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Original Article

Outcomes of Off-Pump Coronary Artery Bypass Grafting in Ischemic Cardiomyopathy

Chusak Nudaeng, MD
Raschareeya Santisevi, MD
Supakorn Srihattapadungkit, MD

Cardiovascular Thoracic Surgery Unit, Department of Surgery, Rajavithi Hospital, Rangsit University, Bangkok, Thailand

Abstract

Objective: Surgical coronary revascularization for coronary artery disease (CAD) with reduced left ventricular ejection fraction (LVEF) entails a high risk of postoperative complications and mortality. This study aimed to evaluate the surgical outcomes of off-pump coronary artery bypass grafting (OPCAB) in ischemic cardiomyopathy patients in our hospital.

Patients and Methods: From January 2012 to December 2018, eighty CAD patients with low LVEF ≤ 35% who underwent isolated OPCAB were included in the present study. In-hospital mortality, major adverse cardiovascular and cerebrovascular events were evaluated, and factors associated with mortality were analyzed.

Results: The mean preoperative LVEF was 26%, while their mean EuroSCORE II was 11.9, and their in-hospital mortality rate was 16% (13 patients). Low cardiac output syndrome was found in 3 patients, congestive heart failure in 2 patients, and cardiogenic shock in 3 patients. There were no postoperative strokes or myocardial infarction, and postoperative LVEF was significantly improved, with an average of 38% ($P = 0.040$). Insulin-dependent type II diabetes mellitus was significantly associated with increased in-hospital mortality ($P < 0.001$).

Conclusions: Patients with coronary artery disease and ischemic cardiomyopathy showed significantly improved left ventricular ejection fraction after off-pump coronary artery bypass grafting surgery. There were no postoperative myocardial infarction or stroke in the present study. Insulin-dependent type II diabetes mellitus was significantly associated with increased in-hospital mortality.

Keywords: Off-pump coronary artery bypass, Cardiomyopathy, Left ventricle dysfunction, Coronary artery disease

Introduction

Ischemic cardiomyopathy is currently defined as significantly impaired left ventricular dysfunction (LVEF ≤ 35%) which results from coronary artery disease. Lack of adequate blood supply, which results in the inability to meet myocardial metabolic demands, can lead to cell death, fibrosis, left ventricular enlargement, and dilation.[1-3] Initially, there is a reversible loss of cardiac contractile function due to decreased oxygen supply to the myocardium; however, when myocardial ischemia persists for a prolonged period of time, irreversible myocardial damage ensues, resulting in cardiac remodeling, primarily brought about by myocardial fibrosis, which results in decreased cardiac function, arrhythmia, and possible cardiac conduction system impairment and abnormality.[4,5] In such patients, the decision about whether or not to perform coronary revascularization is difficult.

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Corresponding author: Chusak Nudaeng, MD, Cardiovascular Thoracic Surgery Unit, Department of Surgery, Rajavithi Hospital, 2 Phyathai Road, Ratchathewi, Bangkok 10400, Thailand; Telephone: +66 61 919 1554; Email: bae_ps@yahoo.com

The Surgical Treatment for Ischemic Heart Failure (STICH) study was designed to test the hypothesis that coronary artery bypass grafting (CABG) plus guideline-directed medical therapy for coronary artery disease, heart failure, and left ventricular dysfunction would achieve better survival than that of optimum medical therapy alone. The STICH study randomized 1,212 patients with ischemic cardiomyopathy with an ejection fraction of less than 35%, with a median follow-up of 56 months. The rate of death from any cause was not significantly different in the CABG group and the medical-therapy group;[6] however, the results from the STICH Extension Study (STICHES) demonstrated improved long-term outcomes over a median period of 9.8 years, revealing that the risk of all-cause death, death resulting from cardiovascular causes, and all-cause death or hospitalization for cardiovascular causes, was significantly lower among patients randomized to receive CABG and guideline-directed medical therapy compared with those who received medical therapy alone.[7]

Coronary artery bypass grafting has been shown to be superior to medical therapy alone in patients with low LVEF, demonstrating significant clinical improvement and increased long-term survival. Nevertheless, CABG in patients with reduced left ventricular (LV) function remains a surgical challenge. Off-pump coronary artery bypass (OPCAB) has been increasingly utilized to prevent deleterious effects of cardiopulmonary bypass, including associated inflammatory response, global myocardial ischemia, and reperfusion injury, and also to preserve heart function. Low LVEF patients have weakened heart function and may not be able to tolerate ischemia and reperfusion in conventional CABG; therefore, these patients could be the best candidates for OPCAB.[8]

Currently, 2018 ESC/EACTS Guidelines on myocardial revascularization recommend the use of the off-pump coronary artery bypass (OPCAB) technique in CAD patients with the atherosclerotic aortic disease (Recommendation I, LOE B) and that experienced off-pump teams should consider it for subgroups of high-risk patients (Recommendation IIa, LOE B).[9] We aimed to study the surgical outcomes of OPCAB for ischemic cardiomyopathy patients in our center.

Patients And Methods

The present retrospective observational study included all patients ≥ 18 years of age with CAD and left ventricular ejection fraction ≤ 35% who underwent isolated off-pump coronary artery bypass from January 2012 to December 2018 in a single center. Demographic, angiographic, and operative data were collected from hospital charts and computer databases in our hospital. Pre-and postoperative left ventricular ejection fraction (LVEF) was measured using a transthoracic echocardiogram by certified cardiologists before surgery and after surgery (before discharge from the hospital, or not more than 1 month after surgery). The European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) was used to calculate the predicted risk of mortality for each patient. EuroSCORE II > 8 was considered as high risk of mortality.

The primary outcome was major adverse cardiovascular and cerebrovascular events (MACCE) defined as in-hospital mortality (death from cardiovascular or any other causes), acute myocardial infarction (AMI), or ischemic stroke. The secondary outcome was factors associated with mortality. All continuous data were expressed as mean ± standard deviation, while categorical data were given as frequency and percentages. Comparisons of continuous variables between two groups were performed using student T-test or Mann-Whitney U-test and categorical variables were compared using Chi-square test. *P*-values < 0.05 was considered statistically significant, and all statistical calculations were performed using SPSS version 22.

Results

During the 7-year study period, 379 patients underwent isolated OPCAB, and 299 of these were excluded from the study due to having preoperative LVEF > 35%. The study sample, therefore, included 80 patients (Table 1) whose mean age was 63.4 ± 10.6 years and mean EuroSCORE II was 11.91, which are considered as high-risk patients. The average preoperative LVEF was 26 ± 5%.

The average number of revascularizations per patient was 2.2 ± 0.9, with complete revascularization in 45 patients. Thirty-two out of the 80 patients had aortic non-touch surgery. Most (69%) had elective surgery and bilateral internal mammary arteries were used in 29 patients (36%). LV aneurysm plication, performed using the off-pump technique, and surgical endarterectomy were performed in 2 and 8 cases respectively. No patient required conversion from off-pump to on-pump CABG (Table 2).

Table 1 Preoperative patient characteristics.

Patient characteristics	Summary (n = 80)
Age (years) : mean ± SD	63.4 ± 10.6
Male sex: n (%)	62 (78)
EuroSCORE II : median (range)	6.0 (2.0 - 59.0)
Cardiac characteristics	
Preoperative LVEF (%): median (range)	25.7 (15 - 35)
Left main disease: n (%)	34 (43)
Single Vessel disease: n (%)	4 (5)
Double Vessels disease: n (%)	19 (24)
Triple Vessels disease: n (%)	57 (71)
LV aneurysm: n (%)	2 (3)
Coronary risk factors: n (%)	
Hypertension	67 (84)
Diabetes mellitus	28 (35)
Insulin-dependent type2 Diabetes mellitus	10 (13)
Dyslipidemia	61 (76)
CKD	35 (44)
ESRD	14 (18)

EuroSCORE II: European System for Cardiac Operative Risk Evaluation, LVEF: left ventricular ejection fraction, LV: left ventricular, CKD: chronic kidney disease, ESRD: End-Stage Renal Disease.

Table 2 Operative characteristics

Operative characteristics	Summary (n =80)
No. of revascularizations : mean ± SD	2.2 ± 0.9
Complete revascularization: n (%)	45 (56)
Total arterial revascularization: n (%)	33 (37)
Aortic non-touch surgery: n (%)	32 (36)
Elective surgery: n (%)	55 (69)
Urgent surgery: n (%)	9 (11)
Emergency surgery: n (%)	16 (20)
Endarterectomy: n (%)	8 (10)
LV aneurysm plication: n (%)	2 (3)
Conversion to CABG: n (%)	0
Conduits: n (%)	
Single IMA	50 (63)
Bilateral IMA	29 (36)
Radial artery	1 (1)
Right gastroepiploic artery	3 (4)
Saphenous vein	44 (55)

LV: left ventricular, CABG: coronary artery bypass grafting, IMA: internal mammary artery

Of 80 patients, 13 (16%) died during admission: 4 succumbed to sepsis, 3 died from ventricular arrhythmia, and 2, 3, and 1 from multiple organ failure, severe left ventricular dysfunction, and cardiogenic shock respectively. Mean postoperative ICU and hospital stays were 5.6 days and 12.3 days respectively. The mean postoperative left ventricular ejection fraction was 38% which was significantly improved from preoperative LVEF (26%) ($p = 0.04$). No case of perioperative or postoperative myocardial infarction was reported during the study period and no patient developed ischemic stroke (Table 3).

Table 3 Postoperative outcomes

Postoperative outcomes	Summary (n =80)
In-hospital mortality: n (%)	13 (16)
Mean ICU stay (days) : median (range)	4 (2 - 53)
Mean postoperative hospital stay (days): median (range)	10 (2 - 90)
Postoperative LVEF (%):	
Median (range)	25.7 (15 - 35)
Mean ± SD	25.6 ± 5.0
Postoperative myocardial infarction: n (%)	0
Reoperation for bleeding: n (%)	0
Hospital-acquired pneumonia: n (%)	6 (8)
Sternal wound infection: n (%)	0
Low cardiac output syndrome: n (%)	3.0 (3.8)
Stroke/transient ischemic attack: n (%)	0.0 (0.0)
Congestive heart failure: n (%)	2.0 (2.5)
Cardiogenic shock: n (%)	3.0 (3.75)
Cardiac arrest: n (%)	2.0 (2.5)
Hemodialysis: n (%)	3.0 (3.75)
Multiple organ failure: n (%)	2.0 (2.5)
Ventricular arrhythmia: n (%)	3.0 (3.8)

ICU: intensive care unit, LVEF: left ventricular ejection fraction

Our study showed that insulin-dependent type2 diabetes mellitus was associated with an increased early mortality rate (p-value < 0.001). However, no association was found between other underlying diseases and mortality. Type of operation, endarterectomy, and LV aneurysm plication procedure were not associated with in-hospital mortality (Tables 4 and 5).

Table 4 Factors associated with mortality: univariable analysis

Factors	Total (n = 80) n	Alive (n = 67) n (%)	Dead (n = 13) n (%)	*p*-value
Sex				0.999
Male	62	52 (78)	10 (77)	
Female	18	15 (22)	3 (23)	
Diabetes mellitus	28	25 (37)	3 (23)	0.526
Insulin-dependent type 2 diabetes mellitus	10	4 (6)	6 (46)	0.001*
Hypertension	67	56 (84)	11 (85)	0.999
Dyslipidemia	61	51 (76)	10 (77)	0.999
Chronic kidney disease	35	31 (46)	4 (31)	0.303
End-Stage Renal Disease	14	10 (15)	4 (31)	0.227
Left main disease	34	29 (43)	5 (39)	0.748
Vessel disease				0.053
Single vessel disease	4	3 (5)	1 (8)	
Double vessels disease	19	19 (28)	0	
Triple vessels disease	57	45 (67)	12 (92)	
Left ventricular aneurysm	2	2 (3)	0	0.999
Post cardiac arrest	4	3 (5)	1 (8)	0.515
Type of operation				0.124
Elective	55	49 (73)	6 (46)	
Urgency	9	7 (10)	2 (15)	
Emergency	16	11 (16)	5 (39)	
Left ventricular aneurysm plication	2	2 (3)	0	0.999
Endarterectomy	8	8 (12)	0	0.999
Off-pump coronary artery bypass				0.608
1 vessel	23	18 (27)	5 (39)	
2 vessels	25	20 (30)	5 (39)	
3 vessels	27	24 (36)	3 (23)	
4 vessels	5	5 (8)	0	

Table 5 Risk factors associated with mortality: multivariable analysis

Factor	Crude OR (95% CI)	*p*-value	Adj. OR (95% CI)	*p*-value
Diabetes mellitus	0.5 (0.1 - 2.0)	0.331	1.2 (0.2 - 5.5)	0.871
Insulin-dependent type2 Diabetes mellitus	13.5 (3.1 - 59.7)	0.001*	14.3 (2.8 - 72.8)	0.001*

OR (95% CI) = Odds Ratio (95% confidence interval) from logistic regression analysis, *Significant at $p < 0.05$

Discussion

Off-pump coronary artery bypass (OPCAB) has recently gained widespread acceptance and entered mainstream clinical practice, propelled by a greater awareness of potential morbidity from cardiopulmonary bypass and aortic manipulation.[10] Several previous retrospective studies have reported that OPCAB is associated with lower incidences of death and stroke compared with conventional on-pump coronary artery bypass grafting,[11-13] while multiple studies have highlighted the potential benefits of OPCAB in high-risk patients. A recent meta-analysis in 2016 by Kowalewski M. et al. demonstrated

a significant correlation between patient risk profile and the benefits of OPCAB, with a reduction in perioperative morbidity.[14] With regards to patients with low left ventricular ejection fraction, a report from the Society of Thoracic Surgeons National Database from 2008 to 2011 of 25,667 patients with low LVEF (< 30%) found that the risks of death, stroke, and major adverse cardiac events (MACE) were significantly lower among OPCAB groups than in those undergoing conventional CABG.[15] These findings were supported by an analysis of the Japan Adult Cardiovascular Surgery Database in which OPCAB was associated with reduced early morbidity and mortality in patients with EF < 30%.[16]

A meta-analysis in 2011 by Jarral OA, et al. summarized that OPCAB may be associated with a lower incidence of early mortality in patients with impaired LVEF; however, the method of handling the conversion-related mortality was unclear and may have affected the results. Furthermore, incomplete revascularization (IR) in the OPCAB group occurred more often, and this may explain why the early superiority in mortality was not maintained in the long term.[17] In our study, 44% of patients received incomplete coronary revascularization, resulting from the presence of large infarcted myocardium on preoperative myocardium perfusion scan or unsuitable target vessels for anastomosis. Later in 2017, a network meta-analysis was performed by Zhao DF et al. to compare postoperative outcomes of all CABG techniques, and this report showed that avoidance of aortic manipulation in OPCAB may decrease the risk of postoperative stroke. In addition, the elimination of cardiopulmonary bypass may reduce short-term mortality, renal failure, atrial fibrillation, bleeding, and length of stay in intensive care units.[18]

A study published in 2017 compared the effects of low and normal EF on clinical outcomes after off-pump coronary artery bypass grafting. The results revealed a significantly higher in-hospital mortality rate of 19.51% in patients with EF ≤ 35% than in those with EF > 35% (8.02%).[19] With regard to the results of the present study, CAD patients with poor left ventricular ejection fraction in our center had a mortality rate of 16% which is comparable with the low LVEF group in the mentioned study.

Insulin-dependent diabetes patients in our study showed a 14.3 times higher mortality rate than diabetes patients. This finding was similar to an observational cohort multicenter study over a period of 11 years evaluated the impact of type 2 diabetes mellitus on short- and long-term mortality after CABG and concluded that diabetes was an independent predictor of long-term mortality; furthermore, mortality was even higher when the diabetes treatment included insulin.[20] According to Kragelund C, et al. Insulin treatment is a marker for more advanced disease, its underlying mechanism has not been fully understood. It may be associated with the impact of a procoagulant imbalance, chronic exposure to high glucose levels, or direct effects of hyperinsulinemia.[21]

The main limitations of the present study included a small sample size and being based on a single center, so our findings might not be representative of the results of other institutions. An extended study with larger populations is required.

Conclusions

CAD patients with ischemic cardiomyopathy displayed significantly improved left ventricular ejection fraction after off-pump coronary artery bypass surgery, and there were no incidences of postoperative myocardial infarction or stroke. Insulin-dependent type II diabetes mellitus was significantly associated with increased in-hospital mortality.

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