

Original Article

Outcome of Patients with Left Main Coronary Artery Disease Together with Left Ventricular Dysfunction Following OPCAB and Conventional CABG Surgery

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Abstract:

In-hospital mortality and morbidities are significantly higher in patients who undergo coronary artery bypass graft (CABG) surgery having a depressed left ventricular function or a left main (LM) coronary artery disease. Due to the improvement in technique and clinical outcome, Off-pump Coronary Artery Bypass (OPCAB) is thought to be beneficial in patients with depressed left ventricular function by avoiding prolonged ischemic time. This study was performed with an aim to assess whether OPCAB is better than conventional on-pump CABG (CCAB) in these sub-groups of patients. We purposively selected 100 patients with left main coronary artery disease (defined as $\geq 50\%$ stenosis) with reduced left ventricular ejection fraction (defined as ejection fraction 40% or less) who underwent elective CABG in National Institute of Cardiovascular Diseases (NICVD) between January 2014 and December 2020. Among them OPCAB was done in 50 patients and conventional CABG in another 50 patients. Both groups had similar pre-operative parameters. Total operative time, intubation time, blood loss, requirement for blood and blood products, intensive care unit (ICU) stay and hospital stay were all significantly lower in the OPCAB group. Post-operative complications were not statistically different among the two groups. Study finds that patients with left main coronary artery disease with left ventricular dysfunction can be safely revascularized in OPCAB technique.

Keywords: OPCAB, CCAB, left main coronary artery disease, left ventricular dysfunction.

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INTRODUCTION

Coronary artery bypass (CABG) grafting remains as the most frequently performed surgery in the practice of an adult cardiac surgeon.¹ Both the early and long-term outcomes of CABG have improved with the advances in instruments, myocardial protection and surgical technique. Therefore, an increased number of high-risk patients suffering from coronary artery disease are now being treated with surgical revascularization.²

As a consequence of increase in the incidence of risk factors of ischemic heart diseases in most of the countries of the world, severe and diffuse coronary artery diseases are becoming more common day by day.³ On the other hand, improvement in invasive cardiology has led to referral of patients having complex and diffuse disease with poor ventricles to surgeons.⁴

A large scale meta-analysis of patients who underwent isolated CABG found seven independent variables of post-operative morbidity and mortality. These included low left ventricular ejection fraction (LVEF) and significant stenosis of the left main coronary artery.⁵

Patients with left main coronary artery disease associated with severe left ventricular dysfunction are more prone to develop ventricular arrhythmias, heart failure and sudden death. Left ventricular dysfunction in patients with coronary artery disease might be caused by scars, repetitive ischemia, myocardial stunning and hibernation or some combination thereof; thus, this condition might be partially or completely reversible in numerous patients who undergo revascularization.⁶ Comparison of medical therapy with CABG surgery for patients with symptomatic coronary artery disease and ejection fraction (EF) as low as 30% have shown a long-term survival benefit for those receiving CABG.⁷

Conventional CABG surgery has long been considered as the gold standard operation for ischemic heart disease but high risk patients specially those having low ejection fraction are extremely sensitive to cardioplegic arrest and have higher intra-operative and post-operative morbidity and mortality.⁸ OPCAB surgery was initially performed on

patients having single or double vessel disease with good left ventricular function.^{9,10} But with the availability of modern retractor-stabilizers, intracoronary shunts, and growing surgeon experience, similar completeness of revascularization and graft patency can be achieved with OPCAB surgery even in patients with left main disease with reduced left ventricular function.^{11,12,13} The international CABG Off or On Pump Revascularization Study (CORONARY) showed no significant treatment-related differences between off-pump and on-pump CABG with regard to any 5-year outcomes.¹³ But the United States-based counterpart of that trial, the ROOBY Follow-up Study (ROOBY-FS) showed that off-pump CABG led to lower rates of 5-year survival and event-free survival than on-pump CABG.¹⁴

The aim of this study was to determine whether Off-pump Coronary Artery Bypass (OPCAB) provides better early outcome in patients with left main coronary artery disease with left ventricular dysfunction in comparison to conventional CABG.

MATERIALS AND METHODS

This prospective non-randomized clinical study was conducted in the Department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD) from January 2014 and December 2020. The study was carried out on patients left main coronary artery disease together with reduced left ventricular ejection fraction ($\leq 40\%$) who were scheduled for elective coronary artery bypass graft surgery in NICVD, during the specified period of time and fulfill the inclusion and exclusion criteria. Among them 100 patients were purposively selected and allocated into two groups on the basis of operative procedure:

Group A: 50 patients who underwent OPCAB (Study group) and

Group B: 50 patients who underwent conventional CABG (Control group).

Anesthesia and Monitoring

Patients were placed in supine position on the operating table. Non-invasive monitoring lines like ECG, non-invasive blood pressure (NIBP), and pulse oxymeter were connected. Two peripheral venous lines were established. Radial arterial cannula was introduced under local anesthesia and was connected to a polygraph monitor for continuous blood pressure monitoring. Under general anesthesia CVP cannula was introduced and was connected to a polygraph monitor for continuous CVP

display. Urinary catheter was introduced to monitor hourly urine output. In patients with low left ventricular ejection fraction ($<35\%$) femoral arterial cannula was introduced because they might intra-aortic balloon pump (IABP) support.

Anesthetic drugs were used as per institutional protocol. After premedication with opioid (morphine or fentanyl) and sedative agent (midazolam/ diazepam), induction of anesthesia was achieved with thiopental sodium or etomidate and muscle relaxation was obtained by pancuronium or vecuronium. Maintenance of anesthesia was achieved by isoflurane/halothane, and propofol along with incremental doses of analgesics and muscle relaxants in both the groups. OPCAB was performed under normothermia and CCAB under mild hypothermia.

Technique of Off-pump coronary artery bypass graft surgery:

OPCAB was done through midline sternotomy. Arterial and venous conduits were harvested following standard protocol. Then patients were heparinized (100 IU/ kg) to achieve an activated clotting time (ACT) of ≥ 300 seconds before grafting. Stabilizer and positioning devices were used for stable grafting. Pericardial traction sutures were applied to expose obtuse marginal arteries where appropriate. Intracoronary shunts were routinely used to maintain coronary flow during distal anastomoses. Humidified blower and normal saline spray were used for better visualization. All left anterior descending (LAD) arteries received left internal mammary artery (LIMA) graft. The sequence of grafting was individualized. Proximal anastomoses were performed on the partially clamped ascending aorta using 6-0 or 7-0 polypropylene suture. For distal anastomoses we used 7-0 or 8-0 polypropylene suture. After grafting, heparin was reversed with protamine in 1:1 ratio. All the wounds were closed in layers. Then patients were transferred to cardiac ICU.

Technique of conventional CABG

Median sternotomy was done as usual. After harvesting of conduits heparin was introduced (300 IU/kg) to achieve an activated clotting time (ACT) >450 seconds. Aortic and two stage single venous cannulation were done for cardiopulmonary bypass (CPB). The flow was maintained between 2.0 to 2.5 L/ min/ m^2 . The blood pressure was kept between 60 to 70 mm Hg. Mild hypothermia was maintained during cardiopulmonary bypass. After cross clamping the aorta antegrade cold blood cardioplegia was administered for myocardial protection. Cardioplegia was

repeated every 20 minutes. Distal anastomoses were performed first. Then proximal anastomoses were performed during rewarming. Patients were weaned from cardiopulmonary bypass. Heparin was reversed with protamine as before. All the wounds were closed in layers. Then patients were transferred to cardiac ICU.

Postoperative Management in ICU

In the cardiac ICU patients were monitored and managed as per standard protocol. Hourly urine output and blood loss were measured. Inotropes and vasodilators were used as per surgeon’s choice. Post-operative complications were treated accordingly. After extubation patients were encouraged to respiratory exercise and early mobilization. Inotropes were weaned, drains were removed when appropriate. Subsequently patients were shifted to general wards and discharged home.

RESULTS

Table-I showed patient characteristics. The study samples of two groups had similar mean ages ($p=0.1428$; >0.05). Sex distribution was homogenous but with male predominance (88% vs. 90%). Although the body mass index (BMI) of two groups were not statistically different ($p=0.0728$; >0.05) overweight and obese patients were more prevalent among CCAB group. Distribution of co-morbidities and risk factors were not different between the groups (p values >0.05). Coronary angiography showed that majority of the left main patients had triple vessel coronary artery disease (TVD) in each group (72% vs 72%; $p=1.000$). Other patients had double vessel disease (DVD) ($p=0.7901$) and left main only ($p=0.7493$). So, pre-operative characteristics were statistically similar among the two groups ($p > 0.05$).

Table-I : Patient Characteristics of Left Main (LM) Coronary Artery Disease and Left Ventricular Dysfunction

Variables	OPCAB group (n=50)	CCAB group (n=50)	<i>p</i> Value
Age (years)	61.2±6.74	59.2±6.8	0.1428 ^{ns}
Male, n (%)	44(88.0)	45(90.0)	0.7493 ^{ns}
BMI (kg/m ²)	26.2±2.2	26.98±2.1	0.0728 ^{ns}
Hypertension, n (%)	30(60.0)	29(58.0)	0.8369 ^{ns}
Diabetes mellitus, n (%)	22(44.0)	23(46.0)	0.8407 ^{ns}
Smoking, n (%)	27(54.0)	26(52.0)	0.8412 ^{ns}
Dyslipidemia, n (%)	21(42.0)	19(38.0)	0.6831 ^{ns}
Family H/O Coronary Artery Disease, n (%)	5(10.0)	6(12.0)	0.7493 ^{ns}
Stroke or Transient Ischemic Attack, n (%)	2(4.0)	1(2.0)	1.000 ^{ns}
COPD, n (%)	6(12.0)	5(10.0)	0.7493 ^{ns}
History of Myocardial Infarction, n (%)	22(44.0)	21(42.0)	0.8399 ^{ns}
Peripheral Vascular Disease, n (%)	5(10.0)	6(12.0)	0.7493 ^{ns}
Renal dysfunction, n (%)	3(2.0)	2(4.0)	1.000 ^{ns}
Arrhythmia, n (%)	4(8.0)	3(6.0)	1.000 ^{ns}
Left Ventricular Ejection Fraction, (%)	38.3 ± 2.6	37.96±2.3	0.4902 ^{ns}
NYHA class II or III, n (%)	5(10.0)	5(10.0)	1.000 ^{ns}
CCS angina class III or IV, n (%)	23(46.0)	26(52.0)	0.5484 ^{ns}
Left Main (LM) Disease only	5(10.0)	6(12.0)	0.7493 ^{ns}
LM + Double Vessel Disease	9(18.0)	8(16.0)	0.7901 ^{ns}
LM + Triple Vessel Disease	36(72.0)	36(72.0)	1.000 ^{ns}

ns = Non-significant

Table-II showed that CCAB group had higher operating time ($p=0.000$) because of the time required for institution and termination of cardiopulmonary bypass. All patients received left internal mammary artery (LIMA) to left anterior descending artery (LAD) graft. Long saphenous vein ($p=1.000$) and radial artery were used similarly ($p=0.6882$). Most of the patients of both groups had 3 grafts.

Table-II: Comparison of Intraoperative Variables between OPCAB and CCAB Groups

Variables	OPCAB group (n=50)	CCAB group (n=50)	p Value
Conversion to Cardiopulmonary Bypass (CPB), n (%)	1(2.0)		
CPB time (minutes)		87.3 ± 12.5	
Total operating time (minutes)	267.7 ± 24.6	309.6 ± 29.7	0.000 ^s
Conduit ^Y			
Left Internal Mammary Artery, n (%)	50(100.0)	50(100.0)	1.000 ^{ns}
Radial artery, n (%)	24(48.0)	22(44.0)	0.6882 ^{ns}
Saphenous Vein, n (%)	50(100.0)	50(100.0)	1.000 ^{ns}
Graft distribution			
Left Anterior Descending, n (%)	50(100)	50(100)	1.000 ^{ns}
Left Circumflex territory, n (%)	48(96.0)	49(98)	0.5577 ^{ns}
Right Coronary Artery, n (%)	46(92.0)	45(90.0)	0.7268 ^{ns}
Intra-aortic Balloon Pump	0(0)	1(2.0)	1.000 ^{ns}

ns =Non-significant; s = Significant

Table-III showed post-operative variables of the study groups. In the ICU OPCAB patients were extubated earlier from mechanical ventilation than CCAB patients ($p=0.000$). Requirements for IABP and inotropes were similar between two groups. Post-operative bleeding and blood product requirement were less in OPCAB group ($p=0.000$). Postoperative stay period in ICU and ward stay were also shorter in OPCAB group ($p=0.000$).

One patient of CCAB group died immediate post-operatively due to cardiac tamponade followed by multi-organ dysfunction from prolonged low output syndrome. None died in OPCAB group ($p=1.000$). Two patients of the CCAB group and one of the OPCAB group developed post-operative myocardial infarction (MI) but all of them recovered completely. Post-operative complications like re-exploration for bleeding, stroke, arrhythmia, renal dysfunction, wound infection and pulmonary complications were not statistically different.

Table III: Comparison of Post-Operative Variables between OPCAB and CCAB Groups

Variables	OPCAB group (n=50)	CCAB group (n=50)	p Value
Operative mortality, n (%)	0(0)	1(2.0)	1.000 ^{ns}
Mechanical ventilation time, hours	6.98±0.5	11.85±0.48	0.000 ^s
Low Output Syndrome or Prolonged inotropic support	3(6.0)	5(10.0)	0.715 ^{ns}
Intra-aortic Balloon Pump	1(2.0)	1(2.0)	1.000 ^{ns}
Chest tube drainage (ml)	460 ± 56	640 ± 62	0.000 ^s
Requirement for blood and blood products (ml)	750 ± 50	1120 ± 40	0.000 ^s
ICU stay (hours)	72 ± 2.8	96 ± 2.0	0.000 ^s
Post-operative hospital stay (days)	7.1 ± 0.4	9.9 ± 0.2	0.000 ^s
Re-exploration	1(2.0)	3(6.0)	0.6175 ^{ns}
Post-operative stroke	1(2.0)	1(2.0)	1.000 ^{ns}
Lung complication	5(10.0)	6(12.0)	0.7762 ^{ns}
New myocardial infarction	1(2.0)	2(4.0)	1.000 ^{ns}
Post-operative arrhythmia	7(14.0)	12(24.0)	0.2025 ^{ns}
Wound infection	3(6.0)	4(8.0)	1.000 ^{ns}
Acute Kidney Injury	6(12.0)	8(16.0)	0.5643 ^{ns}

ns =Non-significant; s = Significant

DISCUSSION

OPCAB is being performed regularly in NICVD. Patients with left main coronary disease with reduced left ventricular ejection fraction ($\leq 40\%$) are a high-risk group for surgical revascularization. As in other studies we found that in-hospital morbidities were less frequent in patients of OPCAB group. Long term studies showed that incomplete revascularization was more common with OPCAB approach which led to increase in cardiac mortalities and morbidities, repeat hospitalization and re-intervention.^{15,3} Two studies performed by Shroyer et al. and Meharwal et al. having large sample showed that the average numbers of grafts were similar between OPCAB and CCAB groups.^{16,17} Youn et al. showed that patients with CCAB had more distal anastomoses, but this was not statistically different between the groups. Complete revascularization can be performed in both techniques.¹⁸ In all OPCAB patients we used intracoronary shunts during distal grafting as we believe them useful to maintain coronary flow and reduce bleeding. During the lateral and inferior grafting in OPCAB procedure blood pressure may fall.¹⁹ Myocardium may further suffer if tourniquets are used around coronary arteries. However, studies have shown inconclusive results regarding their use.²⁰

Some early post-operative parameters like period of mechanical ventilation, blood loss, use of blood and blood products, ICU stay and hospital stay were significantly less in OPCAB patients. Transmission related complications are less in this group of patients.²¹

Studies showed that OPCAB had lower post-operative mortality in high- risk patients having one or more co-morbidities and left ventricular dysfunction.²² In our study, hospital mortalities for OPCAB and CCAB patients with left main disease with reduced left ventricular ejection fraction ($\leq 40\%$) were comparable. Meharwal et al. showed that the operative mortality was lower in OPCAB group (0.97% vs 1.86%; $p < .001$).¹⁷ Ruzzeh et al. in a meta-analysis showed similar result (1.4% vs. 2.9%).²³ However, Sajja et al. (2.8% vs. 3.9%, $p = 0.746$) showed that though mortality was lower in OPCAB group the difference was not statistically significant.²⁴

CONCLUSIONS

There is an ongoing debate whether OPCAB or CCAB has better post-operative outcome. Study found that OPCAB had some favorable post-operative findings e.g. less operative time, mechanical ventilation time, blood loss, blood transfusion, intensive care unit (ICU) stay and hospital stay. However, operative mortality and morbidity were similar among them. This concludes that

these patients can be safely revascularized in OPCAB technique.

Study Limitations:

The limitations of the study are as follows:

1. Purposively selected small sample size.
2. No randomization before grouping.
3. There is chance of biasness because the surgical procedure (OPCAB or CCAB) was chosen by the performing surgeon.
4. This study was of short period without any follow up information.
5. The finding of this research was drawn from NICVD only. So it may not be comparable to that of a large scale study.
6. Variations in surgeon's competence, severity of coronary artery disease and echocardiographic parameters have to be taken in account for better comparison.

Recommendations:

Our recommendations are as follows:

1. Patients with left main disease with reduced left ventricular ejection fraction ($\leq 40\%$) can be safely revascularized by OPCAB procedure.
2. A well designed randomized trial is required to validate the information of our study.

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