pulmonary edema, pneumonia and so on. Transverse injury across spinal cord of the second thoracic above caused by traumatic SCI often result in high paraplegia.

Advanced high paraplegia results in internal and external intercostal muscle paralysis below injured level; especially the injured level above T8 (thoracica spinal nerve 8), abdominal muscles are also implicated. Therefore, the active and passive breathing are affected and ventila-

tion function is decreased. Due to the limited exercise capacity, it would result in skeletal muscle atrophy, decrease of oxygen uptake of skeletal muscle and oxygen concentration of mitochondrial [2]. If all these factors caused inadequate pulmonary ventilation for persistent state, Those factors eventually lead to hypoxemia and hypercapnia.

Pulmonary function is weakened in varying degree in patients with advanced high paraplegia [3]. In recent years, a number of studies report that advanced high paraplegia patients with respiratory complications is the leading cause of mortality [4, 5]. Respiratory muscle dysfunction induces heart function decline, sensation decrease and mental disorders then

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give rise to worse dyspnea and activities of daily living (ADL), life quality decline, and even affect the lifespan of patients [6-8]. Thus improvement of respiratory function respiratory complications are essential for patients with advanced paraplegia [9, 10]. Pulmonary rehabilitation is feasible, effective and sustainable for health care professionals [11], which is recommended as a standard of care for patients with chronic obstructive pulmonary disease [12].

This study mainly observed effects of pulmonary rehabilitation on pulmonary function, daily activities and life quality in high paraplegia patients, aimed to reduce respiratory complications and improve respiratory function of advanced high paraplegia patients.

Patients and methods

Patients

Total of 98 patients with advanced high paraplegia caused by spinal cord injury through traumatism hospitalized in Taian Disabled Soldiers Hospital of Shandong Province were incorporated in our perspective study. All patients were male and the mean age was 62.7 ± 10.8 [range: 29-86] years. The course of advanced high paraplegia was 41.6 ± 10.8 [range: 9-66] years. 98 patients were randomly numbered, odd numbers of 48 cases were defined as experimental group and named group A, even number of 48 cases were defined as control group and named group B.

Inclusion and exclusion criteria

Inclusion criteria: 1. Injury located at C5-C7 (C: cervical spinal nerve), spinal injury of patients conformed to International Standards for Neurological Classification of Spinal Cord Injury (ASIA, 4th Edition, 1992); 2. Patients in stable condition and could cooperate to complete pulmonary function test and pulmonary rehabilitation.

Exclusion criteria: 1. Patients with complications of cardiovascular disease, cerebrovascular disease, cancer, psychiatric disorders and other intolerant rehabilitation diseases; 2. Patients with diseases which affected the objective evaluation of respiratory function such as acute respiratory infections or other

respiratory diseases; 3. Patients took medicine affected the respiratory function.

Ethics

The project was approved by the Ethics Committee of Taian Disabled Soldiers Hospital of Shandong Province. The ethics committee approved the relating screening, inspection, and data collection of the patients, and all subjects signed a written informed consent form.

Rehabilitation therapy

All patients acquired conventional rehabilitation, including psychological rehabilitation and dietary guidance. Given psychological guidance enhance rehabilitation confidence; dietary guidance including provided food rich in protein, energy, vitamins, phospholipids and microelements for patients, prevent from complications of common cold and urinary infections. Experimental group (A group) acquired pulmonary rehabilitation exercise for 12 months, then withdrawal for 1 month; the data of different time points were recorded, including before pulmonary rehabilitation, in pulmonary rehabilitation for 2 months, 4 months, 12 months and after pulmonary rehabilitation for 1 month.

Pulmonary rehabilitation programs

Pulmonary rehabilitation exercises conformed to the pulmonary evidence-based guidelines proposed by American College of Chest Physicians (ACPP) and American Association of Cardiovascular Pulmonary Rehabilitation revised in 2007. Patients were provided pulmonary rehabilitation training and personal supervision to ensure the accuracy of the action. Pulmonary rehabilitation exercises contained breath training and strength training. Breath training included lip breathing and abdominal breathing, lip breathing: deeply inhaling through nose for 2 second and slowly exhaling through mouth for 4-6 seconds approximately, expiration required to whistle-like lips to maintain constant speed; abdominal breathing: patients hold sitting position, left hand on the chest and right hand were put on the abdomen, deep breathing with abdominal distention, then squeezed abdomen to collapse by right hand at the time of lip expiration, the time ratio of inspiration and expiration was 1:2; each training for 20 minutes and three times a day. Strength

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Table 1. Total of 98 patients' demographics

Parameters	Group A	Group B	<i>p</i> -value
Age (years)	62.3±11.2	63.1±10.5	<i>P</i> > 0.05 (0.724)
BMI	21.21±2.77	22.06±2.13	<i>P</i> > 0.05 (0.761)
Paraplegia course (years)	41.2±10.8	41.9±10.9	<i>P</i> > 0.05 (0.738)
Education			
Primary and below	34	41	<i>P</i> > 0.05 (0.26)
Junior	10	6	
Senior	5	2	
Injured part			
T1-2	17	17	<i>P</i> > 0.05 (1)
T3-4	16	16	
T5-6	16	16	
Pulmonary disease			
Yes	8	11	<i>P</i> > 0.05 (0.443)
No	41	38	
Smoke			
Yes	17	8	<i>P</i> > 0.05 (0.063)
No	32	41	
Total	49	49	

Group A: experimental group; Group B: control group; BMI (body mass index); *P* < 0.05 was considered significant.

training: upper limb training such as krankcycle training and lift on the load, gradually increasing the amount of exercise based on indefatigability, each training for 20 minutes and one time a day, heart rate was detected after exercise, expected 75-85% of maximum heart rate indicated the appropriate exercise capacity.

Bias control

The research members consisted of a respiratory department doctor, a rehabilitation physician, and a pulmonary function testing physician, a nurse in department of respiratory medicine and 5 questionnaire investigators Those members acquired rehabilitation training for 2 months, grasped the skills of pulmonary rehabilitation programs and ensured the validity and accuracy of actions.

Pulmonary function testing: spirometers were used and the operations were completed by the same person. The uniform instruments were performed to measure the height and weight of patient before pulmonary function testing. The patients hold upright sitting position during checking process. The best results were recorded. [the last time shouldn't be the best value, the difference between the maximum and the

second largest value of forced expiratory volume in 1 second (FEV1), and forced vital capacity (FVC) were less than 150 mL]. Pulmonary function was detected before pulmonary rehabilitation, in pulmonary rehabilitation 2 months, 4 months, 12 months and after pulmonary rehabilitation 1 month, the data of FEV1, FVC, maximal ventilation volume (MVV) and FEV1/FVC were recorded.

The short form health survey questionnaire (SF-36) was achieved by questionnaire, which was taken by one to one and face to face. 98 questionnaires were provided during every record time and pass rate was 100%.

Statistical analysis

Statistical analyses were performed using SPSS 19.0 (SPSS Inc, Chicago, IL, USA). *P* < 0.05 was statistically significant. The continuous data were expressed as mean ± standard deviation; discrete data were expressed as median [min, max]. Chi-square test, t-test and Fisher exact test were used. The effects of different groups and time points on pulmonary function and life quality were used for analysis of variance; least significant difference (LSD) was used to pair-wise comparison of different time point data.

Results

Basic information of 98 cases

Total of 98 patients were incorporated into our prospective study and randomly divided into two groups of experimental group and control group, the basic information consisted of age, body mass index (BMI), paraplegia course, education, injured part, pulmonary disease and smoke was recorded as **Table 1** shown, we analyzed the data, the mean age of experiment group and control group was 62.3±11.2 years and 63.1±10.5 respectively; BMI was 21.21±2.77 and 22.06±2.13; the mean paraplegia course was 41.2±10.8 and 41.9±10.9 months. There were no significances of age, BMI, paraplegia course, education, injured part, pulmo-

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Table 2. The difference of pulmonary function between experimental groups and control groups

Time	FEV1		FVC		MVV		FEV1/FVC	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
1	1.17±0.25	1.17±0.47	2.16±0.36	2.16±0.42	50.5±11.8	50.5±11.8	0.53±0.17	0.53±0.17
2	1.69±0.39*	1.16±0.46	2.66±0.57*	2.17±0.42	64.4±12.4*	50.5±11.1	0.65±0.15*	0.53±0.16
3	2.20±0.44*	1.17±0.46	2.95±0.56*	2.17±0.42	75.1±6.8*	53.8±11	0.75±0.07*	0.53±0.15
4	2.20±0.45*	1.14±0.44	2.95±0.54*	2.17±0.42	75.2±6.8*	51.5±10.6	0.75±0.08*	0.52±0.15
5	1.18±0.27	1.16±0.46	2.15±0.35	2.16±0.42	53.8±11.0	52.9±11.7	0.56±0.12	0.53±0.16

Group A: experimental group; Group B: control group; Time 1: before pulmonary rehabilitation; Time 2-4: in pulmonary rehabilitation 2 months, 4 months, 12 months; Time 5: after pulmonary rehabilitation 1 month; *On the same time point, the average value of experimental group was significantly different from the control group, $P < 0.01$.

Table 3. The difference of life quality between experimental groups and control groups

Time	Physical function		Social function		Role emotional		Mental health		Body pain	
	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B	Group A	Group B
1	54.2±7.8	54.2±7.8	50.6±11.8	50.6±11.8	54.3±7.85	5.3±6.9	54.1±7.7	54.2±7.8	51.6±11.3	51.2±11.0
2	73.8±7.1*	54.5±7.57	3.7±6.2*	51.9±10.9	64.4±12.0*	54.4±7.7	64.3±12.0*	54.6±7.9	52.7±11.9	50.6±11.8
3	79.8±12.0*	54.4±8.0	79.6±5.4*	50.5±11.8	75.1±6.8*	54.5±7.5	75.3±6.7*	54.1±7.7	52.2±10.5	51.6±11.3
4	81.1±3.1*	54.4±7.7	80.1±9.4*	51.2±11.0	76.3±7.3*	54.3±7.8	75.1±6.8*	54.2±7.8	51.9±10.8	51.5±10.6
5	54.4±8.0	54.6±7.9	51.2±11.0	50.6±11.8	54.2±7.8	54.4±7.7	54.2±7.8	54.2±7.8	51.5±10.6	51.9±10.8

Group A: experimental group; Group B: control group; Time 1: before pulmonary rehabilitation; Time 2-4: in pulmonary rehabilitation 2 months, 4 months, 12 months; Time 5: after pulmonary rehabilitation 1 month; *On the same time point, the average value of experimental group was significantly different from the control group, $P < 0.01$.

nary disease and smoke between experimental group and control group as **Table 1** shown.

The comparison of pulmonary function between experimental group and control group

Lung function indicators included FVC, MVV, FEV1 and FEV1/FVC. As **Table 2** shown. The data analyses including FVC, MVV, FEV1 and FEV1/FVC of patients acquired pulmonary rehabilitation for 2 months, 4 months and 12 months displayed highly significant differences ($P < 0.01$) between experimental group and control group, the indicators of experimental group were obviously higher than control group; but there were no difference ($P > 0.05$) before and after pulmonary rehabilitation 1 month between experimental group and control group, respectively. It indicated that continuous exercise might improve the pulmonary function of patients, once pulmonary rehabilitation withdrawal, the pulmonary function would decline to the state of before pulmonary rehabilitation.

LSD was performed to analyze pair-wise comparison of different time point in experimental group or control group. As **Table 2** shown, pulmonary rehabilitation displayed different effect

in experimental group between time 1 and time 2, time 2 and time 3, except time 3 and 4 time points. It indicated that during pulmonary rehabilitation 2 and 4 months, the FVC, MVV, FEV1 and FEV1/FVC had significant effects for pulmonary function, and 4 months significantly improved than 2 month. However, the indicators between 4 months and 12 months had not significant differences; it indicated the effective of FVC, MVV, FEV1 and FEV1/FVC tended to stability after 4 months pulmonary rehabilitation.

The comparison of life quality between experimental group and control group

SF-36 was used to research the life quality of patients. The index of life quality between experimental group and control group including physical function, social function, role emotional, mental health and body pain, which were shown in **Table 3**. There were statistically significant during pulmonary rehabilitation 2 months, 4 months and 12 months between experimental group and control group ($P < 0.01$), the indicators including physical function, social function, role emotional and mental health of experimental group were obviously higher than control group; but no significance

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($P > 0.05$) before pulmonary rehabilitation and after pulmonary rehabilitation 1 month between experimental group and control group were displayed. It indicated that pulmonary rehabilitation had significant improvement in physical function, social function, role emotional and mental health but the improvement based on continuous exercise, once pulmonary rehabilitation withdrawal, the indicators would decline to the state of before pulmonary rehabilitation. No improvement of body pain indicator was observed between experimental group and control group at different pulmonary rehabilitation time points.

LSD analysis in experimental group showed that different effect of life quality except body pain indicator in experimental group between time 1 and time 2, time 2 and time 3, except time 3 and 4 time. There were no significant differences in before and after pulmonary rehabilitation and during pulmonary rehabilitation 4 and 12 months. Withdrawal pulmonary rehabilitation for 1 month had no difference with before training. The physical function tended to stability after 4 months pulmonary rehabilitation.

Discussion

American Thoracic Society and European Respiratory Society proposes the latest definition of pulmonary rehabilitation in 2013. It is described that pulmonary rehabilitation is based on thorough assessment for patients, and then is tailored the treatment according to the condition of patients, including comprehensive intervention, but not limit in the changes of training, education and behavioral [13]. The purpose is to improve the physical and emotional condition, promote long-term training and healthy of chronic respiratory diseases patients [14]. Lip breathing and abdominal breathing are deep and slow breathing which depend on abdominal and diaphragmatic muscle contraction, could increase tidal volume and alveolar ventilation and significantly improve respiratory muscle function, pulmonary function, reduce dyspnea and improve life quality.

98 patients were incorporated into our study pulmonary rehabilitation effect on advanced high paraplegia patients caused by spinal cord injury. 98 patients were randomly numbered

and divided into experimental group and control group, experimental group was acquired pulmonary rehabilitation. Compared with the conventional rehabilitation in control group, pulmonary function in experimental group during 2, 4 and 12 months pulmonary rehabilitation had significantly improvement, and 4 months was better than 2 months, but 4 and 12 months had no significant differences; withdrawal pulmonary rehabilitation for 1 month, pulmonary function declined to before pulmonary rehabilitation, it indicated that continuous pulmonary rehabilitation could improve pulmonary function.

In our study, patients were acquired breathing pattern and upper-limb exercise to strengthen inspiratory and expiratory muscle, inspiratory muscle including diaphragm and external intercostal muscle, expiratory muscle including abdominal and internal intercostal muscle. The exercises enhance excitation-contraction coupling mechanism and improve pulmonary ventilation function. In case of respiratory muscle lost innervations, exercise strength muscle contraction and expansion was limit, so pulmonary function was trended to be stable after pulmonary rehabilitation for 4 months. In addition, once stopping exercise, the excitement-contraction coupling mechanism of patients turned back again, with pulmonary function returned to pre-exercise. Our study results were consistent with some studies [1, 15].

Pulmonary rehabilitation had significant effects on life quality [16, 17]. In our study, the factors which affected the life quality of patients such as physical function, social function, role emotional, mental health and body pain had been controlled. The role of emotional and mental health had no difference with before received pulmonary rehabilitation, and it indicated that the effects of life quality caused by psychologic obstacle were consistent. However, the role of emotional and mental health had significant improvements after pulmonary rehabilitation; it increased the confidence of patients recovery, eliminated the depressed mood and improved the life quality. The pulmonary rehabilitation also improved the physical function and social function [18, 19].

Disclosure of conflict of interest

None.

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