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Original Article

Clinical efficacy and mechanism of action of cardiac rehabilitation after revascularization for multi-vessel coronary artery disease

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Abstract

Background: Analyzing the clinical efficacy and mechanism of action of cardiac rehabilitation after revascularization for coronary multibranch lesions.

Methods: 150 patients with multiple coronary artery lesions were selected for the study from July 2022 to March 2023, and were randomly divided into observation group (75 cases, complete revascularization + cardiac rehabilitation intervention) and control group (75 cases, complete revascularization). The level of patients' 6 min walking experiment, quality of life, cardiac function indexes, and laboratory indexes were analyzed.

Results: The level of 6-min walking test was significantly higher in the observation group than in the control group ($p<0.05$); the quality of life of patients in the observation group was significantly higher than that of the control group ($p<0.05$); the levels of left ventricular end-systolic internal diameter (LVESD), left ventricular end-diastolic internal diameter (LVEDD), left ventricular pressure (LVP), and interventricular septal thickness (LVS) in patients in the observation group were significantly lower than that of the control group; and the level of LV ejection fraction (LVEFA) levels were significantly higher than those of the control group ($P=0.00$); serum homocysteine (Hcy) and blood uric acid (SUA) levels of patients in the observation group were significantly lower than those of the control group ($P=0.00$).

Conclusion: Complete revascularization + cardiac rehabilitation intervention can effectively improve patients' 6-min walking test level, improve patients' cardiac function indexes, improve patients' quality of life, improve patients' laboratory index levels, and play a significant role in improving patients' prognosis, which is worthy of widespread promotion.

Keywords: Coronary multibranch lesions, Revascularization, Cardiac rehabilitation.

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Coronary artery disease (CAD) is the leading cause of death globally, with 18.6 million people dying from it in 2019 each year (1, 2). Therefore, the diagnosis, treatment and prevention of coronary artery disease remain a key clinical concern. Coronary angiography is the gold standard for the diagnosis of coronary artery disease, and coronary artery disease can be categorized into single vesseldisease (SVD) and multi-vessel disease (MVD) according to the number of vessels involved in the disease. Compared with SVD, coronary MVD is more prone to complications such as shock, pulmonary edema, and heart block after revascularization, with longer average hospital stay and higher postoperative mortality (3, 4). Cardiac rehabilitation is a cost-effective strategy that utilizes an integrated approach that encompasses the physical, emotional, and social aspects of a patient's health-related quality of life (HRQOL) (5).

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The primary goal of cardiac rehabilitation is to accelerate secondary prevention and improve patients' quality of life (QOL) (5). The core elements of CR include exercise training, lifestyle modification, and psychological interventions (6). It is not limited to exercise alone, but also encompasses comprehensive patient care, including medication optimization, nutritional guidance, smoking cessation, stress management, and lifestyle improvement. This integrated approach addresses all aspects of patient health, from physical fitness and cardiovascular risk factors to mental health (7). In this study, we compared different rehabilitation methods in terms of improving patients' quality of life, cardiac function, and 6-minute walk test to further clarify the role of cardiac rehabilitation in the treatment of blood reconstruction after coronary multibranch lesions. This article reveals for the first time the clinical efficacy and mechanism of cardiac rehabilitation after revascularization of coronary multi vessel lesions, which is of great significance for clinical treatment and patient rehabilitation.

Methods

Clinical data: Clinical data were collected from patients who underwent coronary intervention from July 2022 to March 2023 at Huai'an Rehabilitation Hospital, Huai'an City, Jiangsu Province, China. Inclusion criteria: age ≥18 years; 2 or more major coronary vessels (anterior descending, circumflex, left main, and right coronary arteries) with or without major branch disease with ≥70% stenosis; and NYHA cardiac function classification in class I-II. Exclusion criteria: NYHA cardiac function class III ~ IV;Combination of serious arrhythmia, heart valve disease, cardiomyopathy, chronic obstructive pulmonary disease, pulmonary heart disease, blood and rheumatic immune diseases; patients with serious liver, kidney, lung, brain and other important organs insufficiency; pregnant or lactating women and patients who have a plan to give birth during the trial period; people who cannot tolerate exercise or non-cardiac diseases that can be aggravated by exercise; people with mental illness; patients with a clear diagnosis of patients with tumors; complications from surgery, trauma, gastrointestinal bleeding, or percutaneous coronary intervention (PCI). Randomly divided into observation group and control group, 75 cases each. The observation group was 44:31 men and women, aged 62-83 years, with a mean of (71.63±5.27) years; the control group was 42:33 men and women, aged 61-82 years, with a mean of (71.59±4.65) years.

Methods of coronary intervention: All patients were clearly diagnosed with coronary artery disease on admission by electrocardiogram and/or troponin combined with symptoms and signs, and were immediately transferred to the catheterization laboratory for coronary intervention. All patients were given aspirin 100 mg and clopidogrel 75 mg before the procedure. The radial artery was punctured using the Seldinger technique, an arterial sheath tube was placed, and then a guidewire and catheter were placed. The guidewire was placed through the catheter and passed through the occlusion site, the catheter was withdrawn, a balloon was placed for dilatation, and a stent was placed, and an intravenous infusion of tirofiban was administered in the postoperative period (figure1).

Postoperative cardiac rehabilitation: Complete revascularization treatment was implemented in the control group. The main coronary arteries were thoroughly treated after surgery, and the risk factors of coronary heart disease were controlled. Secondary prevention drug therapy for coronary heart disease was routinely administered, and appropriate health education and daily life guidance were provided and instructed each time. 1 time per week for the first 3 months and every 9 months for the next. Follow-up visits by phone or at home every month. Observation group combined cardiac rehabilitation intervention. The main coronary vessels were treated, and the coronary risk factors should be controlled after the operation, and the routine secondary prevention of coronary heart disease medication should be used. In addition, appropriate exercise prescription for out-of-hospital rehabilitation is required, which is performed 3 times per week. Follow-up visits by telephone or at home were conducted every week during the first 3 postoperative months and then changed to every month for the next 9 months. In addition, outpatient follow-up visits were required at months 3 and 12. Prior to discharge, walking training was performed with continued cardiac monitoring to ensure that the heart rate did not exceed 110 beats/min after exercise. Afterwards, the heart rate returned to the pre-exercise level after 5 min of recovery. For the first 3 months after discharge, exercise was performed on average 3 to 4 times per week, 20 min times/min. For the next 9 months, the intensity and duration of exercise increased month by month according to their tolerance level. The main form of exercise was aerobic, including cycling, dancing, walking, Tai Chi and housework. Each exercise is about 1 h, to have consciously feel fatigue. There is also the option of performing resistance exercises, such as using dumbbells and performing sit-ups, 2-3 times per week.

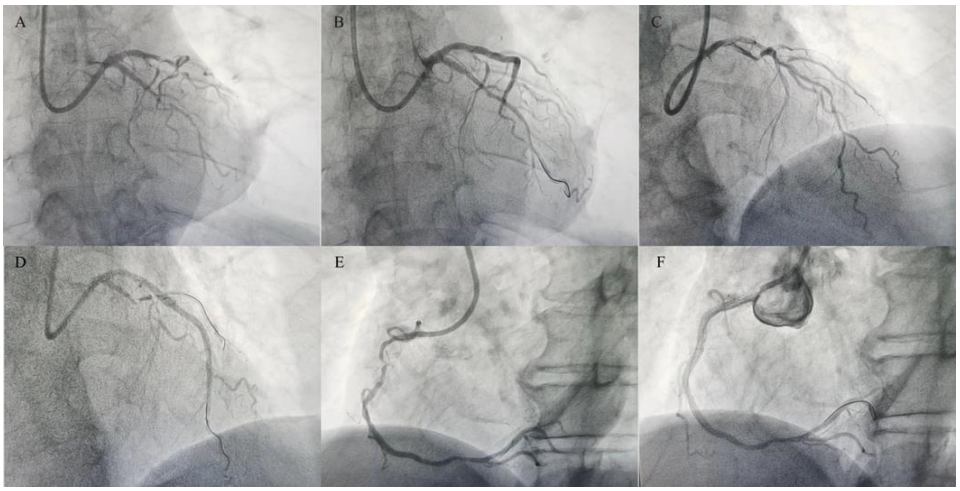

Figure 1. Coronary Artery Intervention Pictures. A, B) Pre- and post-operative gyration branch; C, D) Pre- and post-operative anterior descending branch; E, F) Pre- and post-operative right coronary artery.

If one of the following symptoms occurs during this period of time: a second attack of angina pectoris, a change in heart rate of more than 20 beats/min, a change in blood pressure of more than 20 mmHg, a downward shift of the ST segment of 0.1 mV or an upward shift of 0.2 mV during the activity; or the occurrence of cardiac arrhythmia, chest tightness, shortness of breath, palpitations, dizziness, fainting, paleness, and a large number of cold sweats or other uncomfortable symptoms, then immediately stop the activity and notify the follow-up physician. The physician will decide whether to adjust the rehabilitation program, continue rehabilitation, or withdraw from the study.

Observation indicators:

(1) 6-min walking experiment comparison. Let the patients perform back and forth movement on the flat ground, walking fast or slow at the patients' own discretion, and record the walking distance of the patients (figure2).

(2) Quality of life comparison. The quality of life questionnaire (SF-36) was used for evaluation.

(3) Comparison of cardiac function indexes. Including heart rate (HR), left ventricular end-systolic internal diameter (LVESD), left ventricular end-diastolic internal diameter (LVEDD), left ventricular ejection fraction (LVEF) and so on.

(4) Comparison of laboratory indicators. Including serum homocysteine (Hcy) and blood uric acid (SUA) levels.

Statistical analyses: Statistical analysis was performed using SPSS 22.0, and measurements were expressed as ($\bar{x}$ ±s) using the t-test, and differences were considered statistically significant at $P<0.05$.

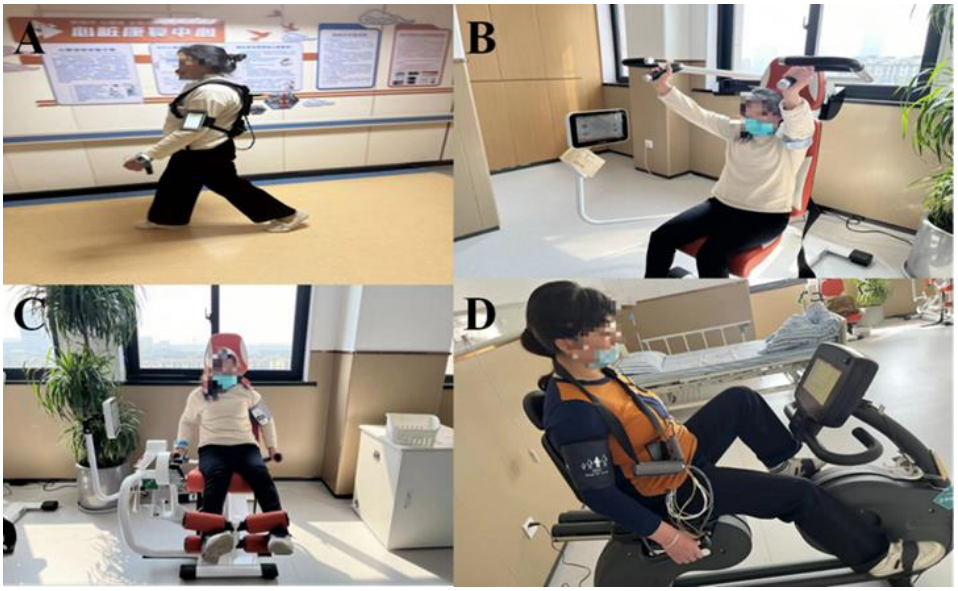

Figure 2. Various experimental methods. (A) 6-minute walk experiment; (B) Upper Limb Movement Experiment; (C) Lower Limb Movement Experiment; (D) Flatbed collapsed vehicle experiment.

Results

Comparison of 6-min walking experiments: The level of 6-min walking test was significantly higher in the observation group than in the control group (P=0.00) (table 1).

Quality of life comparison: The quality of life of patients in the observation group was significantly higher than that of the control group (P=0.00) (table 2).

Comparison of cardiac function indicators: The levels of LVESD, LVEDD, LVP, and LVS were significantly lower and the levels of LVEFA were significantly higher in the patients of the observation group than in the control group (P=0.00) (table 3).

Comparison of laboratory indicators: Serum homocysteine and blood uric acid levels were significantly lower in the observation group than in the control group (P=0.00) (table 4).

Table 1. Comparison of 6-min walking experiments

Groups	n	Pre-treatment	Post-treatment
Observation group	75	246.34±34.13	392.53±54.76
Control group	75	243.84±33.76	298.26±57.13
t		0.521	11.912
P		0.603	0.000

Table 2. Comparison of quality of life

Mark	Times	Observation Group（*n*=75）	Control Group（*n*=7）	t	P
Physiology	Pre-intervention	67.31±6.27	67.29±5.71	0.026	0.979
	Post-intervention	86.73±5.14	76.32±4.79	16.231	0.000
Physiological function	Pre-intervention	68.36±5.23	67.82±6.17	0.731	0.465
	Post-intervention	89.34±7.21	81.25±5.37	9.858	0.000
Body pain	Pre-intervention	69.31±6.27	70.52±5.73	1.561	0.119
	Post-intervention	87.53±5.16	79.57±4.63	12.578	0.000
General health	Pre-intervention	68.52±7.35	69.72±6.73	1.319	0.188
	Post-intervention	87.47±5.16	78.76±4.93	13.370	0.000
Energy	Pre-intervention	69.31±7.25	68.74±6.83	0.627	0.531
	Post-intervention	88.57±6.21	79.86±5.28	11.705	0.000
Social function	Pre-intervention	70.32±5.85	69.43±6.19	1.145	0.254
	Post-intervention	86.79±5.13	78.63±6.72	10.573	0.000
Emotional function	Pre-intervention	69.19±5.27	68.96±4.29	0.371	0.711
	Post-intervention	87.62±5.96	78.45±4.63	13.310	0.000
Mental health	Pre-intervention	68.74±6.27	68.85±4.74	0.153	0.878
	Post-intervention	89.18±5.73	79.52±5.71	13.082	0.000

Table 3. Comparison of cardiac function indices

Groups	n	LVESD	LVEDD	LVP	LVS	LVEFA
Observation group	75	44.68±4.27	53.35±4.16	10.15±1.03	8.91±1.27	55.27±4.26
Control group	75	52.37±4.52	62.28±4.12	12.24±1.35	10.13±1.32	42.28±4.43
t		8.745	10.785	8.703	4.710	14.945
P		0.000	0.000	0.000	0.000	0.000

LVESD: left ventricular end-systolic internal diameter, LVEDD: left ventricular end-diastolic internal diameter, LVP: left ventricular pressure, LVS: left ventricular end-systolic thickness, LVEFA: left ventricular ejection fraction

Table 4. Comparison of laboratory indicators

Groups	n	Hcy	SUA
Observation group	75	11.04±3.15	242.37±27.52
Control group	75	16.27±3.38	172.57±22.16
t		9.010	11.743
P		0.000	0.000

Hcy: serum homocysteine; SUA: blood uric acid

Discussion

With the improvement of living standard, the incidence of coronary heart disease is on the rise. Among the patients with coronary artery disease, coronary multibranch lesions are a common and serious type of lesion. The traditional treatment modalities are mostly drug therapy and revascularization. However, the effects of drug therapy are limited, and although revascularization can reestablish blood flow, the effects on patients' postoperative recovery and quality of life are unclear. Therefore, research on the clinical efficacy and mechanism of action of cardiac rehabilitation after revascularization for multiple coronary lesions is crucial. Multiple coronary artery lesions refer to multiple coronary arteries affected by atherosclerosis, which in turn leads to stenosis or occlusion of the vessels. Such lesions lead to myocardial ischemia and hypoxia, and in severe cases, myocardial infarction. Patients usually experience chest pressure, chest pain and palpitations (8).

Revascularization is a surgical or interventional procedure to restore or improve blood flow through coronary arteries. Common forms of reconstruction for multiple coronary artery injuries include coronary artery bypass surgery and percutaneous coronary intervention. Coronary artery bypass surgery restores blood supply to the heart muscle by implanting a vessel to bypass a narrowed or occluded portion of the coronary artery. Percutaneous coronary intervention, on the other hand, raises narrowed coronary arteries through operations such as balloon dilation and stenting (9). The primary goal of revascularization is to re-establish coronary blood flow and improve myocardial ischemia. After surgery, prevention and treatment of coronary artery disease is the most important step. The prevention and treatment of coronary heart disease relies on a series of thorough rehabilitation and counseling to help most patients improve their cardiorespiratory function, further increase exercise tolerance, reduce patient mortality and improve quality of life. The mechanism of action is as follows: 1) Improvement of myocardial oxygen supply and demand: blood repair surgery can relieve coronary artery stenosis, improve blood supply to the original base of the heart muscle, and reduce the oxygen content of myocardial blood. Cardiac rehabilitation training can improve cardiopulmonary function, increase myocardial oxygen utilization efficiency, and further optimize the balance of myocardial oxygen supply and demand (10). 2) Reducing psychological pressure: Coronary heart disease prevention and treatment not only focuses on physical recovery, but also on relieving psychological pressure. With the help of professional psychological counseling and resistance information management, easing the psychological pressure of anxiety, depression, anxiety and other psychological stresses of most patients is crucial for the complete recovery of cerebrovascular diseases (11). 3) Optimize living habits: In

the specific process of coronary heart disease prevention and treatment, professional doctors will guide most patients to adjust their usual diet on the original basis, and further improve the amount of exercise, regular life and work. This helps to reduce the extra burden on the heart and slow down the progression of cerebrovascular disease (12). 4) Reducing the risk of blood clots: Most patients must take antiplatelet drugs to prevent atherosclerosis after blood repair. Preventing and treating coronary heart disease helps to improve coagulation dysfunction in most patients and reduces a certain risk of thrombosis (13). 5) Improvement of body immunity: moderate exercise and good diet and lifestyle habits can further improve the immunity and resistance of most patients and reduce the occurrence of viral infections and other complications (14). 6) Promote the establishment of collateral circulation: after blood repair, preventing and treating coronary heart disease is conducive to promoting the establishment of collateral circulation and further optimizing the blood supply to the heart muscle (15).

After undergoing multiple coronary artery disease revascularization, the 6-minute walk test results in the observation group were significantly better than those in the control group, implying that the patients in the observation group had an advantage in terms of exercise tolerance. This result was directly and closely related to the quality of life of the patients. The significant improvement in the observation group demonstrates the important role of cardiac rehabilitation in improving the quality of life of patients from a certain point of view. In the comparison of the degree of improvement in cardiac structural parameters, such as left ventricular end-systolic internal diameter (LVESD), left ventricular end-diastolic internal diameter (LVEDD), left ventricular wall thickness (LVP), and left ventricular end-systolic thickness (LVS) were significantly reduced in the observation group than in the control group. This indicates that through effective rehabilitation therapy, the patients' cardiac structure was improved and the left ventricular function was improved.

Meanwhile, the left ventricular ejection fraction (LVEFA) of the observation group was significantly higher than that of the control group, which further confirmed that the cardiac function of the patients in the observation group was significantly improved. In addition, the levels of Hcy and SUA in the observation group were significantly lower than those in the control group, which is worthy of further investigation. The reduction of Hcy and SUA, which are important risk factors for cardiovascular diseases, may be directly related to the improvement of cardiovascular health of the patients. This provides new clues to the mechanism of cardiac rehabilitation, suggesting that rehabilitation therapy may improve patients' cardiovascular health by reducing these risk factors. In summary, revascularization is an effective method to improve myocardial blood supply for patients with coronary multibranch lesions. Scientific cardiac rehabilitation after surgery can further optimize the therapeutic effect and improve the quality of life of patients.

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Ethics approval: The studies involving human participants were reviewed and approved by the Institutional Ethical Committee of the Huai'an Rehabilitation Hospital (Jinhu County People's Hospital) (ethical review number: LLSC: NO.2022-65). The patients/participants provided their written informed consent to participate in this study. The present study fulfills the requirements of the Declaration of Helsinki.

Conflict of interests: The authors affirm that they have no conflicts of interest to disclose for this work.

Authors' contribution: The author made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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