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The Application Effect of Cardiac Rehabilitation Therapy in Patients with Chronic Heart Failure and Its Impact on Pulse Wave Velocity

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Abstract: *Objective*: To evaluate the effectiveness of cardiac rehabilitation therapy in the treatment of patients with chronic heart failure (CHF). *Methods*: 76 patients with CHF who were treated in the hospital from January 2023 to December 2024 were selected and randomly divided into two groups using a random number table. The experimental group (38 patients) received cardiac rehabilitation therapy, while the reference group (38 patients) received conventional drug therapy. The total effective rate, cardiac function indicators, lung function indicators, and pulse wave velocity (PWV) were compared between the two groups. *Results*: The total effective rate was higher in the experimental group than in the reference group. After treatment, the cardiac and lung function indicators were better in the experimental group than in the reference group, and the PWV was lower in the experimental group ($P < 0.05$). *Conclusion*: Cardiac rehabilitation therapy for patients with CHF can improve treatment efficacy, enhance cardiopulmonary function, and regulate PWV levels, with high professionalism and feasibility.

Keywords: Cardiac rehabilitation therapy; Chronic heart failure; Cardiopulmonary function; Pulse wave velocity

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1. Introduction

Chronic heart failure (CHF) is commonly caused by inflammatory diseases, excessive hemodynamic load, or myocardial infarction. The basis of the disease is myocardial injury, often accompanied by changes in myocardial function or structure. Patients with CHF often experience reduced ventricular filling capacity and decreased pumping function [1]. Early symptoms of the disease include general fatigue, upper abdominal pain, or cough, which are nonspecific. As the disease progresses, it can lead to dyspnea and even severe complications such as organ failure. Currently, drug therapy can inhibit myocardial remodeling and alleviate related symptoms, but its long-term treatment effect is general and requires combination with other

treatment methods [2]. Cardiac rehabilitation therapy focuses on patients' diet and exercise status and can be flexibly tailored to the severity of the disease. It can enhance patients' cardiopulmonary function and restore PWV levels. Therefore, this study selected 76 patients with CHF to analyze the clinical advantages of cardiac rehabilitation therapy.

2. Materials and methods

2.1. General information

A total of 76 CHF patients admitted to the hospital between 2023 and December 2024 were selected and randomly divided into two groups using a random number table. The experimental group consisted of 38 patients, including 22 males and 16 females, aged between 41–83 years old with a mean age of (58.65 ± 4.78) years. The course of disease ranged from 6 months to 6 years, with a mean duration of (3.01 ± 0.57) years. According to the New York Heart Association (NYHA) classification, there were 20 cases of class II and 18 cases of class III. The control group also consisted of 38 patients, with 24 males and 14 females, aged between 40–85 years old, and a mean age of (58.71 ± 4.82) years. The course of disease ranged from 7 months to 5 years, with a mean duration of (3.04 ± 0.52) years. In the NYHA classification, there were 23 cases of class II and 15 cases of class III. There was no significant difference between the two groups ($P > 0.05$).

Inclusion criteria: Patients diagnosed with CHF according to the "Guidelines for the Diagnosis and Treatment of Chronic Heart Failure" [2], with complete basic information, NYHA class II or III; normal communication ability and mental state, and full knowledge of the study.

Exclusion criteria: unstable angina, acute or chronic infection; history of embolism in the past month; liver and kidney dysfunction; cerebrovascular disease; participation in other studies; or withdrawal from the study.

2.2. Methods

The control group received conventional drug treatment: oral administration of hydrochlorothiazide tablets at a dose of 25mg once a day, captopril tablets at a dose of 6.25mg three times a day, and metoprolol tartrate tablets at a dose of 25mg twice a day for 2 months.

The experimental group underwent cardiac rehabilitation therapy, which included:

(1) Comprehensive evaluation: A self-made health status assessment scale was used to evaluate patients' basic information, such as mental health, disease status, knowledge mastery, nutritional status, and individual needs. Based on the evaluation results and the characteristics and progression of CHF, a treatment plan was developed.

(2) Cognitive therapy: Audio, graphic, or video materials on cardiac rehabilitation therapy were provided to patients, explaining the treatment items, purposes, cooperation methods, and precautions. Patients' understanding of the knowledge was evaluated, and if there were cognitive blind spots or misunderstandings, a second education session was conducted to ensure that every patient had a clear grasp of the treatment knowledge.

(3) Rehabilitation exercise: The 6-minute walk test (6MWT) was used as a benchmark to assess exercise tolerance. The first week's exercise volume was set based on the initial 6MWT value, with a total walking distance equal to 70% of the initial 6MWT value (60% for elderly or physically weaker patients). During walking training, the heart rate should not exceed the initial maximum heart rate and

strenuous exercise was prohibited. After the first week, the total weekly walking distance exceeded 70% of the initial 6MWT value, combined with aerobic exercises such as Baduanjin or Tai Chi, and resistance training such as dumbbell exercises or stretching with elastic bands. Patients were instructed to warm up for about 10 minutes before and after exercise, and to train at least 4 times a week.

(4) Psychological treatment: Patients' psychological states were evaluated using anxiety and depression self-rating scales, and treatment was provided by a psychologist. For those with anxiety, distraction techniques such as emotional regulation or art therapy were used. For those with depression, positive psychology therapy was adopted, encouraging them to keep a diary, record videos, etc., to discover the joy of life and maintain an optimistic attitude. This therapy lasted for 2 months.

2.3. Observation indicators

(1) Cardiac function indicators: Echocardiography was used to evaluate the levels of left ventricular end-systolic diameter (LVESD), left ventricular ejection fraction (LVEF), and left ventricular end-diastolic diameter (LVEDD).

(2) Lung function indicators: A lung function tester was used to assess forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), and FEV1/FVC levels.

(3) PWV levels: An arteriosclerosis detector was utilized to measure carotid-femoral pulse wave velocity (cfPWV) and brachial-ankle pulse wave velocity (baPWV).

All the above indicators were measured before treatment and after 2 months of treatment.

2.4. Evaluation criteria for therapeutic effect

Significant effect: Symptoms resolved, and NYHA classification improved by ≥2 grades; Initial effect: Symptoms relieved, and NYHA classification improved by 1 grade; No effect: No improvement in symptoms, and no change in NYHA classification. The total effective rate was calculated as the sum of the percentages of significant and initial effects.

2.5. Statistical analysis data

Statistical analysis data were processed using SPSS 28.0 software. Measurement data were expressed as mean ± standard deviation (±s) and compared using the t-test. Count data were expressed as number and percentage [n/%] and compared using the chi-square test. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Comparison of total effective rate between the two groups

The total effective rate of the experimental group was higher than that of the reference group ($P < 0.05$), as seen in **Table 1**.

Table 1. Comparison of total effective rate between the two groups [n/%]

Group	Number of cases	Significant effect	Initial effect	No effect	Total effective rate
Experimental group	38	22(57.89)	14(36.84)	2(5.26)	94.74(36/38)
Reference group	38	19(50.00)	10(26.32)	9(23.68)	76.32(29/38)
x^2					5.208
P					0.023

3.2. Comparison of cardiac function indicators between the two groups

Before treatment, there was no difference in cardiac function indicators between the two groups ($P > 0.05$). After 2 months of treatment, the cardiac function indicators of the experimental group were better than those of the reference group ($P < 0.05$), as seen in **Table 2**.

Table 2. Comparison of cardiac function indicators between the two groups [$\bar{x} \pm s$]

Group	Number of cases	LVESD(mm)		LVEF(%)		LVEDD(mm)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental Group	38	32.28 ± 3.74	26.71 ± 3.12	40.56 ± 4.98	60.58 ± 7.43	60.11 ± 9.25	51.42 ± 5.48
Reference Group	38	32.24 ± 3.77	29.77 ± 3.19	40.51 ± 4.83	47.09 ± 6.42	60.04 ± 8.79	55.04 ± 5.56
t		0.046	4.227	0.044	8.469	0.034	2.858
P		0.963	＜ 0.001	0.965	＜ 0.001	0.973	0.006

3.3. Comparison of lung function indicators between the two groups

Before treatment, there was no difference in lung function indicators between the two groups ($P > 0.05$). After 2 months of treatment, the lung function indicators of the experimental group were higher than those of the reference group ($P < 0.05$), as shown in **Table 3**.

Table 3. Comparison of lung function indicators between the two groups [$\bar{x} \pm s$]

Group	Number of cases	FVC(L)		FEV_1(L)		FEV1/FVC(%)	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Experimental group	38	3.29 ± 0.51	5.54 ± 0.73	2.98 ± 0.44	5.38 ± 0.69	75.27 ± 7.12	90.11 ± 8.05
Reference group	38	3.31 ± 0.54	3.53 ± 0.66	2.96 ± 0.46	3.49 ± 0.61	75.22 ± 7.18	84.59 ± 8.01
t		0.166	12.590	0.194	12.650	0.030	2.996
P		0.869	＜ 0.001	0.847	＜ 0.001	0.976	0.004

3.4. Comparison of PWV levels between the two groups

Before treatment, there was no difference in PWV levels between the two groups (P > 0.05). After 2 months of treatment, the PWV level of the experimental group was lower than that of the reference group ($P < 0.05$), as shown in **Table 4**.

Table 4. Comparison of PWV levels between the two groups [$\bar{x}$±s，cm/s]

Group	Number of cases	cfPWV		baPWV	
		Before treatment	After treatment	Before treatment	After treatment
Experimental group	38	1052.98 ± 234.81	771.53 ± 92.41	1510.53 ± 208.35	1232.53 ± 84.17
Reference group	38	1058.22 ± 230.94	865.92 ± 94.05	1511.41 ± 210.55	1377.43 ± 85.09
t		0.098	4.413	0.018	7.463
P		0.922	＜ 0.001	0.985	＜ 0.001

4. Discussion

CHF progresses rapidly, often leading to multiple complications, posing significant treatment challenges. The long treatment cycle for patients with this disease focuses on alleviating symptoms, preventing related complications, and reducing mortality [3]. Medication serves as the foundational therapy, utilizing drugs such as cardiac stimulants and diuretics to improve heart function, relieve fluid retention, and mitigate disease severity. However, long-term drug therapy has side effects and generally limited long-term prognosis, highlighting its therapeutic limitations.

The decreased physiological function in CHF patients restricts their mobility, directly diminishing their exercise reserve, causing dyspnea or fatigue, and ultimately affecting their quality of life [4]. Based on this pathological process, cardiac rehabilitation therapy can be implemented for these patients. Measures such as cognitive therapy and gradual rehabilitation training can enhance the patients' physical fitness, restore cardiopulmonary function, and improve the efficacy of disease treatment [5].

Results indicate that the total effective rate in the experimental group (94.74%) was higher than that of the control group (76.32%). After two months of treatment, the experimental group's cardiopulmonary function indicators were superior to those of the control group ($P < 0.05$). This improvement can be attributed to cardiac rehabilitation therapy's ability to regulate the body's oxygen supply and consumption levels, thereby enhancing cardiopulmonary function and increasing exercise endurance [6]. Comprehensive assessments provide a holistic summary of the patient's physical state, identifying individualized needs for rehabilitation therapy. Combined with cognitive therapy, this approach corrects patients' misconceptions, raises awareness of the benefits of rehabilitation therapy, and improves compliance [7]. Psychological therapy deeply analyzes patients' current psychological issues and provides differentiated and humane psychological treatments, minimizing psychological stress and increasing treatment acceptance. Additionally, cardiac rehabilitation therapy tailors diverse training measures based on patients' current condition and exercise tolerance, gradually cultivating exercise habits and promoting regular exercise [8]. With gradual and incremental rehabilitation exercises, patients' lung capacity, ventilation, and gas exchange functions are improved, elevating lung function.

Decreased exercise endurance in CHF patients directly affects blood vessel elasticity, prolongs PWV, and exacerbates the disease. Therefore, this study included the PWV indicator. After two months of treatment, the experimental group's PWV level was lower than the control group's ($P < 0.05$). This improvement is attributed to resistance training and aerobic exercise during cardiac rehabilitation, which enhances blood flow shear force and nitric oxide production by endothelial cells, relaxing blood vessels and preventing excessive arterial stiffness [9]. Cardiac rehabilitation also restores autonomic nerve balance, inhibits excessive catecholamine release, reduces blood vessel tension, and improves PWV. Furthermore, it prevents myocardial reverse

remodeling, improves heart function indicators like LVEF, and reduces vascular wall mechanical stress [10]. Rehabilitation exercise significantly improves arterial compliance, matching ventricular systolic function with blood vessel elasticity, lowering PWV levels.

5. Conclusion

In summary, cardiac rehabilitation therapy for CHF patients is highly effective, maximally restoring cardiopulmonary function, improving PWV levels, stabilizing the condition, preventing adverse events, and positively impacting treatment outcomes.

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