Evaluation of the Pulse Pressure Index at the Peak of Exercise Before and After Cardiac Rehabilitation

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Abstract

Introduction: As a new supplementary therapeutic option, cardiac rehabilitation (CR) is getting more attention every day. Several studies have proved its positive impact on qualitative criteria; but few studies have been done on quantitative criteria. The purpose of the present study is to evaluate the impact of CR on non-invasive measurement of maximum cardiac output by Pulse Pressure index (PPI) at the peak of exercise.

Methods: This is a non-randomized prospective cohort study conducted in Hamadan, Iran in 2015. One hundred eligible patients who had undergone coronary artery bypass surgery participated in our study, after obtaining cardiologist permission and informed consent. The PPI was measured at the peak of exercise before and after standard CR program.

Results: Mean PPI was not significantly different before and after CR. PPI was significantly increased in patients younger than 60 years old (P = 0.022). In contrast to hypertensive patients, PPI increased significantly after CR in non-hypertensive patients (P = 0.002). PPI was significantly increased in non-diabetic patients after CR (P = 0.046), but not in diabetic individuals. Other variables did not show any statistically significant effect on PPI in response to CR.

Conclusions: Findings from our study revealed that PPI is associated with vascular atherosclerosis, as well as cardiac output; Positive effects of CR diminish in older, diabetic and hypertensive patients with more progressive atherosclerosis.

INTRODUCTION

Cardiovascular events, particularly coronary artery diseases (CAD), are the most common cause of death worldwide [1]; accounting for almost half of the deaths in industrialized countries and 25 percent in developing ones. These staggering numbers are due to the disease called coronary arteries atherosclerosis which results in impaired myocardial blood supply and subsequent ischemia and infarction [2]. The most important risk factors are male gender, age, positive family history of CAD, smoking, immobility and obesity, hypertension (HTN), hyperlipidemia (HLP), diabetes mellitus (DM), and metabolic syndrome [3]. In general, therapeutic options consist of life style modification, medical therapy and revascularization methods including percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG).

Cardiac rehabilitation (CR) is a medically supervised program which helps improve patients' health and speed up their physical and psychological recovery from acute cardiovascular events or coronary artery bypass graft [4-7]. CR Programs usually involve patient assessment including medical history (evaluation of comorbidities, risk factors, and medications); physical examination; nutritional counseling and weight management; smoking cessation; psychological management of anger, anxiety and depression; physical activity counseling and exercise training. One of the primary steps before participation in CR is exercise tolerance test (ETT), so that the individuals' exercise recommendations will be designed based on the findings of the test, which results in best specification of duration and severity of physical activity [8]. Pulse pressure index (PPI) is an indirect indicator of cardiac output and a good predictor for cardiovascular complications. It is defined as the pulse pressure (systolic blood pressure – diastolic blood pressure) divided by systolic blood pressure (SBP) [9]. Since cardiovascular events are increas

ing quickly among human societies resulting in major disabilities, and on the other hand CR programs improves life quality and reduces complications of surgery, and also the point that most surveys have studied the effects of CR on life quality, it is necessary to study the effects of CR on myocardial function by evaluation cardiac function index. The goal of this study is a comparison between PPI before and after 12 sessions of CR in patients undergoing CABG.

METHODS

This is a non-randomized prospective cohort study (before and after study) conducted in Hamadan, Iran in 2015. The study protocol was approved by the institutional ethic committee of Hamadan University of Medical Sciences. After signing the informed consent forms and obtaining cardiologist permission, 100 eligible patients entered the study. Exclusion criteria were unwillingness of the patient to participate in the program or any condition prohibiting the patient from exercise, i.e. musculoskeletal deformities, major acquired disabilities and severe left ventricle (LV) dysfunction. Before and after participation in 12 sessions of CR with standard protocol, patients underwent ETT with standard Bruce protocol. PPI was calculated at the peak of exercise for each patient before initiation and also at the end of CR program. For all participants, blood pressure and index measurements were performed by the same health professional and one specified standardized device. All patient were treated by standard medical and nutritional protocol and medications were continued before ETTs. For each patient, a questionnaire of needed information (our variables) was filled either

by direct questioning or data extraction from their medical records. Data gathered from the questionnaires were analyzed by SPSS version 16 software. Statistical analysis was performed using Paired t-test and signed-rank test. P value < 0.05 was considered significant.

RESULTS

One hundred patients enrolled in this study including 63 (63%) men and 37 (37%) women. Mean age of participants was 60 ± 5 years with minimum age of 44 years old and maximum age of 80 years old. Patients' demographics are summarized in Table 1.

Table 1: Patient Characteristics

Characteristics	N = 100
Age (years)	60 ± 5
Female	37 (37%)
Diabetes mellitus	36 (36%)
Hypertension	50 (50%)
hyperlipidemia	50 (50%)
Smoker	33 (33%)
Left ventricular function	
EF >= 45%	84 (84%)
30% < EF < 45%	16 (16%)
EF <= 30%	0 (0%)

Data in table are presented as No. (%) or Mean ± SD
Abbreviations: EF, ejection fraction

Table 2: The Comparison of Pulse Pressure Index before and after Cardiac Rehabilitation

PPI changes in different groups	Number	PPI before CR	PPI after CR	Mean Difference	P value
Gender					
Male	63	0.34 ± 0.04	0.35 ± 0.04	0.007 ± 0.05	0.22
Female	37	0.36 ± 0.05	0.37 ± 0.05	0.011 ± 0.06	0.02
Age					
< 60 years	48	0.33 ± 0.04	0.36 ± 0.04	0.01 ± 05	0.022
>= 60 years	52	0.35 ± 0.01	0.35 ± 0.04	0.002 ± 06	0.52
DM					
Yes	36	0.37 ± 0.04	0.37 ± 0.05	0.005 ± 0.05	0.60
No	64	0.34 ± 0.04	0.35 ± 0.04	0.01 ± 0.05	0.046
DLP					
Yes	50	0.36 ± 0.04	0.36 ± 0.05	0.001 ± 0.06	0.24
No	50	0.34 ± 0.04	0.35 ± 0.04	0.008 ± 0.05	0.091
HTN					
Yes	50	0.36 ± 0.04	0.36 ± 0.04	0.001 ± 0.06	0.92
No	50	0.33 ± 0.04	0.35 ± 0.04	0.01 ± 0.05	0.002
Smoker					
Yes	33	0.33 ± 0.04	0.34 ± 0.04	0.01 ± 0.05	0.10
NO	67	0.35 ± 0.04	0.36 ± 0.05	0.01 ± 0.06	0.18
LV function					
Moderate LV dysfunction	16	0.34 ± 0.02	0.35 ± 0.04	0.01 ± 0.04	0.25
Relatively normal LV function	84	0.35 ± 0.04	0.36 ± 0.04	0.01 ± 0.06	0.21

Data in table are presented as No. (%) or Mean ± SD
Abbreviations: PPI, Pulse Pressure index; EF, ejection fraction; DM, diabetes mellitus; DLP, dyslipidemia; HTN, hypertension; LV, left ventricle; CR, cardiac rehabilitation

The minimum and maximum of measured peak SBP before CR, was 90 and 155 mmHg respectively. The mean of peak SBP was 121.95 ± 14.21 mmHg. The minimum and maximum of measured SBP after CR, was 100 mmHg and 150 mmHg respectively with mean of 121.55 ± 11.84 mmHg. Mean of SBP did not significantly change after CR (P = 0.76). The minimum of measured DBP before CR was 60 mmHg and the maximum was 90 mmHg with mean of 78.55 ± 7.18 mmHg. The minimum of measured DBP after CR was 60 mmHg and maximum was 90 mmHg. The mean DBP was 77.35 ± 7.08 mmHg. Mean of DBP was not significantly different before and after CR (P = 0.12) Minimum of PPI before CR was 0.33 and maximum of it was 0.83 with mean of 0.35 ± 0.046. After CR, minimum of PPI was 0.27 and maximum was 0.53 with mean of 0.36 ± 0.048. Mean of PPI was not significantly different before and after CR (P = 0.12). PPI changes were studied separately in different groups (Table 2): PPI did not significantly increase before and after CR, neither in males nor in females. PPI in patients younger than 60 years old significantly increased after CR (P = 0.022). But CR in patients older than this age didn't have any significant effect on PPI. PPI among diabetic patients was not significantly different before and after CR (P = 0.060); however, it increased in non-diabetic individuals (P = 0.046). PPI was not statistically different before and after CR neither in patients with HLP nor in patients with normal lipid profile. PPI among hypertensive patients was not significantly different before and after CR; however, it increased in non-hypertensive individuals after CR (P = 0.002). CR had no significant effect on PPI in smokers and non-smoker patients. According to LV dysfunction degree, PPI in patients did not change after CR.

DISCUSSION

We studied 100 patients, including 63 males and 37 females. In overall, we did not find out any significant difference between mean of PPI before and after CR. Based on world health organization (WHO) reports, more than 17 million people lose their lives because of the cardiovascular events annually and CVD is proposed as the most important disease and the main cause of death by year 2020 due to high mortality and disability rate and also its imposed economic burden [10]. PPI is an indirect quantitative predictor of cardiac output and is defined as the pulse pressure divided by SBP [11]. On the other hand, one of the best measures to increase CABG effectiveness is CR. The goal of this study was to evaluate the effect of CR on PPI in patients undergoing CABG. In Mc Kee et al survey in 2007, the incidence of CVD in adults had increased after third decade of life and the maximum was between age of 45 to 75 years old [12]. In the present study, peak SBP was not significantly affected by CR. Fang cui et al in 2012 studied the effect of CR on exercise tolerance after PCI and demonstrated that peak SBP was not different before and after CR [13]. In a survey done by Siavashi et al in 2012, the effect of CR on hemodynamic status after CABG were evaluated, SBP of patients after CR was not significantly different in comparison with the control group [14]. These results are accordant with findings from the present study.

In our study, the DBP was not significantly different before and after CR, like the results reported by Ghalamghash et al study in 2008 and Siavashi et al study in 2012 [14]. In contrast, in the survey done by Steki et al in 2011, two-months-long CR significantly improved functional capacity and some hemodynamic responses such as resting and maximum systolic and diastolic blood pressure, resting and maximum heart rate, ejection fraction, and rate pressure product in post CABG patients [15]. In our study, 12 sessions of CR did not affect the PPI. Cai et al in 2015 showed that PPI have a significant relationship with intima-media carotid thickness in adults and thus it is a valuable parameter for primary screening of patients with atherosclerosis risk [16]. We can conclude that PPI is associated with vascular atherosclerosis, as well as cardiac output; as a result it's expected that PPI cannot completely show the effect of CR on cardiac function alone; and more accurate indicators of cardiac output like angiographic calculations or **cardiac output** measurements by the **Fick** method that effects on cardiac function are needed, but because of their risks and invasive nature of the procedures, they are not routinely performed for this purpose. In our study, PPI was significantly increased in patients younger than 60 years old. Since aging results in cardiac fibrosis and increased myocardium scar tissue, cardiac reserve is reduced even after CABG and CR. So positive effects of CR are more pronounced in younger patients [17].

In non-hypertensive patients, PPI is increased significantly after CR, in contrast to hypertensive patients. Since HTN has known effects on myocardium by LV hypertrophy, rate of increased cardiac reserve during exercise in hypertensive patients is less than non-hypertensive ones [18]. PPI is significantly increased in non-diabetic patients after CR, but not in diabetic individuals. Verges et al in 2004 reported that exercise compliance of type 2 diabetic patients after an ischemic event, is significantly lower and blood glucose level influences on response to CR in diabetic patients[19]. In our study, gender, HLP, smoking and LV dysfunction severity had not any significant effect on PPI in response to CR.

CONCLUSIONS

The goal of present study was to compare PPI before and after CR in post CABG patients. Although the results showed that PPI didn't have any significant increase after 12 sessions of CR; However, Positive effects of CR diminish in older, diabetic and hypertensive patients with more progressive atherosclerosis.

AUTHORS' CONTRIBUTION

Data collection: Kazemi, Olfat; Data analysis and interpretation: Esna-Ashari; Drafting the article:Yazdi; Critical revision of the article:Yazdi, Najmafshar; Final approval of the version to be published:Yazdi, Najmafshar

CONFLICTS OF INTERESTS

There is no conflict of interest.

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