

Outcome of Cardiac Rehabilitation Following Off-Pump Versus On-Pump Coronary Bypass Surgery

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Abstract

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BACKGROUND: A few studies have compared the cardiac rehabilitation (CR) outcome between those who undergo conventional on-pump bypass surgery and off-pump surgery. We compared this outcome among the patients differentiated by the On-pump and off-pump surgical procedures about cardiovascular variables and psychological status.

METHODS: This longitudinal study recruited 318 and 102 consecutive patients who had undergone CABG (on-pump surgery, n = 318 and off-pump surgery, n = 102) and been referred to the CR clinic.

RESULTS: The off-pump surgery patients had more improvement in their metabolic equivalents (METs) value. The physical and mental components of health-related quality of life (QOL) (based on SF-36 questionnaire) as well as depression-anxiety (based on Costello-Comrey Depression and Anxiety Scale) were notably improved in the two study groups after the CR program, while changes in the QOL components scores and also depression-anxiety score were not different between the off-pump and on-pump techniques.

CONCLUSIONS: Regarding QOL and psychological status, there were no differences in the CR outcome between those who underwent off-pump bypass surgery and those who underwent on-pump surgery; nevertheless, the off-pump technique was superior to the on-pump method on METs improvement following CR.

Introduction

Recent trials have shown that the two techniques of off-pump and on-pump coronary artery bypass grafting (CABG) may lead to different mortality and morbidity, especially in high-risk patient populations [1]. Different rates of morbidity in these two techniques have been observed in post-operative cognitive impairment, the incidence of renal failure, blood loss, prolonged mechanical ventilation, and length of stay in hospital and intensive care unit [2-5]. Most previous studies have confirmed that off-pump CABG is a safe and viable alternative to conventional CABG as a treatment modality for surgical coronary revascularization [6-9]. However, the use of more blood products in the on-pump technique and the need to contend with heart motion during off-pump surgery are known to be considerable. Some other studies have demonstrated that off-pump surgery

reduces peri-operative morbidity, but it has yet to be fully determined whether or not the outcome of off-pump surgery is similar to that of the on-pump technique [10].

Irrespective of the use of off-pump or on-pump surgery, cardiac rehabilitation (CR) as an important supportive approach following cardiac revascularization can improve exercise capacity [11], modify risk factors [12, 13], reduce mortality and morbidity rates [14], and enhance quality of life (QOL) and psychology status [15]. For all the studies in the existing literature comparing the advantages and complications of the two CABG techniques, there is still a paucity of data on the comparison of the CR outcomes between those who undergo conventional on-pump bypass surgery or off-pump surgery. A recent study by Aron et al. could show no differences in outcomes between these two patient groups after the CR program [14]. Nonetheless, the researchers

mainly focused on cardiovascular parameters and the QOL components, which mean that more studies are required to delve into CR effects on psychological aspects such as depression and anxiety status.

The goal of the present study was to compare CR outcomes between patients differentiated by the On-pump and off-pump surgical procedures about cardiovascular variables as well as psychological status.

Methods

Study population: This longitudinal study recruited 640 consecutive patients who had undergone CABG and been referred to the CR clinic at Tehran Heart between August 2008 and February 2009 to participate in 20 to 24 sessions of an exercise-based CR program. Among these participants, those who were referred following isolated coronary bypass surgery for the first time and an off-pump or on-pump procedure was deemed technically feasible for them were considered eligible. Exclusion criteria included emergency or concomitant major surgeries, Q-wave myocardial infarction in the preceding six weeks, left ventricular dysfunction, clinically significant valve disease, and inability to provide consent. Finally, 420 patients who met the inclusion criteria (318 patients in the on-pump group and 102 patients in the off-pump group) were included into the study. The study was carried out according to the principles of the Declaration of Helsinki. The study protocol was approved by the Ethics Committee of Tehran Heart Center and informed written consent was obtained from all the patients.

Study data: Key variables were baseline characteristics, coronary artery disease risk factors, function class (evaluated by the New York Heart Association (NYHA) classification), risk stratification of high-, intermediate-, and low-risk groups according to the American Association of Cardiovascular and Pulmonary Rehabilitation risk stratification criteria ("Outpatient Cardiac Rehabilitation and Secondary Prevention," 1999), left ventricular ejection fraction according to the echocardiography report, aerobic capacity and stress test results, oral medications, health-related quality of life (QOL) scores (based on SF-36 questionnaire [15], and depression-anxiety scores (based on Costello-Comrey Depression and Anxiety Scale [16]).

Self-reported data were collected using a self-administered questionnaire via an interview on the day of admission to the CR clinic; baseline characteristics and medical history were collected by trained staff; data on clinical situation, risk stratification, and medication were completed by a rehabilitator physician; echocardiographic information

was collected by a cardiologist; and psychological and lifestyle indices were collected by a clinical psychologist.

CR protocol: The complete CR program was three 20-25 minute periods of cardiovascular exercise on a treadmill per week for eight weeks (total of 24 sessions). There was a 20-minute period of stretching and callisthenics for warm-up, and the session finished with 20 minutes of stretching and callisthenics for cool-down; the total duration of each session was approximately 1 hour. All the patients received psychological counselling regarding coping strategies to accept and live with their cardiac incident. Furthermore, nutritional counselling and individualised diet plan were also provided to establish a diet goal.

Study end points: The main end points of the current study were improvement in the cardiovascular variables (resting and post-exercise systolic blood pressure, peak heart rate, heart rate recovery, peak oxygen consumption, and metabolic equivalents [METs]), QOL scores (physical and psychological components summary scores and total SF-36 score), and depression-anxiety score in the two study groups.

Statistical analysis: Data are presented as the mean \pm standard deviation (SD) for the quantitative variables and summarised by absolute frequencies and percentages for the categorical variables. The continuous variables across the two groups were compared using the t-test or non-parametric Mann-Whitney test whenever the data did not appear to have normal distribution or when the assumption of equal variances was violated. Within-group changes between baseline and final session were tested with a paired t-test.

To compare the differences in the improvement of outcome between the case and control groups, analysis of covariance (ANCOVA) was used on the cardiac parameters adjusted for potential cofounders, including demographic characteristics, function class, risk stratification, ejection fraction, and general risk factors for coronary artery disease. All the analyses were performed using SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL). Statistical significance level was set at P value < 0.05, and all the P values are two-sided.

Results

The baseline characteristics are shown in Table 1. The On-pump and off-pump surgery groups were similar with regards to age, body mass index, function class, risk stratification, left ventricular ejection fraction, and the overall prevalence of general coronary artery disease risk factors. However, the male to female ratio was higher in the on-pump group

(4.9 vs. 2.3). No significant differences were found in baseline medications between the two groups (Table 2).

Table 1: Demographic characteristics and medical data of study patients

	On-pump group (n = 318)	Off-pump group (n = 102)	P value
Male gender	264 (83.1)	71 (69.6)	0.003
Age (year)	61.06 ± 9.17	60.28 ± 10.34	0.498
Body mass index (kg/m ²)	26.82 ± 3.74	27.10 ± 4.31	0.569
Left ventricular ejection fraction	48.10 ± 8.32	48.79 ± 8.05	0.687
Function class			0.995
I	2358 (81.1)	83 (81.4)	
II	51 (16.0)	16 (15.7)	
III	9 (2.8)	3 (2.9)	
Risk stratification			0.648
Mild	217 (68.2)	74 (72.5)	
Moderate	73 (23.0)	19 (18.6)	
Severe	28 (8.8)	9 (8.8)	
Medical history			
Cigarette smoking	98 (30.8)	20 (28.2)	0.661
Opium use	15 (4.7)	4 (5.6)	0.746
Diabetes mellitus	96 (30.2)	26 (36.6)	0.291
Hyperlipidemia	171 (53.8)	40 (56.3)	0.695
Hypertension	146 (45.9)	33 (46.5)	0.931
CAD Family history	128 (40.4)	35 (49.3)	0.169
Renal failure	5 (1.6)	0 (0)	-

Data are presented as mean ± SD or number (%).

There were no differences in all the measured stress test parameters at baseline as well as at the end of the CR sessions between the participants, who underwent either on-pump or off-pump surgeries (Table 3).

Table 2: Baseline oral medications in study patients

Characteristics	On-pump group (n = 318)	Off-pump group (n = 102)	P value
Beta-blocker	294 (92.5)	94 (92.2)	0.922
Calcium-blocker	40 (12.6)	20 (19.6)	0.078
ACE-inhibitor	90 (28.3)	34 (33.3)	0.332
Diuretic	55 (17.3)	18 (17.6)	0.935
Anti-hyperlipidemia	279 (87.7)	93 (91.2)	0.342
Anti-hyperglycemia	62 (19.5)	23 (22.5)	0.504
Nitrates	222 (69.8)	63 (61.8)	0.130

Data are presented as mean ± SD or number (%).

Regarding changes in the cardiovascular parameters, improvement in post-exercise systolic blood pressure was found in both study groups. Nevertheless, improvement in METs value was significantly observed in both groups, and peak O₂ consumption was significantly changed only in the off-pump group (Table 3). ANCOVA analysis showed more positive changes in METs value in the patients who underwent off-pump surgery (P-value = 0.001).

Table 4 shows that the physical and mental summary scores of QOL were notably increased in the two study groups after the CR program. On the changes in the depression-anxiety score, the score was only reduced in those who underwent on-pump surgery, whereas changes in the depression-anxiety score in the off-pump group were not significant.

However, using ANCOVA analysis, changes in the QOL component score and also depression-anxiety score were not different between the off-pump and on-pump techniques.

Table 3: Changes of cardiac parameters following cardiac rehabilitation in on-pump and off-pump surgery groups

Variable	On-pump group (n = 318)	Off-pump group (n = 102)	P-value	ANCOVA, P value
METs value				0.001
Before CR	7.52 ± 2.66	7.88 ± 3.77	0.384	
After CR	8.15 ± 3.68	10.93 ± 3.00	0.054	
P value	< 0.001	0.048		
Maximum Heart Rate				0.713
Before CR	127.41 ± 19.30	135.63 ± 20.65	0.578	
After CR	124.57 ± 26.43	125.97 ± 22.84	0.252	
P value	0.463	0.356		
Heart Rate Recovery				0.839
Before CR	112.58 ± 19.33	113.50 ± 15.30	0.158	
After CR	111.37 ± 24.45	109.07 ± 21.53	0.782	
P value	0.072	0.819		
Maximum Blood Pressure				0.496
Before CR	136.90 ± 20.00	139.68 ± 16.32	0.496	
After CR	135.43 ± 21.78	133.80 ± 19.82	0.706	
P value	0.017	0.034		
Resting Blood Pressure				0.173
Before CR	118.13 ± 117.35	120.22 ± 17.59	0.319	
After CR	117.35 ± 16.30	116.19 ± 21.45	0.893	
P value	0.136	0.578		
Peak O ₂ consumption				0.612
Before CR	29.91 ± 34.38	26.70 ± 8.86	0.141	
After CR	43.52 ± 71.38	38.24 ± 10.52	0.745	
P value	0.231	0.003		

Data are presented as mean ± SD.

Discussion

Advances in the technical aspects of cardiac surgery allow on-pump CABG to be performed with considerable low mortality and with excellent outcome so that the on-pump technique is still the most widely used CABG procedure.

Table 4: Changes in quality of life and psychological scores following cardiac rehabilitation in On-pump and off-pump surgery groups

Variable	On-pump group (n = 318)	Off-pump group (n = 102)	P value	ANCOVA, P value
Physical Summary Score				0.461
Before CR	34.78 ± 13.44	43.40 ± 14.90	< 0.001	
After CR	49.41 ± 17.47	48.52 ± 18.00	0.044	
P value	< 0.001	0.042		
Mental Summary Score				0.735
Before CR	38.25 ± 38.96	43.69 ± 13.75		
After CR	50.94 ± 18.34	52.03 ± 18.89	0.035	
P value	< 0.001	0.001	0.045	
Total SF-36 Score				0.946
Before CR	36.29 ± 25.78	42.61 ± 13.65	0.001	
After CR	49.49 ± 17.68	49.74 ± 18.34	0.081	
P value	< 0.001	0.003		
Depression-Anxiety Score				0.245
Before CR	80.89 ± 13.52	71.92 ± 13.81	< 0.001	
After CR	70.69 ± 13.69	69.25 ± 14.08	0.233	
P value	< 0.001	0.310		

Data are presented as mean ± SD.

On the other hand, off-pump surgery as a newer technique is believed to have lower complications. Regarding the short- and long-term outcomes of these two techniques, most recent studies have confirmed low mortality rates (1-2%) as well as equal effectiveness [17], although it seems that off-pump surgery is more cost-effective than on-

pump CABG [7], and is hence more desirable for patients. In spite of the fact that the early and late outcomes of the two study procedures have been widely compared, changes in the patient's status after these procedures and following complete CR sessions have not been clearly determined. The current study was conducted to evaluate the beneficial effects of CR on physical capacity and psychological status in the On-pump and off-pump techniques.

First and foremost among the findings of the present study was the superiority of the off-pump technique in enhancing METs as an important indicator of metabolic maintenance after participation in the CR program. In our study, not only were the pre- and post- CR METs values in the off-pump surgery group higher than those in the on-pump surgery group but also the positive changes of this index appeared more frequently in the former group. It has been demonstrated that off-pump surgery confers better post-operative renal function, less incidence of metabolic acidosis and oxidative stress, reduced myocardial injury, and lower activation of the inflammatory mediators than cardiopulmonary bypass. In fact, off-pump surgery leads to considerably lower metabolic disturbances than on-pump CABG [21]. Some studies have revealed that patients undergoing on-pump surgery tend to develop peripheral hypo perfusion and hypoxia. Also, higher values of some basic metabolisms and tissue perfusion markers such as glucose, lactate, pyruvate, and glycerol in the skeletal muscle have been demonstrated during the period of cardiopulmonary bypass [22]. Changes in tissue metabolic activity may influence post-operative clinical outcomes. Therefore, because the metabolic needs of different vital organs and muscle tissue can be higher in the on-pump rather than the off-pump technique, patients in the off-pump group could metabolically benefit from the exercise-based CR more than the on-pump group.

To our knowledge, this is the first study of its kind to focus on CABG patients' psychological status following the CR program. Study on psychological changes following CR after Off-pump versus on-pump CABG in the current study showed no differences in the depression and anxiety score between the two techniques, although the off-pump group experienced lower depression and anxiety status following their CR sessions. Some studies conducted during the 1990s pointed to a decline in psychological functioning after on-pump CABG [23], but recent studies incorporating pre-operative-versus-post-operative neuropsychological comparisons have not reinforced that suggestion [24]. The Shroyer et al. study confirmed that off-pump CABG offered no advantage over the on-pump procedure on neuropsychological aspects [24]. It seems that both groups of patients similarly benefited from the CR program regarding psychological improvement.

In our study, although the baseline scores of QOL were significantly lower in the on-pump surgical

technique, both groups experienced similar improvement in physical and psychological scores following the CR program adjusted for baseline characteristics. Recent studies have demonstrated no clinically relevant difference in early post-operative QOL between the two groups [25, 26]. It seems that the patients in both techniques similarly benefited from the CR sessions regarding QOL and psychological aspects. The CR program is, therefore, a safe protocol for improving patients' QOL and reducing psychological stress following different techniques of cardiac surgery.

The authors recommend to other researchers to test the validity of the results of this study in a study with bigger sample size and more intervention parameters.

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Authors Contribution

Reza Arefizadeh contributed in writing and drafting the manuscript. Seyed Yaser Hariri contributed in statistical processes and also editing the manuscript. Adel Johari Moghadam was responsible for writing, editing, submitting and revising the manuscript.

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