Original Article

Effects of the Cardiac Rehabilitation Program on the Myocardial Performance Index in Patients With a History of Coronary Artery Bypass Surgery

Amir Hossein Yazdi[1], MD; Shahram Homayounfar[1]*, MD; Hamidreza Majidian[1], MD; Faezaneh Esna-Ashari[2], MD

ABSTRACT

Background: Cardiac rehabilitation (CR) programs effectively decrease mortality and lead to a better quality of life. Our study addresses the effects of these programs on the myocardial performance index (MPI) as a marker of cardiac function in post-bypass patients.
To evaluate the effects of CR on the MPI as a quantitative cardiac function index according to different baseline characteristics including the left ventricular ejection fraction, we designed this cohort before-and-after trial.

Methods: We enrolled 65 outpatients with a history of coronary artery bypass surgery (CABG). The MPI and ejection fraction indices were measured before and after the completion of an individualized 12-session CR program.

Results: After the successful completion of a CR program by the subjects, the mean MPI showed a significant decline (0.50 vs 0.55; $P < 0.001$) and the left ventricular ejection fraction exhibited a significant rise ($P < 0.001$). The change was more pronounced specifically in the group with a moderately reduced left ventricular dysfunction (mean MPI = 0.52 vs 0.63).

Conclusions: We successfully showed that a supervised individualized CR program can affect the MPI and systolic ejection fraction indices in post-bypass patients positively. Thus, an individualized CR program should be considered for this group of patients as a complement to the standard therapy. ***(Iranian Heart Journal 2019; 20(3): 6-11)***

KEYWORDS: Rehabilitation, Coronary artery bypass, Cardiac function tests

[1] Department of Cardiology, School of Medicine, Hamadan University of Medical Sciences, Hamadan, IR Iran.
[2] Department of Epidemiology, School of Medicine, Hamadan University of Medical Sciences, Hamadan, IR Iran.

***Corresponding Author:** Shahram Homayounfar, MD
Email: shahram1338@gmail.com **Tel:** 09181115202

Received: August 2, 2018 **Accepted:** December 25, 2018

Cardiac diseases are among the leading causes of death and disability worldwide. There are standards for care treatments that have been proven to be beneficial to patients in terms of mortality and quality of life. These include medical treatment, revascularization strategies like coronary artery bypass grafting surgery (CABG), and

percutaneous coronary intervention (PCI). [1, 2] Cardiac rehabilitation (CR) programs have gained a great deal of attention recently and have proven to be beneficial to patients with respect to both treatment and prevention of disease progression. [3, 4]

Previous research has shown a significant decline in recurrent myocardial infarction after 8 weeks of CR. [5] One significant issue after CABG is the patient's return to normal daily activities, both physically and mentally. CR programs are cumulative actions that prepare the patient for returning to an active life and also diminishing the progression of the disease. [6-8] These programs include medical assessments; risk factor modifications; physical training; education; and dietary, psychological, and stress management consults.

The cornerstone of such programs is physical training, which confers an increase in physical capacity and a reduction in angina, thus indirectly improving the lipid profile, blood pressure, and the endothelial index. [9, 10]

What is of significance in this regard is a thorough assessment of the effects of CR programs on the myocardial performance index (MPI) as a marker of the cardiac function. A useful tool to assess both systolic and diastolic cardiac functions, The MPI is easily measured by Doppler echocardiographic evaluations via the following formula:

MPI = isovolumic contraction time (IVCT) + isovolumic relaxation time (IVRT) / left ventricular (LV) ejection time (LVET)

A normal LV MPI is 39.0 ± 0.05, and it is widely used for the evaluation of the right ventricular function in patients with pulmonary hypertension. It should be borne in mind, however, that the progression of diastolic dysfunction is in tandem with a rise in these numbers. [11, 12]

The MPI has some benefits in that it is easily measured, is independent of blood pressure or heart rate, shows the systolic cardiac function of both left and right chambers of the heart, and finally has a good correlation with the invasive measurements of the systolic cardiac function.[13] There are conflicting data on the efficacy of CR programs in post-bypass patients. In a study by Danker et al, [14] the authors showed the insignificant impact of these programs on post-CABG patients. In another study, there was a considerable improvement in the 6-minute walking test after CR. [15] Some investigators have suggested that CR programs only affect the diastolic function and are ineffective on the systolic function. [16]

Smart et al [17] showed an improvement in the systolic function based on the improvement in the ejection fraction (EF), end-diastolic volumes, and the stroke volume but no effects on diastolic measurements such as the A velocity, the E/A ratio, and the E velocity.

Accordingly, given the importance of CR programs and the MPI as a novel quantitative variable for assessing the effectiveness of such programs on the global cardiac function, we sought to evaluate the effects of 12 sessions of a supervised CR program on the MPI as a marker of both systolic and diastolic improvements in post-CABG patients. We also examined the MPI in terms of diabetes mellitus, hypertension, and different LVEFs. Further, we compared the objectives in the same patient before and after the CR program in order to have the same baseline characteristics in both groups with a view to minimizing confounding factors.

METHODS

In this before-and-after cohort study, we determined the sample size using the Formula For Sample Size For The Mean and enrolled 65 consecutive post-CABG patients hospitalized in our center. The inclusion criterion was any patient with successful CABG who was fit to be discharged from the hospital. Two months after discharge from the hospital, the patients underwent echocardiographic evaluations by 2 different cardiologists. After providing

informed consent, all the patients were referred for the CR program, which consisted of twelve 45-minute sessions of a supervised individualized exercise program by a cardiologist and a sports medicine specialist. The program included treadmill training, bicycle training, and weight training.

After the completion of these 12 sessions, echocardiographic evaluations were repeated by the same cardiologist and the data were analyzed by using the Paired *t*-test and the Wilcoxon signed-ranked test.

The exclusion criteria were the unwillingness of the patient to participate in the program or any condition prohibiting the patient from exercises like musculoskeletal deformities, major acquired disabilities, and very severe LV dysfunction.

With the objective to minimize the inter/intraobserver variability, all the measurements were done by 2 cardiologists and if there was more than a 5% difference, all the data were rechecked by a third cardiologist.

The results were obtained in subgroups based on a history of diabetes mellitus, hypertension, and the EF:

1-severe dysfunction (EF < 30%)
2-moderate dysfunction (EF 30–44%)
3-relatively good function (EF > 45%)

The MPI was measured using septal tissue Doppler imaging, and the electromechanical delay was removed.

The patients participated in the CR program voluntarily, and they completed and signed informed consent. The results were kept confidential throughout the study. The study protocol was approved by our institutional ethics committee. We closely monitored the CR program of each patient to ensure complete training and case-loss prevention.

RESULTS

Our study population was comprised of 76.9% male and 23.1% female patients at a mean age of 61.8 ± 8.8 years. Diabetes was reported in 21.5%, hypertension in 43.1%, and hyperlipidemia in 27.6% of the patients. Among the patients, 1.5% had severe and 9.2% had moderate LV dysfunction, whereas 89.2% had a relatively good LV function. After the completion of the CR program, there were no patients in the severe LV dysfunction group. Additionally, moderate LV dysfunction was reduced to 3.1% of the patients and 96.9% of them were in the relatively good LV function group.

The pre-program LVEF was between 25% and 55%, and the post-program LVEF increased to between 40% and 60%. The mean EF increased from 48% to 50%, which was significant based on the Wilcoxon signed-rank test ($P < 0.001$).

Moreover, the minimum and maximum MPIs were 0.27 and 0.86, respectively, before the program; and after the completion of the program, they dropped to 0.25 and 0.77, correspondingly ($P < 0.001$) (Table 1).

Table 1. Mean MPI and LVEF pre and post rehab program

Variable	pre Rehab	post Rehab	*P* value
Mean MPI	0.55	0.50	<0.001
Mean LVEF	48%	50%	<0.001

MPI, Myocardial performance index; LVEF: Left ventricular ejection fraction

The mean LVEF in 28 patients with hypertension before and after CR was 48.5% and 50.7%, correspondingly, and the difference according to the Wilcoxon signed-rank test was significant ($P < 0.003$). The mean MPI before and after the CR program was 0.55 and 0.52, respectively; this decline according to the paired samples test was significant ($P = 0.01$).

In a comparison between the patients with hypertension and the others, the tests revealed no significant differences as regards a reduction in the mean MPI and an improvement in the LVEF after the CR program ($P = 0.14$).

The mean LVEF in 14 patients with diabetes before and after CR was 50% and 51%, respectively, and the difference according to the Wilcoxon signed-rank test was not significant

(P =0.18). The mean MPI before and after the CR was 0.51 and 0.49, correspondingly; this decline according to the paired samples test was not significant (P = 0.45).

The mean MPI before and after the CR program in the patients with a relatively good LV function decreased from 0.54 to 0.50 (P = 0.03), in those with moderate dysfunction decreased from 0.63 to 0.52 (P < 0.001), and in the only patient with severe dysfunction decreased from 0.62 to 0.60 (Table 2).

Table 2. Mean MPI pre and post program in 3 subgroups

Variable	Severe Dysfunction	Moderate Dysfunction	Relatively Good Function
Mean MPI pre	0.60	0.63	0.54
Mean PMI post	0.62	0.52	0.50

MPI: Myocardial performance index

DISCUSSION

In the current study, we evaluated the effectiveness of a CR program in a group of post-CABG patients and showed that the program successfully improved the LVEF measurements. Our findings are concordant with the findings reported by Smart et al, [17] who showed an improvement in systolic indices like the EF, end-systolic and end-diastolic volumes, and the stroke volume. Unlike the mentioned study, however, we showed an improvement in the MPI measurement, which is a novel quantitative echocardiographic index not related to afterload or preload and also the drug regime background as a confounding factor.

The before-and-after trial design of our study enabled us to compare the objectives in the same patient before and after the CR intervention. We, therefore, had the same baseline characteristics in both groups with a view to minimizing confounding factors.

Overall, we observed a significant reduction in the before-and-after rehabilitation mean value of the MPI.

In our moderately reduced LV function group, the drop in the mean MPI was more pronounced than that in the others.

Interestingly, the CR program successfully improved the MPI and the LVEF significantly in the patients with a history of CABG and hypertension. Nevertheless, the program failed to improve these indices in our patients with diabetes.

CR programs have positive effects by improving mortality, functional capacity, quality of life, lipid levels, smoking, and other conventional risk factors. [17] Be that as it may, despite the obvious benefits of CR programs in patients with cardiovascular diseases, these programs have remained mainly underused. In the United States, Medicare data indicate that CR services are only used by 14% of eligible patients after acute myocardial infarction and 31% of eligible patients following CABG. [18]

These are due to various reasons including insufficient referral from physicians, distance, financial issues, and poor education among patients. Among the risk factors for failure to complete the CR program are advanced age, female gender, and low activity levels before the program. [19]

It is deserving of note that by augmenting the ability of the cardiovascular system to deliver oxygen to muscles and, thus, improving the functional capacity after rehabilitation, more patients may also continue aerobic exercises.

CONCLUSIONS

The results of the present study showed that our 12-week CR program significantly reduced the MPI in patients following CABG. This finding may be associated with better long-term survival.

REFERENCES

1. Serruys PW, Morice MC, Kappetein AP, Colombo A, Holmes DR, Mack MJ, et al. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. The New England journal of medicine. 2009 Mar 5;360(10):961-72.

2. Serruys PW, Morice MC, Kappetein AP, Colombo A, Holmes DR, Mack MJ. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. The New England journal of medicine. Mar 5;360(10):961-72.

3. Gharib M. Rehabilitation in coronary heart disease. Tehran: In 12th Cardio-vascular Congress; 2001.

4. Lie I, Arnesen H, Sandvik L, Hamilton G, Bunch EH. Effects of home based intervention program on anxiety and depression 6 months after coronary artery bypass grafting. J Psychosomatic Res. 2007; 62(4):411-8.

5. Davoud Vand ShM, Elahi N, Ahmadi F, Haghighi Zadeh MH. Effectiveness of the short-term cardiac rehabilitation programs on the rate of disease relapse again refer and rehospitalization in patients with myocardial infarction (Persian). J Rehab. 2008;9.

6. Menezes AR, Lavie CJ, Milani RV, Arena RA, Church TS. Cardiac rehabilitation and exercise therapy in the elderly: Should we invest in the aged? Journal of Geriatric Cardiology : JGC. 2012 10/19/received 12/16/revised 12/23/accepted;9(1):68-75.

7. Stewart KJ, Badenhop D, Brubaker PH, Keteyian SJ, King M. Cardiac rehabilitation following percutaneous revascularization, heart transplant, heart valve surgery, and for chronic heart failure. Chest. 2003 Jun;123(6):2104-11.

8. Smith SC, Jr., Blair SN, Bonow RO, Brass LM, Cerqueira MD, Dracup K, et al. AHA/ACC Scientific Statement: AHA/ACC guidelines for preventing heart attack and death in patients with atherosclerotic cardiovascular disease: 2001 update: A statement for healthcare professionals from the American Heart Association and the American College of Cardiology. Circulation. 2001 Sep 25;104(13):1577-9.

9. Taylor RS, Brown A, Ebrahim S, Jolliffe J, Noorani H, Rees K, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. Am J Med. 2004 May 15;116(10):682-92.

10. Vanhees L, Fagard R, Thijs L, Staessen J, Amery A. Prognostic significance of peak exercise capacity in patients with coronary artery disease. Journal of the American College of Cardiology. 1994 Feb;23(2):358-63.

11. Öcal B, Oğuz D, Karademir S, Birgen D, Yüksek N, Ertem U, et al. Myocardial Performance Index Combining Systolic and Diastolic Myocardial Performance in Doxorubicin-Treated Patients and Its Correlation to Conventional Echo/Doppler Indices. Pediatric Cardiology. 2014 2014//;23(5):522-7.

12. Tei C, Nishimura RA, Seward JB, Tajik AJ. Noninvasive Doppler-derived myocardial performance index: Correlation with simultaneous measurements of cardiac catheterization measurements. Journal of the American Society of Echocardiography.10(2):169-78.

13. Abd El Rahman MY, Abdul-Khaliq H, Vogel M, Alexi-Meskischvili V, Gutberlet M, Hetzer R, et al. Value of the new Doppler-derived myocardial performance index for the evaluation of right and left ventricular function following repair of tetralogy of fallot. Pediatr Cardiol. 2002 Sep-Oct;23(5):502-7.

14. Dankner R, Geulayov G, Ziv A, Novikov I, Goldbourt U, Drory Y. The effect of an educational intervention on coronary artery bypass graft surgery patients' participation rate in cardiac rehabilitation programs: a controlled health care trial. BMC Cardiovasc Disord. 2011;11:60.

15. Fiorina C, Vizzardi E, Lorusso R, Maggio M, De Cicco G, Nodari S, et al. The 6-min walking test early after cardiac surgery. Reference values and the effects of rehabilitation programme. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery. 2007 Nov;32(5):724-9.

16. Yu CM, Li LS, Lam MF, Siu DC, Miu RK, Lau CP. Effect of a cardiac rehabilitation program on left ventricular diastolic function and its relationship to exercise capacity in patients with coronary heart disease: experience from a randomized, controlled study. Am Heart J. 2004 May;147(5):e24.

17. Smart N, Haluska B, Jeffriess L, Marwick TH. Exercise training in systolic and diastolic dysfunction: effects on cardiac function, functional capacity, and quality of life. Am Heart J. 2007 Apr;153(4):530-6.

18. Suaya JA, Shepard DS, Normand SL, Ades PA, Prottas J, Stason WB. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation. 2007 Oct 9;116(15):1653-62.

19. Daly J, Sindone AP, Thompson DR, Hancock K, Chang E, Davidson P. Barriers to participation in and adherence to cardiac rehabilitation programs: a critical literature review. Progress in cardiovascular nursing. 2002 Winter;17(1):8-17.