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Original Article

Application of optimized cardiac rehabilitation program in exercise tolerance and quality of life of elderly patients undergoing percutaneous coronary intervention for acute myocardial infarction

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Abstract: Objective: To analyze the application of optimized cardiac rehabilitation program (OCRP) in improving exercise tolerance (ET) and life quality (QL) of elderly patients undergoing percutaneous coronary intervention (PCI) for acute myocardial infarction (AMI). Methods: Retrospective analysis was conducted on the clinical data of 128 cases of elderly patients undergoing PCI for AMI. Patients were divided into two groups based on whether or not they were enrolled in the cardiac rehabilitation program; the control group consisted of 57 patients who were given normal treatment and necessary health education; the observation group consisted of 71 patients, who were enrolled in cardiac rehabilitation program, received in-hospital rehabilitation training, rehabilitation training within 1 month after discharge and rehabilitation training afterwards on the basis of treatment received in control group; target heart rate (THR), metablic equivalent (METs) and 6-minute walk were taken as observation indicators of ET; SF-36 Health Questionnaire as the tool to evaluate QL; comparison of cardiac function between the two groups before and after rehabilitation was made. Results: THR of the two groups were obviously improved 1 month, 3 months and 6 months after discharge, compared with when they were admitted to hospital. The differences were of statistical significance (all $P<0.05$); while THR, METs and 6-minute walk of the observation group 1 month, 3 months and 6 months after discharge were better than the control group (all $P<0.05$); after the rehabilitation, the score of observation group on SF-36 Health Questionnaire was remarkably improved compared with the control group ($P<0.05$); besides, stroke volume and left ventricular ejection fraction (LVEF) of the observation group after the rehabilitation were distinctly increased compared with before; left ventricular end systolic diameter (LVESD) and left ventricular end-diastolic dimension (LVEDD) also were significantly narrowed than before (all $P<0.05$). Conclusion: OCRP is beneficial to the recovery of cardiac function of elderly patients undergoing PCI for AMI. Since it helps improving ET and QL of patients after surgery, it is of high clinical application value and worth further study and application.

Keywords: Acute myocardial infarction, percutaneous coronary intervention, optimized cardiac rehabilitation program, exercise tolerance, quality of life

Introduction

In recent years, percutaneous coronary intervention (PCI) has been widely used in treating acute myocardial infarction (AMI), progressively on the elderly. In the past, more attention was paid to the treatment of elderly patients undergoing PCI for AMI at acute phase and less to post-operative cardiac rehabilitation, which resulted in relapse and readmission to hospital and decreased quality of life (QL) of patients [1, 2]. Nowadays, cardiac rehabilitation has drawn much attention and proved to be effective. However, as the expectation towards rehabilitation of elderly patients undergoing PCI for AMI rises, cardiac rehabilitation method for such patients has changed-traditionally rehabilitation was performed at stable stage and now cardiac rehabilitation was carried out at early postoperative stage. Optimized cardiac rehabilitation program (OCRP) suits better for elderly patients undergoing PCI for AMI. With various intervention measures, it achieves cardiac rehabilitation standardization, lowers relapse

risks and improves QL and thereby, helps patients to get back to normal life [3]. Reports and researches on application of OCRP are relatively limited in China, compared with overseas reports. Notwithstanding, it is a consensus that OCRP has remarkable effect on elderly patients undergoing PCI for AMI. To date, elderly patients undergoing PCI for AMI has become an indication of OCRP which is good for improving patients' cardiac function and thereby improves their exercise tolerance (ET) and QL. But unfortunately, it is yet to be widely used and to be attach importance to [4, 5]. This study is to further confirm the effect of OCRP on elderly patients undergoing PCI for AMI, as well as analyzing the application of OCRP on ET and QL of elderly patients undergoing PCI for AMI.

Materials and methods

General data

Approved by the Ethics Committee of Affiliated Hospital of Jining Medical University, this study retrospectively analyzed clinical data of 128 elderly patients undergoing PCI for AMI admitted to our hospital between May 2015 and May 2016. Patients were divided into two groups based on whether or not they were enrolled in the OCRP; the control group consisted of 57 patients who were given normal treatment and necessary health education; the observation group consisted of 71 patients who were, besides given the same normal treatment and health education as those of the control group, enrolled in the OCRP group. All patients admitted into this program were volunteered and had signed informed consent.

Inclusion criteria: Patients aged between 65 and 80, diagnosed by coronary arteriography as AMI with one or more main artery stenosis over 75% while PCI stenosis degrees lower than 20%; NYHA II-III elderly patients undergoing PCI for AMI, restored to sinus rhythm; left ventricular ejection fraction (LVEF) over 35%; systolic pressure lower than 150 mmHg; diastolic pressure lower than 90 mmHg; x-ray films show normal, without diseases of respiratory system, limb or joint diseases or other bone diseases; in compliance with follow up; with complete clinical data.

Exclusion criteria: Not in conformance with diagnostic criteria of AMI; there were other serious fundamental diseases; unstable post-operation conditions; yet to be restored to sinus rhythm; there was serious limited activity condition irrelative to AMI; unstable haemodynamics; patients with serious complication and low treatment compliance or those incapable of normal communication.

Research methods

The control group was given conventional treatment and necessary health education, including advice of stay in bed, treatment of moderate sedative and anti-anxiety drugs; when dyspnea happened, oxygen inhalation based on patient's condition vital sign monitoring (oxyhemoglobin saturation should exceed 90%) and anti-infection. Prior to PCI surgery, aspirin together with clopidogrel was used as antiplatelet treatment, then a stent was placed at the branch of stenosis to restore blood perfusion and ensure that remaining part of stenosis was less than 20%. After surgery, aspirin was given to patients 100 mg/day, clopidogrel 75 mg/day and Atorvastatin 20 mg/day; health education was enhanced, and pathologic changes of AMI and how to prevent risk factors and get rid of unhealthy lifestyle, dietary habits and psychological states that were bad for cardiac rehabilitation were advised to patients.

The observation group, on the basis of the control group, was enrolled in the OCRP including: 1) in-hospital rehabilitation training, detailed as follows: passive exercise with the help of medical workers or family, slowly turning over on bed; together with bedside sitting training, according to patients' conditions and sitting tolerance, 1 metabolic equivalent (MET) of bedside sitting should be ensured; initiative exercises on bed and at bedside, of which on-bed exercise was considerable resistance exercise such as making a fist, bending elbow, swaying hands and feet, doing ankle pump, etc., while bedside exercises were mainly standing and sitting on bedside at the intensity of 2 METs; walking at bedside, at the intensity of 2-3 METs, namely 10 minutes per time, three times per day, at the speed of 60-70 step/min; walking in ward hallway at the intensity of 3 METs, namely 10 minutes per time, three times per day, at the speed of 70-90 step/min; climbing stairs of 2 floors each time at the intensity of 4 METs; 2) rehabilitation training within 1 month after discharge, detailed as follows: indoor walking at

Table 1. Comparison of clinical baseline data of the two groups (n, %)

Item	Control group (n=57)	Observation group (n=71)	Statistical quantity	P
Male (%)	38 (66.67)	47 (66.20)	0.75	0.59
Age (years old)	67.87±0.35	68.19±0.41	0.42	0.75
BMI (kg/m^2)	24.35±0.28	23.76±0.31	0.71	0.54
Smoking	23 (40.35)	29 (40.85)	0.63	0.63
Drinking	11 (19.30)	14 (19.72)	0.95	0.45
Hypertension	37 (64.91)	41 (57.75)	1.04	0.15
Blood lipid rises	3 (5.26)	4 (5.63)	0.28	0.86
Blood glucose rises	10 (17.54)	12 (16.90)	0.25	0.92
Myocardial infarction position			1.24	0.09
Anteroseptal	43 (75.44)	53 (74.65)		
Paries inferior	14 (24.56)	18 (25.35)		
NYHA cardiac functions grades			1.30	0.10
II	38 (66.67)	45 (63.38)		
III	19 (33.33)	26 (36.62)		

Note: BMI, body mass index.

the intensity of 5 METs, namely 15 min per time, three times per day, at the speed of 70-90 step/min; climbing stairs of 3 floors each time at the intensity of 6 METs; outdoor walking at the intensity of 7 METs, namely 15-30 min per time, 2-3 times per day, at the speed of 70-90 step/min; 3) rehabilitation training 1 month after discharge, detailed as follows: outdoor walking, at the intensity of 8-10 METs, namely increase by 30 minutes each time, 3 times per day, at the speed of 70-120 step/min; walking and jogging alternated, namely jogging for 30s after walking for 1 minute and gradually increase to walking and jogging distanced 2 km, 2-3 times per day, at the intensity of 12 METs; jogging 15-20 min per time, 2-3 times per day, at the intensity of 15 METs.

Observation indicators

Target heart rate (THR), METs and 6-minute walk were taken as the observation indicators of ET and SF-36 Health Questionnaire as the tool to evaluate QL. Patients were advised to go back to hospital for recheck 1 month, 3 months and 6 months after discharge. Indicators and recordings made at these times were reviewed to compare with those made at their admission; of which THR = ((220 - age) - resting heart rate) * (60-80%) + resting heart rate; a metabolic unit used to quantify the intensity of physical activity, which is defined as the ratio of the metabolic rate during exercise to the metabolic rate at rest, and daily activities' METs are as follows: sitting (1 MET), eating (2 METs), bathing (3 METs), slow jogging (4 METs), mopping (5 METs), speed-walking (6 METs), heavy work (7 METs), walking uphill (8 METs), climbing stairs (9 METs), bicycling at moderate speed (10 METs), running (11 METs), climbing upstairs with load for 2 floors (12 METs), continuous fast running (13 METs). SF-36 Health Questionnaire consists of 36 articles and 8 health dimensions including physical function, limited role caused by physical health issue, physical pain, sense of general health, life vitality, social function, limited role and spiritual health caused by emotional issues; the higher the score of SF-36 Health Questionnaire, the better the QL. Stroke volume, LVEF, left ventricular end systolic diameter (LVESD) and left ventricular end-diastolic dimension (LVEDD) were taken as the observation indicators of cardiac function [6-8].

Data processing

Experimental data was processed by SPSS18.0. Measurement data in conformity with normal distribution and of homogeneity of variance was represented by mean ± standard deviation and t-test was used for the comparison between the two groups; while the measurement data not in conformity with normal distribution was expressed as M (Q1, Q3) and tested by Mann-Whitney U; enumeration data was tested by χ^2; and ranked data by rank sum test; if $P<0.05$, then the differences were of statistical significance.

Results

Comparison of clinical baseline data of the two groups

Gender, body mass index (BMI), smoking, drinking, hypertension, blood lipid rises, blood glucose rises, myocardial infarction position, NYHA cardiac functions grades of patients of the

Table 2. Comparison of THR of the two groups at admission, 1 month, 3 months, 6 months after discharge

Group	Case	THR			
		At hospital admission	1 month after discharge	3 months after discharge	6 months after discharge
Control group	57	79.58 (71.35, 87.97)	94.76 (85.34, 105.36)*	99.68 (88.45, 112.32)*	101.36 (91.64, 124.78)*
Observation group	71	80.63 (72.43, 89.64)	107.64 (95.17, 121.45)*	114.77 (102.74, 127.61)*	115.89 (102.74, 130.72)*
Z		0.13	-4.31	-5.04	-5.07
P		0.840	<0.001	<0.001	<0.001

Note: Mann-Whitney U test was adopted; compared with those at admission, the differences were significant, *P<0.05; THR, target heart rate.

Table 3. Comparison of METs of the two groups at 1 month, 3 months, 6 months after discharge

Group	Case	METs		
		1 month after discharge	3 months after discharge	6 months after discharge
Control group	57	9.24 (7.91, 10.23)	10.45 (9.26, 12.44)	10.63 (9.12, 11.88)
Observation group	71	11.83 (9.23, 13.78)	13.56 (12.42, 13.76)	13.72 (12.66, 13.95)
Z		-5.13	-6.76	-5.42
P value		<0.001	<0.001	<0.001

Note: Mann-Whitney U test was adopted; METs, metabolic equivalent.

Table 4. Comparison of 6-minute walk of the two groups at 1 month, 3 months, 6 months after discharge

Group	Case	6-minute walk (meter)		
		1 month after discharge	3 months after discharge	6 months after discharge
Control group	57	462.17 (441.61, 487.43)	486.67 (462.67, 513.89)	498.79 (483.66, 519.47)
Observation group	71	511.95 (498.46, 523.67)	556.45 (547.87, 579.63)	612.54 (596.15, 636.82)
Z		-5.06	-6.37	-6.22
P		<0.001	<0.001	<0.001

Note: Mann-Whitney U test was adopted.

Table 5. Comparison of SF-36 Health Questionnaire scores between the two groups before and after rehabilitation

Group	Case	SF-36 Health Questionnaire score (point)	
		Before rehabilitation	After rehabilitation
Control group	57	14.25 (12.95, 15.87)	16.47 (14.85, 17.91)
Observation group	71	14.36 (13.04, 15.92)	18.96 (17.58, 19.74)
Z		0.16	-8.74
P value		0.840	<0.001

Note: Mann-Whitney U test was adopted.

two groups were tested by χ^2 test, and ages of the two groups were tested by t test, differences of which turned out to have little statistical significance (all P>0.05). See **Table 1**.

Comparison between the two groups: THR at different time points, MET and 6-minute walk

THR difference of the two groups at hospital admission was of little statistical significance (P>0.05); while THR of the two groups at 1 month, 3 months, 6 months after discharge from hospital were distinctively higher than that at admission and the differences were of statistical significance (all P<0.05). THR, METs and 6-minute walk of the observation group at 1 month, 3 months, 6 months after discharge were better than those of the control group and the differences were of statistical significance (all P< 0.05). See **Tables 2**-**4**.

Comparison of SF-36 Health Questionnaire scores of the two groups before and after rehabilitation

Before rehabilitation, difference of the two groups on SF-36 Health Questionnaire scores was of little statistical significance (P>0.05);

Table 6. Comparison of cardiac function observation indicators of the two groups before and after rehabilitation

Group	Stroke volume (L/min)	LVEF (%)	LVESD (mm)	LVEDD (mm)
Control group				
Before rehabilitation	3.12±0.19	34.91±0.36	49.74±0.47	62.69±0.54
After rehabilitation	3.76±0.16	38.63±0.59	43.04±0.34	56.24±0.33
Observation group				
Before rehabilitation	3.21±0.23	34.60±0.25	49.65±0.51	62.03±0.49
After rehabilitation	5.02±0.41*,#	48.85±0.47*,#	34.12±0.26*,#	48.29±0.26*,#
t1/P1	5.41/0.036	6.74/<0.001	1.85/0.060	2.95/0.050
t2/P2	10.49/<0.001	20.45/<0.001	5.24/0.036	15.47/<0.001
t3/P3	0.06/0.960	0.65/0.800	1.25/0.100	0.21/0.750
t4/P4	5.15/0.040	10.75/<0.001	4.93/0.046	10.16/<0.001

Note: t testwas adopted; comparison within control group, t1/P1; comparison within observation group, t2/P2; comparison of the two groups before rehabilitation, t3/P3; comparison of the two groups after rehabilitation, t4/P4; LVEF, left ventricular ejection fraction; LVESD, left ventricular end systolic diameter; LVEDD, left ventricular end-diastolic dimension. Comparison within groups before rehabilitation,*P<0.05; Comparison with control group after rehabilitation, #P<0.05.

after rehabilitation, the observation group's SF-36 Health Questionnaire score was remarkably increased. Compared with that of the control group, the difference was of statistical significance (P<0.05). See **Table 5**.

Comparison of cardiac function observation indicators of the two groups before and after rehabilitation

Before rehabilitation, differences of stroke volume, LVEF, LVESD and LVEDD of the two groups were of little statistical significance (all P>0.05); after rehabilitation, the observation group's stroke volume and LVEF were increased while LVESD and LVEDD were narrowed than before. Compared with those of the control group, the differences were of statistical significance (all P<0.05). See **Table 6**.

Discussion

In the past, elderly patients undergoing PCI for AMI were used to be suggested to rest in bed for 24 h and take on-bed exercises at early stage of rehabilitation, which is lack of safety advantages [9]. Whereas there is a variety of types of cardiac rehabilitations for elderly patients undergoing PCI for AMI, OCRP was as the key part of cardiac rehabilitation in this study. Past studies have shown that the OCRP helps increasing coronary lumen diameter and perfusion, and can significantly improve coronary flow reserve, ET, refection, and reduce coronary restenosis, resulting in effective cardiac rehabilitation [10-12]. In this study, the observation group enrolled in the OCRP was given rehabilitation training as soon as possible. They got passive exercise at first and then active such transition can guarantee patients' health and improve cardiac function, ET and QL. From the analysis of the OCRP in this study, it can be concluded that it is beneficial for increasing myocardial blood flow, improving coronary results as well as balancing the relation between myocardial contraction and relaxing factor, enhancing regulating capability of blood vessel and facilitating recovery of cardiac function to take rehabilitation training, including in-hospital rehabilitation training, rehabilitation training within 1 month after discharge and rehabilitation training 1 month later after discharge and take gradually increasing exercises. At early stage, exercises were mainly passive exercise and active exercise on bed and at bedside, and bedside walking, then walking in doors, climbing stairs and then walking out doors. At last, depending on patients' ET, patients took out-door walking and jogging alternately then to jogging.

By retrospectively analyzing clinical data of 128 elderly patients undergoing PCI for AMI, this study discussed the influence of the OCRP upon ET and QL, with THR, METs, 6-minute walking as the observation indicators of ET. Changes of the indicators were the evidence for cardiac rehabilitation of such patients. THR, as a critical indicator of aerobic exercise, mainly refers to the effective and safe exercise heart

rate appeared when cardiovascular circulation system function was improved during aerobic exercise [13, 14]. According to **Table 2** in this study, THR difference of the two groups at admission was of little statistical significance (P>0.05); while THR of the two groups at 1 month, 3 months, 6 months after discharge from hospital were distinctively higher than that at admission. The differences were of statistical significance (P<0.05). THR, METs and 6-minute walk of the observation group 1 month, 3 months, 6 months after discharge were better than those of the control group and the differences were of statistical significance (P<0.05); therefore, the OCRP is good for improving THR of elderly patients undergoing PCI for AMI, evidence of which is that patients' ET and cardiac function were enhanced. MET is an observation indicator reflecting energy metabolism level and exercise intensity of the body at state of motion, based on resting energy consumption [15-17]. In this study, though it was not allowed to do METs test on elderly patients undergoing PCI for AMI when they were admitted to the hospital, due to their conditions, it can be told from **Table 3** that, METs of the observation group 1 month, 3 months, 6 months after discharge were better than those of the control group. The differences were of statistical significance (P<0.05); so the OCRP has positive effect on improving ET.

In addition, as a simulation of patients' daily life, 6-minute walk test can better reflect the influence of PCI surgery on elderly AMI patients' QL. The test results were also good for evaluating patients' ET. Besides, 6-minute walk test is simple and highly acceptive among patients and can objectively and accurately reflect patients' daily activities [18-20]. Although it was not allowed to do 6-minute walk test on elderly patients undergoing PCI for AMI when they were admitted to the hospital, due to their conditions, there was no test result, but 6-minute walk result of the observation group at 1 month, 3 months, 6 months after discharge were better than those of the control group; meanwhile, after rehabilitation, stroke volume, LVEF, LVESD and LVEDD of the observation group were distinctly better than those of the control group, which showed that after taking the OCRP, ET and QL of elderly patients undergoing PCI for AMI were largely increased. Cardiac function was also improved. The whole result was better than normal medical treatment, which might have something to do with enhanced myocardial ischemia and anoxia.

This study was lack of sufficient samples, long-term follow-up data and intravascular imageological examination data. Therefore, it inevitably has its limitation; besides, other factors such as gender, age and fundamental diseases on effects of patients' cardiac rehabilitation was not considered in this study. Hence, it is necessary to increase sample quantity, carry out prospective study, and prolong follow up period to verify the effectiveness and safety of the OCRP on improving cardiac function of elderly patients undergoing PCI for AMI. Multiple factors that can impact on the effect of patients' cardiac rehabilitation should be analyzed, too.

In conclusion, OCRP is worth further research and application as it can speed on the cardiac function recovery for patients with AMI, and significantly improve their ET and QL after surgery.

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Disclosure of conflict of interest

None.

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