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Original Article

Effects of early passive movement on troponin, brain natriuretic peptide, ejection fraction and incidence of adverse cardiovascular events in acute myocardial infarction patients after percutaneous coronary intervention

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Abstract: Objective: This study aimed to analyze the effects of early passive movement (EPM) on Troponin (Tn), Brain Natriuretic Peptide (BNP), ejection fraction (EF) and adverse cardiovascular events of acute myocardial infarction (AMI) patients after percutaneous coronary intervention (PCI). Methods: In total, 80 AMI patients who underwent PCI in our hospital from January 2019 to December 2019 were divided into the study group (SG, n=40, EPM at 12 h after the surgery) and the control group (CG, n=40, conventional postoperative intervention). Serum Tn, BNP, left ventricular ejection fraction (LVEF) and stroke volume (SV) before intervention, out-of-bed movement at 7 d after surgery, 6 min walk distance at 7 d, 15 d, 1 month and 3 months after surgery, as well as the incidence of adverse cardiovascular events during the 6-month follow-up were compared between the two groups. Results: (1) Compared with the CG at 3 months after intervention, the SG had lower Tn and BMP levels, and higher LVEF and SV ($P<0.05$). (2) At 7 d after surgery, the incidences of dizziness, leg weakness and sweating during out-of-bed activities were lower in the SG ($P<0.05$). (3) At 7 d, 15 d, 1 month and 3 months after surgery, the 6 min walk distance was longer in the SG ($P<0.05$). (4) During the 6-month follow-up, SG had lower incidence of adverse cardiovascular events ($P<0.05$). Conclusion: EPM of AMI patients 12 h after PCI can improve their cardiac function and exercise tolerance, and reduce the out-of-bed reactions and the incidences of adverse cardiovascular events.

Keywords: Early passive movement, AMI, PCI, Tn, BNP, EF, adverse cardiovascular events

Introduction

With changes of lifestyle and diet in recent years, the incidence of cardiovascular and cerebrovascular diseases has increased year by year. Acute myocardial infarction (AMI) is myocardial necrosis caused by acute or persistent ischemia and hypoxia in the coronary artery, with the main clinical manifestation of persistent and severe retrosternal pain [1, 2]. AMI is characterized by acute onset and critical condition, usually accompanied by arrhythmia, heart failure or shock, all of which seriously threatens the patient's life. According to data, AMI accounts for the majority of deaths worldwide. Each year, about 500,000 new cases of AMI are reported in China, and its mortality has ranked top among all diseases since 2014 [3, 4]. Percutaneous coronary intervention (PCI) is a common treatment for AMI. It can correct the blood circulation of the coronary artery, rapidly improve myocardial ischemia/hypoxia, and plays an irreplaceable role in saving the endangered myocardium. Studies have shown that surgery is also very significant for improving the survival of AMI patients [5, 6].

Some recent studies have also found that although PCI con rapidly restore myocardial reperfusion, quickly alleviate the clinical syndromes of AMI patients and reduce the fatality rate;, it may induce and exacerbate local coronary artery inflammation, in which some patients reported restenosis 6 to 9 months after surgery [7, 8]. Data revealed that about 20% of the AMI patients may have in-stent restenosis (ISR) 6 to 9 months after surgery with obvious ischemic angina or even reinfarction in some cases. Therefore, how to effectively improve cardiac function and reduce the incidence of adverse cardiovascular events in AMI patients after PCI is the focus of current clinical studies [9, 10].

Previous studies have evidence for postoperative active recovery intervention not only being conducive to preventing coronary atherosclerosis in AMI patients after PCI, but is also conducive to accelerating their coronary endothelial functional recovery and the construction of collateral circulation from the coronary artery [11]. As a common recovery intervention for patients who underwent a large-scale surgery, passive movement plays an active role in preventing pulmonary infection, reducing the incidence of venous thrombus and promoting whole body recovery. In this study, it was found that the early implementation of passive movement in AMI patients within 12 h after the PCI could improve the indices of cardiac functions and exercise tolerance, and reduce out-of-bed reactions and incidences of adverse cardiovascular events.

Materials and methods

General materials

A total of 80 AMI patients who underwent PCI in our hospital from January 2019 to December 2019 were divided into the study group (SG, n=40) and the control group (CG, n=40) according to the postoperative intervention.

Inclusion criteria: (1) Patients who were clinically diagnosed with AMI for PCI; (2) Who had clear consciousness to cooperate with the study; (3) Who had complete medical records; (4) Who were aged ≤70 years; (5) This study obtained approval from the Ethics Committee of the hospital; (6) Patients or their family members had explicit understanding of the study process, methods and principles, and informed consent was provided.

Exclusion criteria: (1) Patients who were complicated with metal disorders, or had other surgical diseases, uncontrollable arrhythmia, decompensated heart failure, or malignant tumor; (2) Patients with PCI contraindications; (3) Patients with poor treatment compliance; (4) Patients with unstable conditions after PCI.

Withdrawal criteria: patients who had worsening conditions and other sudden major diseases affecting the results, and who gave active proposal of withdrawal, or death during the study.

Methods

All patients received conventional internal treatment and basic health education after PCI. The specific measures were as follows: (1) General treatment. Patients were required to rest in bed, administered with antidepressants or anti-anxiety drugs, supplied with oxygen based on their specific conditions, and closely monitored for vital signs; and patients with hypertension and diabetes were symptomatically treated. (2) Conventional drug intervention. After surgery, patients were treated with Enteric Coated Aspirin (Tablet) + clopidogrel + atorvastatin. (3) Health education. The notes after PCI and the knowledge related to AMI were transmitted to the patients and their families through broadcasting, manuals and WeChat. Patients were assisted to correct any hazards and change unhealthy living habits.

Patients in the CG stayed in bed for 7 d after surgery without special intervention measures. On the same basis, SG patients were required to have EPM. After surgery, they were absolutely immobilized at 6 h, stayed in bed for rest at 12 h-24 h, and then assisted by families for passive joint movement, including arm cranking, leg cranking, posture changes, *etc*., and for cleaning and dinning in bed, they had active joint exercise at 24 h-48 h, including fist clenching, elbow bending and straight leg raising. They were also assisted to practice sitting, or other strength resistance as appropriate based on the actual conditions. Other exercise included bedside active exercise at 48 h-72 h when they had dinner in the bed, in the form of sitting for 15-20 min per time, two to three times a day. Bedside walking exercise of 60-70 steps per min for about 10 min each time and three times daily at 72 h-96 h; as well as ward walking exercise of 25-50 m, two to three times daily. At 96 h-120 h post-surgery when they could clean themselves and have dinner by the bedside; corridor walking exercise of 100-150 m, two to three times daily. At 120 h-144 h post-surgery, exercise was supplemented with staircase climbing (one story) as the case when they can take care of themselves independently. Staircase climbing at 144 h-168 h, with two to three stories each time, two to three times daily.

Observation indices and evaluation criteria

Laboratory indices before and after intervention: Immediately and at 3 months after surgery, 5 ml blood samples were collected from all the patients, mixed with heparin for anticoagulation, and centrifuged at 3000 r/min for 5 min. The serum was stored at -80°C. Within 6 h after sampling, the Tn and BNP in the blood samples were tested by Siemens ADVIA1800 automatic biochemical analyzer, and the methods of ELISA and Chemiluminescence, respectively.

Cardiac function indices before and after intervention: Immediately and at 3 months after surgery, all patients were tested for left ventricular ejection fraction (LVEF) and stroke volume (SV) with a Siemens ACUSONX S2000 Color Ultrasound Diagnostic Instrument. During the test, they were kept in a left lateral decubitus position, and LVEF and SV were measured by the single-plane method. Each index was measured 3 times continuously, and the average value was taken.

Out-of-bed activities at 7 d after surgery

At 7 d after surgery, the medical staff organized the patients to get out of bed, with upright walking as the specific method, and 5 min as the time standard. During the activity, the incidences of dizziness, leg weakness, sweating, high blood pressure and low blood pressure during the out-of-bed activities were measured and compared between the two groups [12]. Medical staff protected the patients in this process. If the patients voluntarily request to stop the test, they were immediately stopped and did follow-up nursing work.

Postoperative exercise tolerance

At 7 d, 15 d, 1 month and 3 months after surgery, all patients were tested for exercise tolerance according to the *6 min Walking Test Guide* [13]. The guide provides a comprehensive evaluation of respiratory, circulatory, blood and neuromuscular systems to objectively reflect the patients' exercise tolerance. During the evaluation, patients had a rest of 10 min on the chair in the corridor and then tried their best to walk for 6 min. The maximal walking distance was recorded. Drugs and equipment were prepared in case of emergency, and the test was suspended in case of expiratory dyspnea and pectoralgia.

Postoperative incidence of adverse cardiovascular events

All patients were followed up for 6 months by telephone or in person follow-up to calculate their 6-month incidences of heart failure, arrhythmia and reinfarction for intergroup comparison.

Statistical analysis

Statistical analysis was performed with SPSS 22.0. In case of nominal data expressed as [n (%)], comparison studies were carried out through X^2 test for intergroup comparison; in the case of numerical data it was expressed as mean ± standard deviation (SD), comparison studies were carried out through *t* test. Intergroup comparison at multiple points was carried out by ANVOA for real-time difference and F test. For all statistical comparisons, $P<0.05$ was considered significant [14].

Results

Intergroup comparison of general clinical materials

There was no significant difference in terms of clinical materials such as gender, average age, educational background, marital status, monthly income, BMI and underlying diseases ($P>0.05$), which were comparable between the two groups (**Table 1**).

Intergroup comparison of Tn and BNP before and after intervention

Laboratory testing found that immediately after surgery, there was no statistically significant difference in Tn and BNP between the two groups ($P>0.05$). At 3 months after surgery, a significant reduction was observed in both indices ($P<0.05$). Intergroup comparison revealed lower Tn and BNP levels in the SG as compared with the CG ($P<0.05$) (**Table 2** and **Figure 1**).

Table 1. Intergroup comparison of general clinical materials ($\overline{x} \pm s$)/[n (%)]

Materials		SG (n=40)	CG (n=40)	t/X^2	*P*
Gender	Male	21	22	0.209	0.647
	Female	19	18		
Age (y)		59.98±2.31	60.13±2.19	0.324	0.747
Educational background	Illiteracy	5	5	0.312	0.601
	Primary school	13	12		
	Junior middle school	14	15		
	Senior middle school and colleges	8	8		
Marital status	Married	32	33	0.001	0.977
	Unmarried	8	7		
Monthly revenue (RMB Yuan)	<1000	5	4	0.443	0.546
	1000-3000	27	27		
	>3000	8	9		
Average BMI (kg/m^2)		22.38±2.31	22.41±2.29	0.058	0.954
Hypertension	Yes	13	14	0.056	0.813
	No	27	26		
Diabetes	Yes	12	14	0.228	0.633
	No	18	26		

Table 2. Intergroup comparison of Tn and BNP levels before and after intervention ($\overline{x} \pm s$)

Group	n	Tn (ng/ml)		BNP (ng/mL)	
		Immediately after surgery	3 months after surgery	Immediately after surgery	3 months after surgery
SG	40	2.91±0.32	1.34±0.21*	2.01±0.23	1.21±0.11*
CG	40	2.87±0.34	1.56±0.19*	1.97±0.21	1.45±0.22*
t	-	0.591	5.332	0.881	6.827
P	-	0.556	<0.001	0.38	<0.001

*: P<0.05 vs conditions immediately after surgery.

Intergroup comparison of cardiac function indices before and after intervention

According to tests, there was no statistically significant difference in the LVEF and SV immediately after surgery between the two groups ($P>0.05$), and the two indices were significantly increased at 3 months after surgery ($P<0.05$). Intergroup comparison revealed higher LVEF and SV levels in the SG as compared with the CG ($P<0.05$) (**Table 3** and **Figure 2**).

Intergroup comparison of out-of-bed activities at 7 d after surgery

At 7 d after surgery, there was 1 case of dizziness, 1 case of leg weakness, 3 cases of sweating, 0 cases of arrhythmia, 0 cases of high blood pressure and 0 cases of low blood pressure in the SG, and the corresponding numbers of cases were 30, 36, 30, 5, 6 and 6 in the CG. The incidence of adverse events in the SG was lower than that in the CG ($P<0.05$) (**Table 4** and **Figure 3**).

Intergroup comparison of postoperative exercise tolerance

A rising tendency was observed in the 6 min walk distance from 7 d to 3 months after surgery ($P<0.05$). Meanwhile, intergroup comparison showed that the 6 min walk distance was significantly longer in the SG ($P<0.05$) (**Table 5** and **Figure 4**).

Incidence of adverse cardiovascular events during the 6-month follow-up after surgery

During the 6-month follow-up after surgery, the SG reported 2 cases of arrhythmia, with a total

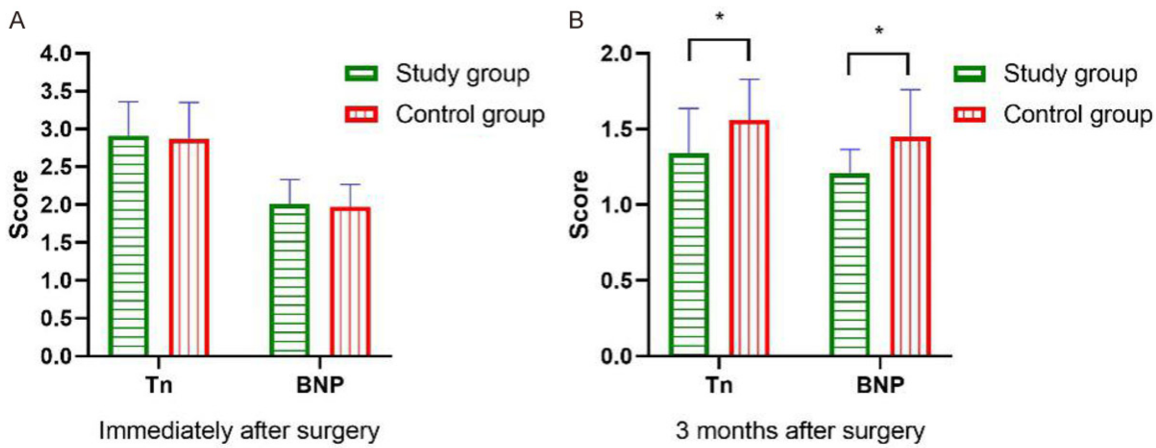

Figure 1. Intergroup comparison of Tn and BNP levels immediately and at 3 months after surgery. Immediately after surgery, no statistical significance was observed between the two groups in terms of Tn and BNP levels (*P*>0.05) (A). At 3 months after surgery, the Tn and BNP levels were lower in the SG (*P*<0.05) (B). **P*<0.05 vs CG for the same index.

Table 3. Intergroup comparison of LVEF and SV before and after intervention ($\overline{x} \pm s$)

Group	n	LVEF (%)		SV (ml)	
		Immediately after surgery	3 months after surgery	Immediately after surgery	3 months after surgery
SG	40	31.78±5.21	43.28±4.33*	40.19±3.23	50.19±5.11*
CG	40	32.01±4.98	38.89±4.01*	39.89±3.17	46.12±4.38*
t	-	0.219	5.109	0.456	4.145
P	-	0.827	<0.001	0.649	<0.001

*: P<0.05 vs conditions immediately after surgery.

incidence of 4.00%, and the CG found 1 case of heart failure, 6 cases of arrhythmia and 1 case of reinfarction, with a total incidence of 20% (*P*<0.05) (**Table 6** and **Figure 5**).

Discussion

AMI is a critical type of coronary heart disease, with typical clinical manifestations including severe chest pain and dyspnea. In addition to poor prognosis, some patients will also suffer from decreased cardiopulmonary function, exercise tolerance and self-care ability, which seriously affects their normal life [15-17].

As a common AMI surgery, PCI is used to treat stenosis or occlusion of coronary arteries via cardiac catheterization to improve myocardial perfusion. In 2012, PCI was recognized by the European Society of Cardiology (ESC) as the most important emergency treatment for AMI patients, and has been widely promoted in clinic. Studies have found that AMI patients are still at risk for coronary artery restenosis after PCI, and it is believed that AMI patients who received PCI need about 6 weeks to form solid cicatricial tissue around the cardiac muscle, and about 6-8 weeks to rest in bed before any out-of-bed activities [18, 19] according to the theoretical basis provided by Mallory et al in the 1930s. According to clinical practice, long-term rest in bed will bring great adverse effects on the patients' body, resulting in compromised gas exchange, increased risk of postoperative pulmonary infection, thrombosis and myophagism, increased blood viscosity, decreased exercise tolerance, and increased risk of muscle atrophy [20, 21]. Henceforth, many studies have been conducted on the necessity of early recovery movement of AMI patients after PCI.

In this study, patients were divided into the SG and the CG to study the effects of EPM on Tn, BNP, EF, and adverse cardiovascular events in AMI patients after PCI. Results were as follows. In comparison with the CG, patients in the SG showed lower Tn and BNP levels at 3 months

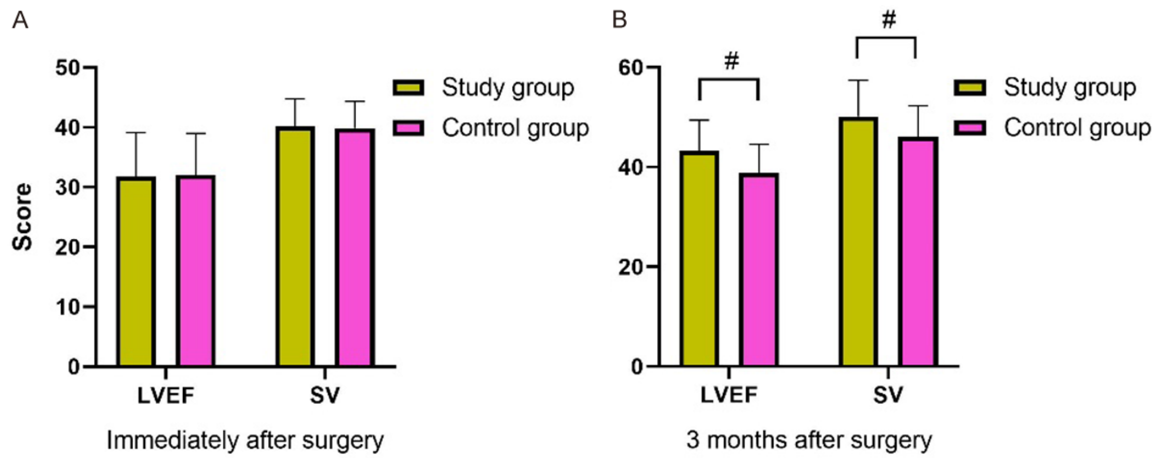

Figure 2. Intergroup comparison of LVEF and SV immediately and at 3 months after surgery. Statistical difference was not found between the two groups for LVEF and SV immediately after surgery ($P>0.05$) (A). At 3 months after surgery, the SG had significantly higher LVEF and SV ($P<0.05$) (B). #$P<0.05$ vs CG for the same index.

Table 4. Intergroup comparison of out-of-bed activities at 7 d after surgery [n (%)]

Group	n	Dizziness	Leg weakness	Sweating	Arhythmia	High blood pressure	Low blood pressure
SG	40	1 (2.50)	3 (7.5)	3 (7.5)	0 (0.00)	0 (0.00)	0 (0.00)
CG	40	30 (75.00)	36 (90.00)	30 (75.00)	5 (12.50)	6 (15.00)	6 (15.00)
X^2	-	44.292	54.484	37.602	5.333	6.486	6.486
P	-	<0.001	<0.001	<0.001	0.021	0.011	0.011

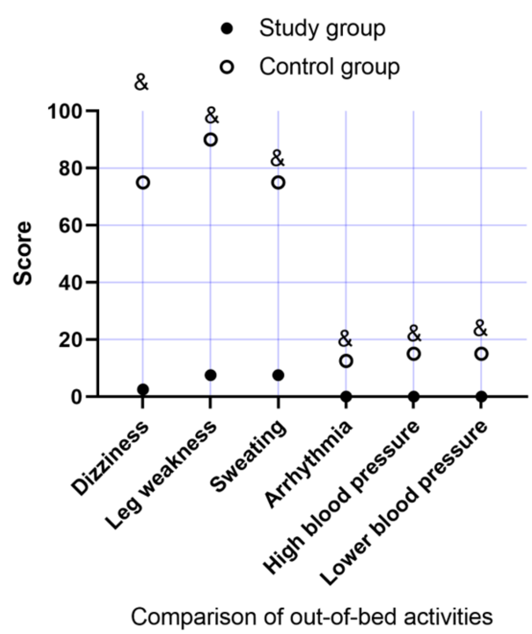

Figure 3. Intergroup comparison of out-of-bed activities at 7 d after surgery. At 7 d after surgery, the incidences of dizziness, leg weakness, sweating, arrhythmia, high blood pressure, and low blood pressure were 2.50%, 7.50%, 7.5%, 0.00%, 0.00% and 0.00% respectively in the SG; and 75.00%, 90.00%, 75.00%, 12.50%, 15.00%, and 15.00% respectively in the CG ($P<0.05$). &$P<0.05$ vs CG for the same index.

after surgery. Tn and BNP are two laboratory indices commonly used to reflect the degree of cardiac muscle injury, and are positively associated with the degree of cardiac muscle injury according to the investigation of AMI patients. The underlying mechanism is that ischemia and hypoxia lead to the rupture of cardiomyocytes, and consequently, Tn and BNP enter the blood circulation through cell membranes [22]. Three months after surgery, the Tn and BNP levels were lower in the SG patients; indicating that in the SG, the cardiomyocyte injury was less serious as compared with the CG's as a result of EPM, which managed to improve the AMI patients' vascular endothelial system, accelerate the reconstruction of collateral circulation, and save the dying cardiomyocytes. In the meantime, studies have shown that EPM promotes the synthesis and release of carbon monoxide, which accelerates the neovascularization to a certain degree. Therefore, the indices showed that cardiomyocyte injury were lower in the SG patients after surgery [23]. Furthermore, SG patients had better cardiac function than the CG, in particular, higher LVEF and SV at 3 months after surgery. This may be because EPM is a non-drug intervention which stimulates the cardiac muscles injured by AMI,

Table 5. Intergroup comparison of exercise tolerance after the surgery ($\bar{x} \pm s$) (m)

Group	n	7 d after surgery	15 d after surgery	1 month after surgery	3 months after surgery
SG	40	231.91±23.21	376.29±32.21	510.28±26.29	562.19±20.38
CG	40	200.12±18.28	300.18±26.98	489.27±20.31	521.81±22.01
t	-	7.359	12.409	4.323	9.284
P	-	<0.001	<0.001	<0.001	<0.001

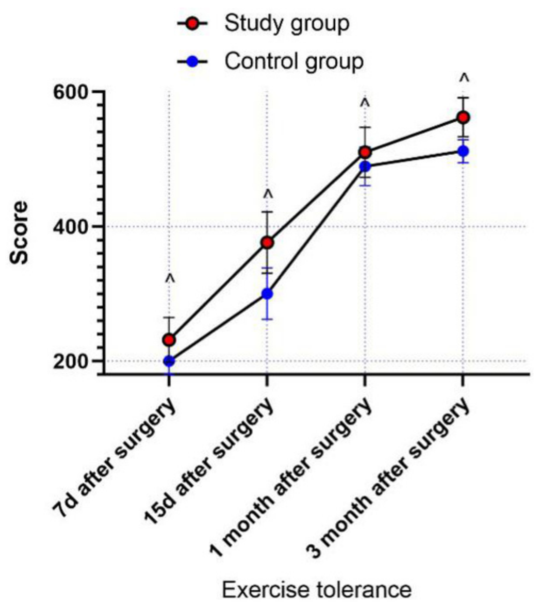

Figure 4. Intergroup comparison of postoperative exercise tolerance. At 7 d, 15 d, 1 month and 3 months after surgery, the 6 min walk distances obtained by the SG were longer than the CG's ($P<0.05$). ^$P<0.05$ vs CG for the same index.

reinforcing the contraction coordination and contractility, and increases cardiac output, intravenous tension around the heart, and returned blood volume. As a result, cardiac preload, afterload and patient's SV are increased synchronously. Reduced myocardial compliance and myocardial remodeling are usually found in AMI patients due to ischemia and hypoxia. The change of LVEF is attributed to the roles of EPM in alleviating myocardial remodeling, slowing down the process of myocardial interstitial fibrosis, expanding the coronary artery by regulating endothelial cell activity, and improving the cardiac reserve capacity and therefore cardiac function [24, 25].

These views are also confirmed by the intergroup comparison for out-of-bed activities at 7 days after surgery and postoperative exercise tolerance. EPM can clearly accelerate the postoperative recovery process by stimulating muscle groups to avoid myophagism and amyasthenia on the one hand, and cardiac muscles to prevent the overresponse of blood platelets during movement on the other hand. Some studies have pointed out that recovery exercise is a method to reduce the platelet viscosity, simulate neurohormone secretion and improve the exercise tolerance of AMI patients by cardiac function regulation. The intergroup comparison of adverse cardiovascular events suggests that EPM has positive significance in improving the long-term quality of life of AMI patients. This is because EPM can reduce atherosclerosis, delay the progression of coronary lesions, improve myocardial ischemia and blood reservation capability of coronary arteries, and ultimately affect the incidence of adverse cardiovascular events.

In conclusion, the AMI patients with passive movement at 12 h after PCI could improve cardiac function indices, exercise tolerance, reduce out-of-bed reactions and incidence of adverse cardiovascular events. The defects of this study include the following aspects: (1) Limited sample size and sampling scope, leading to limited conclusions; (2) Failure of studying the effects on patients' long-term quality of life. Future studies shall be based on larger sample size and longer follow-up time to improve the scientificness and comprehensiveness of the intervention results, and provide a broader theoretical basis for the recovery treatment of AMI patients after PCI.

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Disclosure of conflict of interest

None.

Table 6. Intergroup comparison of the incidence of adverse cardiovascular events during the 6-month follow-up [n (%)]

Group	n	Heart failure	Arhythmia	Reinfarction	Total incidence
SG	40	0 (0.00)	2 (5.00)	0 (0.00)	2 (4.00)
CG	40	1 (2.50)	6 (15.00)	1 (2.50)	8 (20.00)
t	-	-	-	-	4.114
P	-	-	-	-	0.043

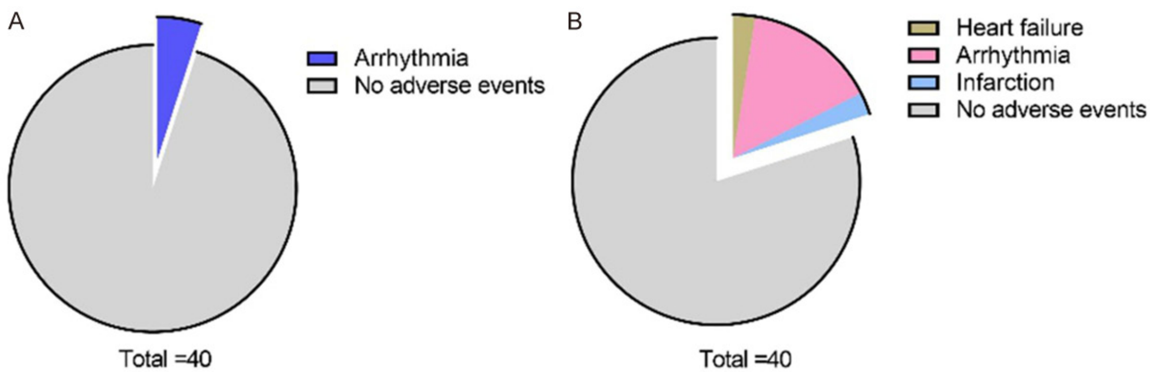

Figure 5. Intergroup comparison of incidence of adverse cardiovascular events during the 6-month follow-up. During the 6-month follow-up, the SG reported 2 cases of arrhythmia (4%) (A), and the CG reported 1 case of heart failure and reinfarction, and 6 cases of arrhythmia (20.00%) (B) (*P*<0.05).

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