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Peer Reviewer of *World Journal of Clinical Cases*, Che-Chun Su, MD, PhD, Associate Professor, Department of Internal Medicine, Changhua Christian Hospital, Changhua 500, Taiwan. 115025@cch.org.tw

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ORIGINAL ARTICLE

Retrospective Study

Effect of early stepwise cardiopulmonary rehabilitation on function and quality of life in sepsis patients

Ming-Hui Zheng, Wen-Jun Liu, Juan Yang

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Ming-Hui Zheng, Division of Cardiovascular First Ward Departments of Internal Medicine, Liyuan Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430077, Hubei Province, China

Wen-Jun Liu, Department of Respiratory Medicine, PuRen Hospital Affiliated to Wuhan University of Science and Technology/Respiratory Medicine, Wuhan 430000, Hubei Province, China

Juan Yang, Department of Cardiology, Huanggang Central Hospital, Huanggang 438000, Hubei Province, China

Corresponding author: Juan Yang, MM, Attending Doctor, Department of Cardiology, Huanggang Central Hospital, No. 126 Qi'an Road, Huangzhou District, Huanggang 438000, Hubei Province, China. yang223332023@163.com

Abstract

BACKGROUND

Sepsis, as a non-limiting host infection disease, can be accompanied by serious complications such as organ failure, which seriously threatens patient quality of life.

AIM

To investigate the effect of early stepwise cardiopulmonary rehabilitation on cardiopulmonary function and quality of life in patients evacuated from mechanical ventilation with sepsis.

METHODS

A total of 80 patients with sepsis who were hospitalized in our hospital from January 2021 to January 2022 were selected and divided into the observation group (n = 40) and the control group (n = 40) according to the random number table method. The observation group was treated with early stepwise cardiopulmonary rehabilitation, and the control group was treated with a conventional treatment regimen. Cardiac function indexes (central venous pressure, cardiac troponin I, B-type brain natriuretic peptide), lung function indicators (diaphragmatic mobility, changes in central venous oxygen saturation, oxygenation index), and quality of life (Quality of Life Evaluation Scale) were compared between the two groups after treatment.

RESULTS
After treatment, the central venous pressure, diaphragm mobility, central venous oxygen saturation, oxygenation index, and Quality of Life Evaluation Scale scores in the observation group were higher than those in the control group, and the differences were statistically significant ($P < 0.05$). The observation group was less than that of the control group for other parameters, and the differences were statistically significant ($P < 0.05$).

CONCLUSION
Early stepwise cardiopulmonary rehabilitation can effectively enhance cardiac and pulmonary function and improve the quality of life in patients evacuated from mechanical ventilation with sepsis.

Key Words: Stepwise cardiopulmonary rehabilitation; Sepsis; Evacuation of mechanical ventilation; Cardiopulmonary function; Quality of life

Core Tip: Sepsis is an uncontrolled body infection, which can be life-threatening in severe cases. Therefore, it is extremely important to explore the intensive care measures for sepsis patients. In this study, early step-by-step cardiopulmonary rehabilitation was selected, and it was found that this treatment method can effectively improve the cardiopulmonary function of patients, improve life treatment, and improve prognosis.

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INTRODUCTION

Sepsis is thought to be an uncontrolled host response to infection and leads to life-threatening organ dysfunction[1,2]. When sepsis progresses to a certain extent, patients often experience serious complications such as microcirculation disorders, cardiopulmonary and other organ failure, and disseminated intravascular coagulation, which seriously threaten the lives of patients[3-5]. The overall incidence of sepsis has been increasing year by year in recent years. Fleischmann *et al*[5] conducted a meta-analysis of 27 clinical studies from developed countries covering the period from 1979 to 2015. The results showed that the annual incidence of sepsis and severe sepsis was 288/100000 and 148/100000, respectively, during the study period. The annual incidence of sepsis and severe sepsis increased to 437 per 100000 and 270 per 100000, respectively, in the last 10 years. Sepsis case fatality rates have also remained high. In a meta-analysis, the in-hospital mortality rate for sepsis in developed countries has been 17% over the past 10 years, and the inpatient fatality rate for severe sepsis has been as high as 26%[5]. The incidence of severe sepsis (including septic shock) in intensive care units in China is 37.3%, and the intensive care units case fatality rate and inpatient mortality rate are 28.7% and 33.5%, respectively[6]. Improving cardiopulmonary function and reducing mortality in patients with sepsis is an important issue for critical care departments.

Previous studies have shown that the pathogenesis of sepsis mainly involves out-of-control systemic inflammatory response, hypercoagulability, and capillary leakage leading to cardiopulmonary dysfunction and its interaction[7,8]. This causes patients to often develop respiratory failure and circulatory failure clinically and requires mechanical ventilation to assist breathing. Mechanical ventilation plays a key role in the treatment of patients with sepsis as a means of improving oxygen supply and microcirculation throughout the body, but prolonged mechanical ventilation increases the risk of complications and medical costs such as ventilator-associated pneumonia in patients with sepsis[9-11]. It brings a heavy financial burden and a threat to the safety of patients.

Early stepwise cardiopulmonary rehabilitation is a rehabilitation program that increases the frequency of cardiopulmonary function assessment and rehabilitation activities to adjust the training content according to the patient's condition. Studies have found that early stepwise cardiopulmonary rehabilitation can help improve cardiopulmonary function in critically ill patients, reduce the incidence of complications such as ventilator-related pneumonia, shorten the duration of mechanical ventilation and hospital stay, improve the quality of life of patients, and reduce mortality and disability rates[12-14].

However, there are few studies on sepsis and cardiopulmonary rehabilitation. Based on this, this study adopted early stepwise cardiopulmonary rehabilitation for sepsis evacuated mechanical ventilation patients and discussed its effect to provide new ideas for the clinical treatment of sepsis patients. It also provided a basis for improving the cardiopulmonary function of patients and reducing the mortality rate and disability rate.

MATERIALS AND METHODS

Study population

In this single-center, case-control study, we enrolled 80 patients with sepsis evacuation mechanical ventilation who were hospitalized in our hospital from January 2021 to January 2022. We used the following inclusion criteria: (1) Met the clinical diagnostic criteria for sepsis[15]; (2) The patient withdrew from mechanical ventilation; and (3) The patient exhibited a certain degree of microcirculation disorders or oxygen partial pressure < 50 mmHg after adequate oxygen therapy. We used the following exclusion criteria: (1) Cardiac function ≥ grade III; (2) Patients with severe hepatitis and chronic renal failure; and (3) Impairment of consciousness.

Method

The control group received conventional treatment, *i.e.* symptomatic supportive treatment such as anti-infection, improvement of microcirculation, and protection of gastric mucosa. The observation group received conventional treatment combined with early stepwise cardiopulmonary rehabilitation. After admission, patients were evaluated for early cardiopulmonary rehabilitation, and then individualized early step-by-step cardiopulmonary rehabilitation treatment plans were formulated according to their condition. Cardiopulmonary rehabilitation treatment plans included: (1) Position management. The head of the bed is gradually shaken up by nearly 90°, and no orthostatic hypotension can be advanced to the bedside sitting position, 10 min/time, 3 times/d; (2) Exercise therapy. Giving active and passive joint range of motion training + massage + muscle strength training, 20 min/time, 2 times/d; (3) Electrical stimulation therapy. Including neuromuscular electrical stimulation, intermediate frequency pulsed electrical therapy, myoelectric biofeedback, *etc*, 20 min/time, 2 times/d; (4) Swallowing function training. Swallowing action training, eating training, *etc*, 2 times/d, 20 min/time; (5) Cough training. Cough training, breathing control (holding breath for 1-3 s), pronounce "HO" sound, without fatigue, 5-10/time, 4 times/d; and (6) Respiratory muscle training. Using an external diaphragm pacemaker to stimulate the diaphragm, 30 min/time, 2 times/d. In the early stage, it mainly focused on posture management, limb passive movement + massage electrical stimulation therapy, and respiratory muscle training and gradually transitioned to electrical stimulation therapy, swallowing function training, cough training, and active and passive joint range of motion training + massage + muscle strength training after the condition improved. The patient's heart function and lung function were regularly evaluated to understand the patient's tolerance to the rehabilitation treatment plan. The rehabilitation treatment plan was adjusted according to the patient's condition. The treatment time was 30 d in both groups.

Data collection

The following data were collected: (1) General information such as age, sex, body mass index, site of infection, and acute physiology and chronic health status score II score; (2) Cardiac function indicators of patients, including central venous pressure (CVP), cardiac troponin I (cTnI), and brain natriuretic peptide (BNP); (3) Lung function indicators including diaphragm activity, central venous oxygen saturation ($ScvO_2$), oxygenation index (PaO_2/FiO_2); (4) Quality of life pretreatment and post-treatment utilizing the Quality of Life Evaluation Scale (SF-36)[16]. The scale includes role function, somatic function, emotional function, cognitive function, and social function for a total of 5 dimensions with each dimension scoring up to 100 points. The higher the score, the higher the quality of life; and (5) Statistics on patient complications.

Statistical analysis

SPSS 22.0 was used to analyze the obtained data. The measurement data were confirmed by normality test and homogeneity of variance test to conform to the homogeneity of variance and approximately obey the normal distribution. Data were expressed as mean ± standard deviation and analyzed by t test. Counting data were expressed as percentage (%) and analyzed by χ^2 test. A P value < 0.05 indicated that the difference was statistically significant.

RESULTS

General data comparison

A total of 80 patients evacuated from mechanical ventilation with sepsis were hospitalized in our hospital. Compared to the control group, no significant differences in general data such as age, sex, body mass index, infection site, and acute physiology and chronic health status score II score were observed in the observation group (P > 0.05; Table 1).

Comparison of cardiac function

There were no significant differences in CVP, cTnI, and BNP between the observation and control groups before treatment (P > 0.05). The CVP increased in both groups after treatment, and the observation group was significantly larger than that of the control group (P < 0.05). After treatment, cTnI and BNP decreased in both groups, and the observation group was significantly smaller than that of the control group (P < 0.05; Table 2).

Comparison of lung function

There were no significant differences in diaphragm mobility, $ScvO_2$, and PaO_2/FiO_2 between the two groups (P > 0.05). The diaphragm mobility, $ScvO_2$, and PaO_2/FiO_2 increased in both groups after treatment, and the observation group was

Table 1 Comparison of general data of patients in the two groups

Items		Observation group, n = 40	Control group, n = 40	t/χ^2 value	P value
Age (yr)		52.28 ± 5.12	52.75 ± 6.21	0.392	0.695
Sex	Male	25 (62.50)	27 (67.50)	0.219	0.639
	Female	15 (37.50)	13 (32.50)		
BMI (kg/m²)		22.79 ± 1.13	22.93 ± 1.22	0.532	0.595
Infection site	Abdominal cavity	7 (17.50)	8 (20.00)	0.569	0.752
	Blood system	5 (12.50)	7 (17.50)		
	Lung	28 (70.00)	25 (62.50)		
APACHEII		18.56 ± 3.94	18.21 ± 4.59	0.365	0.715

Data are n (%) or mean ± SD. APACHEII: Acute physiology and chronic health status score II; BMI: Body mass index.

Table 2 Comparison of changes in cardiac function before and after treatment

Groups	Time	CVP in cmH_2O	cTnI in μg/L	BNP in pg/mL
Observation group, n = 40	Before treatment	3.36 ± 1.12	5.52 ± 1.03	825.34 ± 227.87
	After treatment	10.67 ± 2.28[a]	1.83 ± 0.48[a]	478.96 ± 153.54[a]
Control group, n = 40	Before treatment	3.54 ± 1.38	5.48 ± 0.86	846.59 ± 268.35
	After treatment	8.32 ± 2.08[a]	2.25 ± 0.96[a]	618.15 ± 166.82[a]
t value After treatment		4.815	2.474	3.882
P value After treatment		< 0.001	0.015	< 0.001

[a]P < 0.05 compared with before treatment.
Data are mean ± SD. BNP: Brain natriuretic peptide; cTnI: Cardiac troponin I; CVP: Central venous pressure.

significantly larger than that of the control group (P < 0.05; Table 3).

Quality of life comparison

No significant differences were observed in SF-36 scores before treatment for role, somatic, emotional, cognitive, and social functions (P > 0.05). The scores of these functions in both groups after treatment were higher than those before treatment. The observation group had a larger score than the control group, and the difference was statistically significant (P < 0.05; Table 4).

Comparison on the occurrence of complications

There was no significant difference in the incidence of complications after treatment in the two groups (P > 0.05; Table 5).

DISCUSSION

In the early stage of sepsis, under the action of various pathogenic factors, a large number of inflammatory cells can be activated, leading to the interaction of the proinflammatory response and anti-inflammatory response, causing increased capillary permeability, which results in generalized edema and a large amount of pleural and abdominal effusion[17-19]. Persistent generalized edema and large pleural effusions can cause hypotension, hypoxemia, and microcirculation disorders, and sustained hypoperfusion of systemic organs can cause organ dysfunction and ultimately respiratory and circulatory failure[20-22]. Therefore, timely improvement of cardiopulmonary function in patients with sepsis is important.

cTnI is considered the most sensitive specific marker of myocardial injury and can assess the degree of myocardial injury in patients with sepsis[23,24]. In addition, BNP levels also increase markedly with myocardial damage[25,26]. In this study, the CVP of the two groups after treatment was greater than that before treatment. After treatment, cTnI and BNP in both groups were smaller, which indicated that both conventional treatment regimens and early stepwise cardiopulmonary rehabilitation programs could improve patients' heart function. However, the early stepwise cardiopulmonary rehabilitation program improved the indicators more significantly. The reason is that simple passive exercise can

Table 3 Comparison of changes in lung function before and after treatment

Groups	Time	Diaphragmatic range of motion in mm	$ScvO_2$	PaO_2/FiO_2 in mmHg
Observation group, n = 40	Before treatment	22.28 ± 4.63	0.55 ± 0.06	176.36 ± 25.87
	After treatment	46.94 ± 5.18[a]	0.73 ± 0.045[a]	312.44 ± 29.78[a]
Control group, n = 40	Before treatment	23.16 ± 5.12	0.54 ± 0.05	181.54 ± 26.45
	After treatment	43.72 ± 6.06[a]	0.69 ± 0.02[a]	285.61 ± 25.94[a]
t value after treatment		2.554	4.697	4.296
P value after treatment		0.012	< 0.001	< 0.001

[a]P < 0.05 compared with before treatment.
Data are mean ± SD. PaO_2/FiO_2: Oxygenation index; $ScvO_2$: Central venous oxygen saturation.

Table 4 Comparison of changes in quality of life before and after treatment

Groups	Time	Role function	Somatic function	Emotion function	Cognitive function	Social function
Observation group, n = 40	Before treatment	68.79 ± 3.95	64.57 ± 3.62	65.77 ± 3.89	63.56 ± 3.85	64.93 ± 3.51
	After treatment	85.64 ± 3.98[a]	86.78 ± 3.16[a]	88.34 ± 4.09[a]	85.73 ± 3.59[a]	89.33 ± 2.27[a]
Control group, n = 40	Before treatment	68.47 ± 3.52	63.99 ± 3.06	65.82 ± 4.01	63.14 ± 4.12	65.02 ± 3.62
	After treatment	74.15 ± 3.23[a]	73.75 ± 3.49[a]	74.84 ± 3.97[a]	76.83 ± 4.25[a]	75.84 ± 3.24[a]
t value after treatment		14.177	17.503	14.979	10.117	21.566
P value after treatment		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

[a]P < 0.05 compared with before treatment.
Data are mean ± SD.

Table 5 Comparison of complications

Groups	n	Ventilator-associated pneumonia	Tracheostomy	ICU-acquired frailty
Observation group	40	2 (5.00)	1 (2.50)	1 (2.50)
Control group	40	5 (12.50)	4 (10.00)	3 (7.50)
χ^2 value		0.626	0.853	0.263
P value		0.428	0.355	0.607

Data are n (%). ICU: Intensive care unit.

induce changes in microcirculation and induce the anti-inflammatory effect of early sepsis, while light to moderate exercise can partially reverse the damage of inflammatory factors and do not cause damage to the condition of critically ill patients.

Mechanical ventilation can cause increased production and release of proinflammatory cytokines, which can lead to diaphragmatic dysfunction[27,28] leading to decreased lung function. In this study, the diaphragm mobility, $ScvO_2$, and PaO_2/FiO_2 of the two groups after treatment were greater than those before treatment. However, the observation group was larger than that of the control group, which indicated that both conventional treatment regimens and early stepwise cardiopulmonary rehabilitation programs could improve patients' lung function. However, the early stepwise cardiopulmonary rehabilitation program improved the indicators more significantly. The reason may be that early stepwise cardiopulmonary rehabilitation improves the patient's cough and sputum discharge ability through cough training, respiratory muscle training, *etc.*

Patients with sepsis are affected by multiple organ dysfunction and have a poor quality of life. In this study, the scores of SF-36 in role function, somatic function, emotional function, cognitive function, and social function improved in both groups. This shows that both conventional treatment regimens and early stepwise cardiopulmonary rehabilitation programs can improve the quality of life of patients. However, the early stepwise cardiopulmonary rehabilitation program has a more significant improvement effect.

There were limitations to our study such as a relatively small sample size and short follow-up time. Therefore, future studies should include larger sample sizes to further study the effect of early stepwise cardiopulmonary rehabilitation on cardiopulmonary function and quality of life in patients evacuated from mechanical ventilation with sepsis.

CONCLUSION

In summary, the application of an early stepwise cardiopulmonary rehabilitation program in sepsis patients with evacuation of mechanical ventilation can significantly improve the cardiopulmonary function of patients and improve the quality of life of patients, which can provide a reference for the clinical treatment of patients with sepsis.

ARTICLE HIGHLIGHTS

Research background

Patients with sepsis often need mechanical ventilation to maintain respiratory function. However, mechanical ventilation itself will also cause some damage to the respiratory system, leading to respiratory muscle atrophy, lung function damage, *etc*. Therefore, early rehabilitation therapy such as aerobic exercise can effectively improve the respiratory function and quality of life in patients with sepsis.

Research motivation

Identifying methods to improve cardiopulmonary function and reduce mortality and disability rates will greatly benefit patients.

Research objectives

This study aimed to investigate the effect of early stepwise cardiopulmonary rehabilitation on cardiopulmonary function and quality of life in septic patients.

Research methods

Sepsis patients who met the inclusion criteria were randomized into the control and observation groups. Patients in the control group received conventional treatment, and patients in the observation group received early stepwise rehabilitation combined with conventional treatment.

Research results

The cardiopulmonary function and quality of life were significantly improved in the observation group, while the improvement was relatively small in the control patients.

Research conclusions

Early stepwise cardiopulmonary rehabilitation can effectively improve cardiopulmonary function and quality of life in septic patients after withdrawal.

Research perspectives

Future studies should include larger sample sizes and a longer follow-up period to identify long-term benefits of stepwise cardiopulmonary rehabilitation.

FOOTNOTES

Co-first authors: Ming-Hui Zheng and Wen-Jun Liu.

Author contributions: Zheng MH and Liu WJ designed the research; Yang J, Zheng MH, and Liu WJ contributed new reagents/analytical tools; Yang J, Zheng MH, and Liu WJ analyzed the data; Zheng MH and Liu WJ wrote the paper; All authors were involved in the critical review of the results and read and approved the final manuscript. Zheng MH and Liu WJ contributed equally to this work as co-first authors to this work. The reasons for designating Zheng MH and Liu WJ as co-first authors are threefold. First, the research was performed as a collaborative effort, and the designation of co-corresponding authorship accurately reflects the distribution of responsibilities and burdens associated with the time and effort required to complete the study and the resultant paper. This also ensures effective communication and management of post-submission matters, ultimately enhancing the paper's quality and reliability. Second, the overall research team encompassed authors with a variety of expertise and skills from different fields, and the designation of co-first authors best reflects this diversity. This also promotes the most comprehensive and in-depth examination of the research topic, ultimately enriching readers' understanding by offering various expert perspectives. Third, Zheng MH and Liu WJ contributed efforts of equal substance throughout the research process. The choice of these researchers as co-first authors acknowledges and respects this equal contribution, while recognizing the spirit of teamwork and collaboration of this study. In summary, we believe that designating Zheng MH and Liu WJ as co-first authors is fitting for our manuscript as it accurately reflects our team's collaborative spirit, equal contributions, and diversity.

Institutional review board statement: This study protocol was approved by Huanggang Central hospital, and all the families have voluntarily participated in the study and have signed informed consent forms.

Informed consent statement: All study participants, or their legal guardian, provided informed written consent prior to study enrollment.

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