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Original Article

On-Pump versus Off-Pump Coronary Artery Bypass Grafting in The Surgical Management of High-Risk Patients, A Clinical Randomized Study

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Abstract

Background: Surgical treatment modalities of coronary artery diseases (CAD) include on-pump or off-pump coronary artery bypass grafting (CABG). CABG performed on the beating heart can avoid complications that might occur on cardiopulmonary bypass. Our objective was to compare the effectiveness of on-pump versus off-pump CABG in high-risk patients stratified according to the EuroSCORE scoring system.

Methods: This randomized clinical study included 80 high-risk patients who underwent CABG and assigned into two groups; each contains 40 patients. Patients with valvular affection, ischemic ventricular septal defect or left ventricle and aortic aneurysms, and/or those exhibiting significant neurological pathology were excluded from the study. Study outcomes were blood loss, length of ICU and hospital stay, inotropic use, re-exploration rate, and operative mortality.

Results: The study showed significant higher use of inotropic drugs intra and post-operatively (57.5% vs 40%, p = 0.021), more low cardiac output (12.5% vs 2.5%, p = 0.031), lower blood loss (337±67 vs 498±68 ml, p = 0.01), lower blood transfusion (1.1±0.2 vs 1.2±0.4 unit, p = 0.024), more prolonged ICU stay (4.0±1.6 vs 3.0±0.9 day, p = 0.001) and the higher re-exploration rate (17.5% vs 7.5%, p = 0.035) in the on-pump group. Hospital stay (8.7±2 vs 8.1±1, p = 0.121) and early mortality (7.5% vs 2.5%, p = 0.451) did not differ significantly between the two groups.

Conclusion: Management of coronary artery disease is still challenging, and there is still a place for off-pump CABG in CAD in high-risk patients due to its advantages in the early complications while has the same total hospital stay when compared with on-pump CABG.

KEYWORDS

On-pump CABG; Off-pump CABG; Coronary artery disease

Article History

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Introduction

Coronary artery bypass grafts surgery (CABG) can be performed either with cardiopulmonary bypass (CPB), which exposes the blood to a non-physiological environment [1], or on beating heart with or without CPB support. One of the most challenging aspects of CABG is the management of high-risk patients to achieve acceptable morbidity, mortality, and quality of life [2].

Off-pump CABG avoids the potential pump complications, including humoral and cellular

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inflammatory responses of CPB, embolic accidents, metabolic, endocrine and electrolyte changes, lung injury, renal failure, the effect on viscera and liver and neurologic system [3, 4].

Favorable short-term and long-term survival after CABG continue to be reported despite a subset of increasingly high-risk patients undergoing cardiovascular surgical procedures [5]. Some complications of CABG are thought to be related to cardiopulmonary bypass; consequently, interest has been raised in off-pump CABG, especially in high-risk patients [6, 7].

There are many scoring systems that developed aiming to assess the high-risk patient's morbidity and mortality; EuroSCORE is a prognostic scoring system developed in Europe for patients undergoing cardiac surgery [8]. EuroSCORE was published as an additive system in which each risk factor is given a number of points, which, when added, provide an estimate of the predicted operative mortality for a patient undergoing CABG. In EuroSCORE the patients are divided into low-risk patients (0-2), moderate-risk patients (3-5), and high-risk patients (6 and above) [9]. Our objective was to compare the effectiveness of On-pump versus Off-pump CABG in high-risk patients stratified according to the EuroSCORE scoring system.

Patients and Methods:

Design:

This prospective randomized study included 80 high-risk patients, "according to EuroSCORE" who underwent CABG. The patients were classified into two groups: Group I: 40 patients who underwent on-pump CABG; and Group II: 40 patients who underwent off-pump CABG. Stratified randomization method was utilized, patients were stratified according to age, gender, and EuroSCORE then assigned to one of the groups in a random way. Ethical Committee has approved the study, and patients' consent was taken before enrollment.

Patients with acute mitral regurge, ischemic ventricular septal defect or left ventricular aneurysm, aortic aneurysms, valvular disease, and/or patients exhibiting significant neurological pathology were excluded from this study.

Data collection:

Preoperatively, patients were assessed by complete history taking and comprehensive clinical examination. Preoperative investigations included cardiac catheterization, ECG, chest X-ray, echocardiography, routine preoperative laboratory tests.

Operative data recorded included the number of distal anastomosis, types of grafts used, intra-aortic balloon pump (IABP), the need for inotropic support, and low cardiac output (COP) syndrome during weaning.

Study outcomes:

Study endpoints included hospital mortality, intensive care unit (ICU) stay, total blood loss, the need for blood transfusion, the re-exploration rate and its causes, complications, the need for inotropic drugs, hospital stay, and the outcomes after one month of follow-up.

Statistical Analysis

Continuous data were presented as mean ± standard deviation and were compared using the t-test. Categorical data were presented as numbers and percentages and were compared using Chi-square and Fisher tests. Data were analyzed using IBM SPSS software package version 20.0 (Belmont, Calf, 2013). A p-value ?0.05 was considered statistically significant.

Results

Patient demographics

There was no difference in age and sex between both groups (p= 0.638 and 0.942, respectively). The EuroSCORE of group I ranged between 6-11 with a mean value of 7.13±1.95 while in group II it ranged between 6-11 with a mean value of 6.93±1.83 and the statistical analysis revealed that there was no statistically significant difference between both groups. (P = 0.637) (Table 1).

Intraoperative data

There was no statistically significant difference between both groups regarding the number of distant anastomoses (P = 0.648). The use of the

Table 1: Preoperative patients' data. (Continuous variables are presented as range, mean and standard deviation, categorical variables are presented as number and percent)

Variable	Group I (n=40)	Group II (n=40)	P
Age			
• Range	49-65	50-72	0.638
• Mean±S.D	60.05±5.5	59.5±5.4	
Sex			
• Male	27 (67.5%)	14 (35%)	0.942
• Female	13 (32.5%)	26 (65%)	
• Male/Female ratio	2.1:1	1.9:1	
EuroSCORE			
• Range	6-10	6-10	0.637
• Mean±S.D	7.13±1.95	6.93±1.83	

saphenous vein was more in group II. (Table 2). Low cardiac output syndrome occurred more in group I (p= 0.031), and more patients required inotropic support (p= 0.021). Operative data are presented in Table 2.

Postoperative data

Patients in group I had a more prolonged ICU stay (P = 0.001) and had more exploration than group II (P = 0.035). Postoperative data are summarized in Table 3.

Discussion

Coronary artery disease (CAD) can be treated with medical therapy, percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). Despite substantial improvements in surgical strategies, cardiac surgery is associated with severe complications. Several approaches have been implemented to reduce the risk during surgery (hypothermia, cardioplegic solutions, and the limitation of procedure times). These strategies have led to a pronounced reduction in mortality and morbidity; however, biomarkers of ischemia indicate persisting postoperative myocardial damage [10,11].

The choice of optimal revascularization techniques for complex coronary artery disease (CAD) has been a matter of debate for the last two decades [12]. The most widely performed surgical coronary revascularization technique remains the left internal mammary artery (LIMA) to the left anterior descending (LAD) artery and reversed long saphenous vein to other arteries, performed using cardiopulmonary bypass on an arrested heart [13].

Table 2: Operative data (Continuous variables are presented as range, mean and standard deviation, categorical variables are presented as number and percent)

	Group I (n=40)	Group II (n=40)	P
Internal mammary artery	6 (15%)	4 (10%)	0.222
Internal mammary + vein	34 (85%)	21 (52.5%)	0.031
Vein	0	15 (37.5%)	0.01
Number of distant anastomosis			
Range	2-5	1-3	0.648
Mean±S.D	3±0.72	2±0.67	
Intraoperative inotropes	23 (57.5%)	16 (40%)	0.021
IABP	4 (10%)	3 (7.5%)	0.584
Low cardiac output syndrome	5 (12.5%)	1 (2.5%)	0.031
Intraoperative blood loss (ml)			
Range	220-500	350-650	0.01
Mean±S.D	337±67.9	498.3±68.8	
Blood units needed			
Range	1-2	1-2	0.024
Mean±S.D	1.05±0.22	1.23±0.42	

Table 3: Postoperative data. (Continuous variables are presented as range, mean and standard deviation, categorical variables are presented as number and percent)

Variable	Group I (n=40)	Group II (n=40)	P
Re-exploration	7 (17.5%)	3 (7.5%)	0.035
Postoperative inotropes	30 (75%)	21 (52.5%)	0.023
ICU stay (days)			
Range	1-7	1-5	0.001
Mean±S.D	3.98±1.6	3.03±0.86	
Surgical site infection	4 (10%)	3 (7.5%)	0.235
Mediastinitis	1 (2.5%)	0	
Operative mortality	3 (7.5%)	1 (2.5%)	0.451
Hospital stay (days)			
Range	6-15	7-12	0.121
Mean±S.D	8.7±1.99	8.1±1.17	

Despite a large body of evidence, there is an ongoing, controversial debate whether coronary artery bypass graft surgery should be performed with or without extracorporeal circulation. This intense debate is held between three schools of thought: the "pure", off-pump surgeons, the on-pump surgeons, and the "selectivists" group that reserves off-pump surgery for selected cases only. Historically, the shift towards off-pump coronary artery bypass grafting was proposed both to reduce the operation cost in developing countries but also to avoid the deleterious effects of the contact of blood with the artificial extracorporeal circuit [14 – 16].

The ROOBY trial demonstrated that the proportion of patients with fewer grafts than initially planned was higher in the off-pump arm than in the on-pump arm, and similarly, the off-pump versus on-pump CABG in elderly patients trial revealed that fewer grafts were performed in the off-pump arm compared to on-pump arm [15, 17, 18]. Off-pump CABG is technically demanding and hemodynamic instability can occur during the procedure which affects the number of grafts anastomosed. These findings are consistent with several reports, which reported fewer grafts in patients who had off-pump CABG [19, 20].

The ROOBY trial demonstrated no difference in reoperation for bleeding, and the use of mechanical support [17]. In the CORONARY trial, the use of off-pump reduced perioperative transfusions, reoperation for perioperative bleeding, acute kidney injury, and respiratory complications. Two large meta-analyses of randomized clinical trials [14,16] found no difference in myocardial infarction rates between on-pump or off-pump. Additionally, Deppe and colleagues found a low incidence of low cardiac output and infection with the use of off-pump. Furthermore, the number of patients needing a transfusion and the chest tube drainage was significantly reduced in the off-pump group, but with no difference in re-thoracotomy rates, all the above studies run in lines with our results regarding complications [15].

Deppe and colleagues found that repeated revascularization was higher in off-pump than on-pump CABG during the first postoperative month, which disagrees with our results [14]. This finding could be attributed to the lower number of grafts used in off-pump surgery. Similarly, several studies reported that revascularization surgery was more common in off-pump cases than in on-pump during the first postoperative month, but in the long run, revascularization surgery was similar in both groups [18, 19].

Wang and colleagues found that there was no difference between off-pump and on-pump regarding early mortality, which run in line with our results [21]. Deppe and colleagues found that there was no difference between off-pump and on-pump groups regarding the 30 days mortality

rate [14]. Several studies found that there was no difference between off-pump and on-pump groups of the study regarding the 30-day mortality rate [16, 18, 19]. However, Taggart and colleagues and Møller and coworkers found that the 30-day mortality in off-pump was more prominent than on-pump CABG operations [22, 23].

The long-term outcomes of off-pump versus on-pump CABG continue to be debated. Hattler and colleagues demonstrated in their study a reduced 5-year survival for patients undergoing off-pump CABG [24].

The debate between on-pump and off-pump CABG continues. Incomplete revascularization was reported with off-pump CABG; however, off-pump showed lower short-term complications in high-risk patients.

Study limitations

The major limitation of the study is the short-term follow-up. The major difference between both techniques occur during longer follow-up; however, the high-risk patients may benefit from the technique which reduces early morbidity and mortality.

Conclusion

Management of coronary artery disease still a challenging subject, and the choice of techniques for revascularization still a matter of debate. There is still a place for the off-pump CABG technique to be used in CAD in high-risk patients. It has the advantage of less early complications than on-pump.

Conflict of interest: Authors declare no conflict of interest.

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