

# Off-pump coronary artery bypass grafting in patients with significant left ventricular dysfunction

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## Abstract

**Objective :** Off-pump coronary artery bypass grafting (OPCAB) is known to preserve left ventricular function better than conventional coronary artery bypass grafting (CCAB). This study was carried out to investigate the safety, feasibility and efficacy of off-pump coronary artery bypass grafting in patients with significant left ventricular dysfunction.

**Methods:** Three hundred and eighty eight consecutive patients with preoperative left ventricular ejection fraction  $\leq 39\%$  who underwent CABG between January 2001 through October 2007 were included in this retrospective study. Two hundred and eleven patients were operated by off-pump technique (group 1) and 178 patients were operated by on-pump technique (CCAB) (group 2). The postoperative outcomes were analyzed. Of these, 204 (52.57%) patients were diabetics, 355 (91.49%) patients had documented prior myocardial infarction, 316 (81.44%) patients were in canadian cardiovascular society (CCS) class III and 47 (12.11%) patients were in CCS class IV.

**Results:** There was no significant difference in the number of grafts per patient between the two groups [group 1  $3.02 \pm 0.76$  vs group 2  $3.18 \pm 0.72$  ( $P=0.07$ ) and the index of completeness of revascularization was comparable [ $1.08 \pm 0.08$  (OPCAB) vs  $1.04 \pm 0.06$  (CCAB) ( $p=0.52$ )] The left internal thoracic artery was anastomosed to left anterior descending artery in 98% of patients. Operative mortality was 2.8% (6 deaths) following OPCAB and 3.93% (7 deaths) following CCAB ( $p=0.746$ ). Postoperative usage of IABP support was higher in CCAB group (12 patients vs 4 patients:  $P<0.03$ ) and usage of moderate or higher doses of inotropic support was also higher in the conventional group ( $p<0.0006$ ). More worsening of preexisting renal insufficiency was observed in CCAB group ( $p=0.01$ ) and no significant difference in the incidence of atrial fibrillation was observed between the groups.

**Conclusions:** Off-pump coronary artery bypass grafting is feasible and safe in patients with depressed left ventricular function and the postoperative morbidity was less in OPCAB group compared to on-pump group. (*Ind J Thorac Cardiovasc Surg* 2008; 24: 110-115)

**Key words:** Coronary artery bypass grafting, OPCAB, Cardiopulmonary bypass

## Introduction

The prevalence of patients presenting with severe left ventricular dysfunction is increasing together with an increasing profile of co-morbidities<sup>1</sup>. Severe left

ventricular (LV) dysfunction has been reported as an independent predictor of operative mortality in patients undergoing coronary artery bypass grafting<sup>1-4</sup>. Off-pump technique has theoretical and practical advantages over conventional coronary artery bypass grafting in this subset of high risk patients. Multiple studies showed that CABG results in considerable improvement in long-term survival, as well as, improvement in ejection fraction and symptomatic class<sup>1,3</sup>. Off-pump coronary artery bypass grafting (OPCAB) has become a valid treatment for coronary artery disease especially for those with cerebrovascular

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Received - 24/11/07; Review Completed - 04/04/08; Accepted - 07/04/08.

disease, renal impairment and other co-morbidities<sup>5,6</sup>. The aim of the present study was to compare early outcomes of conventional CABG (CCAB) and OPCAB techniques among the patients with left ventricular ejection fraction (LVEF)  $\geq 39\%$ .

## Patients and Methods

All the data were collected prospectively at the time of operation and entered into a database. During a period of six and half years (January 2001 through October 2007), a total of 4199 patients underwent isolated coronary artery bypass grafting at our institution. Of these patients, 388 (9.24%) patients had reduced left ventricular function, LVEF  $\leq 39\%$  as calculated by 2D-echocardiography were retrospectively study.

These patients were divided into two groups according to the operative technique used. Group 1 (n=211) patients had revascularization using off-pump technique and group 2 (n=177) had conventional CABG using cardiopulmonary bypass. The choice of the technique was based on surgeon's preference and more number of patients during the later part of the study were subjected to off-pump technique (i.e from the middle of the year 2004 onwards). An OPCAB technique was also preferentially used for the patients with preoperative co-morbidities like renal insufficiency, history of cerebrovascular accident, chronic obstructive pulmonary disease and obesity. The mean EuroSCORE for OPCAB patients was  $3.45 \pm 1.8$  and for on pump patients was  $3.30 \pm 1.4$  ( $p=0.36$ ) and both groups were comparable in terms of surgical risk stratification.

### *Anesthetic and Surgical Techniques*

*Anesthetic techniques:* The anesthetic technique was standardized for all patients. The anaesthesia was induced by fentanyl 1 to 5  $\mu\text{g}/\text{kg}$ , propofol 2 to 3  $\text{mg}/\text{kg}$ , sevoflurane 1.4 to 1.8 MAC, midazolam 0.5 to 5  $\text{mg}$ , and maintained by air/oxygen and propofol 6 - 10  $\text{mg}/\text{kg}/\text{hr}$ . Neuromuscular blockade was achieved with vecuronium bromide in a dose of 80 to 100  $\mu\text{g}/\text{kg}$  for intubation and 22 to 30  $\mu\text{g}/\text{kg}$  at regular intervals. The hemodynamic monitoring in all patients was done by both radial and femoral arterial lines for systemic pressures and Swan- Ganz catheter for pulmonary artery pressure monitoring.

### *Surgical Techniques*

*General:* Surgical access to the heart was through standard median sternotomy in all patients. All incisions and closure techniques were the same in the both groups. No cell saver was used during these procedures. Patients in whom complete revascularization was considered technically not possible with OPCAB technique, and the patients who were hemodynamically unstable during the procedure were converted to on- pump technique. The distal anastomosis for left internal thoracic artery graft was constructed with 8-0 polypropylene continuous suture and for the saphenous vein grafts and radial artery grafts 7-0 polypropylene suture was used. All proximal anastomoses of radial artery grafts were constructed using 7-0 polypropylene suture and the saphenous vein grafts were constructed using 6-0 poly propylene suture.

### *OPCAB technique*

OPCAB was performed as described earlier using Octopus 3 or 4 or Evolution (Medtronic Inc., Minneapolis, MN, USA) stabilizing devices to achieve target coronary artery stabilization<sup>6</sup>. Posterior and lateral target coronary arteries were accessed by deep pericardial traction sutures and/or with the use of Starfish cardiac positioner (Medtronic Inc. Minneapolis, MN, USA). A mean systemic arterial pressure was maintained around 65-70 mm of Hg throughout the procedure. An intra coronary shunt was used whenever it was possible while constructing the coronary anastomosis for all the vessels. A humidified carbon dioxide blower/mister (Medtronic Inc, Grand Rapids, MI, USA) was used to disperse the blood from the anastomotic site while constructing the distal anastomosis. The coronary artery grafting strategies were to graft left internal thoracic artery to left anterior descending artery first, followed by either obtuse marginal arteries or right coronary artery whichever was critically stenosed.

### *CABG with CPB technique*

While doing coronary artery bypass grafting with the aid of cardiopulmonary bypass (CPB), every effort to minimize the effect of CPB was made. All diabetic patients received infusion of insulin glucose potassium solution throughout the procedure. Myocardial protection was achieved with either intermittent ischemic fibrillatory arrest technique or with cold blood cardioplegic arrest technique based on the operating surgeon's preference. The patients were

cooled to 32° Celsius. A Myotherm (Medtronic Inc, Minneapolis, MN, USA) was used to deliver intermittently cold (4°C-8°C) high potassium blood cardioplegia with a ratio of 4:1.

### Statistical analysis

The data were collected prospectively and recorded in a data base developed in Microsoft Access by Dr. P.V. Satyanarayna (Dusk Database). The baseline characteristics and hospital outcomes for the two groups of patients was compared using Chi-square test for categorical data and the Student's test for continuous variables. The results are reported as the mean ± standard deviation or as absolute frequencies and proportions in the text and tables unless not applicable. Statistical significance was defined as a *p* value of less than 0.05.

### Results

During a period of 6½ years, a total of 388 (9.24%) patients with left ventricular ejection fraction ≤39% underwent primary isolated coronary artery bypass grafting. Of the 388 patients, 211 patients received off-pump surgery and 177 patients received on-pump surgery. The preoperative variables were comparable between the two groups (Table1), except for the incidence of preoperative renal insufficiency which was higher in OPCAB group compared to on pump group (*P*≤0.008). The proportion of patients receiving OPCAB surgery increased steadily over a period from less than 5% (year 2000) to 90% (during the year 2007) and at present the only indications, in this sub- group, for the use of CPB are diffuse coronary artery disease with small caliber vessels and recurrent hemodynamic instability during induction and conduit harvesting. Patients with significant left main stenosis and other co-morbidities like chronic kidney disease, chronic obstructive pulmonary disease, symptomatic carotid artery stenosis and severe peripheral vascular disease were preferentially subjected to OPCAB technique.

There was neither significant difference in the number of grafts per patient, (OPCAB 3.02±0.76 grafts per patient vs CCAB. 3.18±0.72 grafts per patient (*P*=0.07) nor was a significant difference in the index of completeness of revascularization (ICOR). [(OPCAB 1.08 ± 0.08 Vs CCAB 1.04±0.06 *P*= 0.52)]. There was no difference in the number grafts received for obtuse marginal branches and posterior descending arteries between the two groups (Table 2). Five OPCAB (2.37%) patients were converted to on-pump CABG in this series and these patients remained in the OPCAB group

for comparison as this is an intention – to – treat analysis. All 5 patients survived the procedure and were discharged to home. Two of these patients the conversion to on-pump was done after completion of the last distal anastomosis and were hemodynamically unstable. The patients were weaned off from

**Table 1. Patient characteristics**

Variable	Off-pump (n=211)	On-pump (n=177)	P value
Age (yrs) (Mean ± SD)	53.21 ± 12.27	51.67 ± 12.69	NS
Females	44	36	NS
CHF	32	29	NS
CCS class III or IV	194	169	NS
LVEF (mean ± SD)	34.76	34.18	NS
Prior MI	192	163	NS
Hypertension	51	46	NS
Diabetes	111	93	NS
Family history	27	24	NS
Smoking	48	41	NS
Obesity	25	20	NS
COPD	34	28	NS
Renal insufficiency creatinine <1.5mg /dL	55	26	0.008
Prior CVA	16	12	NS
No. of diseased vessels			
One	7	6	NS
Two	39	36	NS
Three	165	135	NS
Status of surgery	187	163	NS
Elective			
Urgent / Emergency	24	14	NS

CCS: Canadian cardiovascular society, CHF: congestive heart failure, COPD: chronic obstructive pulmonary disease, CVA: cerebrovascular accident, MI: myocardial infarction

**Table 2. Comparison of Operative Data**

Variable	OPCAB	CCAB	P value
CPB time	NA	83.2 ± 29.43	NA
Cross clamp time	NA	58.1 ± 18.42	NA
No. of grafts / patient	3.02 ± 0.76	3.18 ± 0.72	0.07
ICOR	1.08 ± 0.08	1.04 ± 0.06	0.52
LIMA to LAD	207	152 173	0.48
Graft to diag	25 (12%)	28 (16%)	0.37
Grafts to LCx/OM	208 (98.4)	172 (97.4%)	0.86
Grafts to RCA/PDA	84 (39.71%)	79 (44.7%)	0.47
RA conduit	15 (7.1%)	20 (11.1%)	0.34

CCAB: conventional coronary artery bypass grafting, CPB: cardiopulmonary bypass, ICOR: index of completeness of revascularization, LAD: left anterior descending artery, LCx: left circumflex artery, LIMA: left internal mammary artery, OM: obtuse marginal branch, OPCAB: off-pump coronary artery bypass grafting, PDA: posterior descending artery, RA: radial artery, RCA: right coronary artery

cardiopulmonary bypass (CPB) after initiation of intra aortic balloon pump support.

All cause mortality was higher in group II (CCAB) than in group I (OPCAB) : 3.9% vs OPCAB: 2.8% ( $p=0.746$ ) although the difference did not reach statistical significance. There was no difference in the incidence of perioperative myocardial infarction between the two groups. The use of inotropic support and intra-aortic balloon pump support were significantly higher among the patients of CCAB group. (44.7% vs 27.8%  $P= < 0.0006$  and 6.8% vs 1.9%,  $p<0.03$ ) respectively. The requirement of homologous blood transfusion was significantly lesser in OPCAB group ( $P \leq 0.001$ ). Although there was no significant difference in the postoperative ventilatory time (OPCAB group  $11.6 \pm 8.02$  hrs vs CCAB group  $15.43 \pm 9.51$ ), ( $p:0.02$ ) but intensive care unit (ICU) and hospital stays were comparable between the two groups (Table 3). Although there was no statistically significant difference in the incidence of new onset acute renal failure between the groups, there was a significant worsening of preexisting renal insufficiency in the on-pump group ( $p=0.01$ ). Other postoperative complications were

**Table 3. Postoperative outcomes**

Variable	OPCAB (n=211)	CCAB (n=177)	P value
Early mortality	6 (2.8%)	7 (3.9%)	0.746
Periop MI	5 (2.37%)	5 (2.87%)	-
IABP usage	4 (1.89%)	12 (6.77%)	0.03
Postop inotropes	58 (27.8%)	79 (44.7%)	0.0006
ST changes (>1mV)	5 (2.4%)	12 (6.7%)	-
AF	23 (11.1%)	33 (18.4%)	NS
VT/VF	4 (1.89%)	6 (3.38%)	-
Reoperation for bleeding	3 (1.42%)	7 (3.95%)	0.212
Blood Transfusion			
Nil	68	Nil	-
1 unit	101	8	<0.001
2 or more units	42	169	<0.001
Ventilator time (hrs)	$11.6 \pm 8.02$	$15.43 \pm 9.51$	0.02
Wound infection (sternal)	8 (3.79%)	8 (4.5%)	0.58
New onset renal failure	3 (1.42%)	7 (3.9%)	0.212
Worsening of existing renal insufficiency	3 (1.42%)	12 (6.77%)	0.01
ICU stay (days)	$2.62 \pm 1.6$	$2.93 \pm 2.52$	NS
Hospital stay (days)	$9.2 \pm 2.7$	$10.4 \pm 5.7$	NS

AF: atrial fibrillation, CCAB: conventional coronary artery bypass grafting, IABP: intra aortic balloon pump, ICU: intensive care unit, OPCAB: off-pump coronary artery bypass grafting, MI: myocardial infarction, VF: ventricular fibrillation, VT: ventricular tachycardia

comparable between the groups (Table 3).

## Discussion

In general, the definition of severe left ventricular dysfunction is unclear. We chose ejection fraction  $\leq 39\%$

like others as the criterion of severe LV dysfunction although several other authors defined severe LV dysfunction as ejection fraction (EF)  $<30\%$ <sup>1,7</sup>. The growing need to perform coronary revascularization in patients with severely compromised left ventricular function is the result of increasing number of patients presenting with end stage ischemic cardiomyopathy, reduced possibility of performing heart transplantation owing to economic reasons, infrastructural problems as well as of brain death is unacceptable among the relatives of potential donors in our country.

For patients with congestive heart failure, mortality is directly related to the severity of ventricular systolic dysfunction<sup>8</sup>, extent of the viability of hypo contractile myocardium<sup>9</sup> and the chosen form of treatment, as suggested by published registry studies and randomized trials<sup>10</sup>.

Management of patients with poor left ventricular function caused by coronary artery disease remains a challenge. Surgical intervention by coronary artery bypass grafting has been regarded as a high risk procedure<sup>4</sup>. However, recent studies have reported encouraging early, mid and long- term results<sup>1,4,11-14</sup>.

OPCAB techniques are becoming increasingly popular and are associated with good surgical outcome during the past decade<sup>6,13,15-17</sup>. The off-pump technique has demonstrated better myocardial protection compared to on-pump technique in a randomized study<sup>18</sup>. Many non-randomized comparisons of OPCAB and CCAB groups applying sophisticated statistical methods have reported significant reduction in risk adjusted mortality, stroke, acute renal failure, prolonged ventilator dependence and re-exploration for bleeding with OPCAB<sup>19,20</sup>.

In this study OPCAB in-hospital mortality was 2.8% which was comparable to other published series (Darwazah and co-investigators : 6.1%; Ascione and associates :7%, Tugtekin and colleagues 6.5% and Arom and associates 4.4%<sup>11,15,21,22</sup>). Majority of patients who died in our study were urgent cases in both the groups as shown previously by other investigators that non elective operations are independent predictors of mortality<sup>1,21,23</sup>. Complete revascularization of diseased coronary arteries can only be done provided that quality of vessels is suitable for grafting. To perform complete revascularization, the heart has to be elevated. The degree of elevation depends on the target vessels requiring grafting. The grafting of left anterior descending artery and diagonal branches require only gentle displacement and is not usually associated with any hemodynamic deterioration, but grafting of the

obtuse marginals, posterior descending artery and posterolateral ventricular branches require more ventricular displacement. Grundeman and colleagues showed that coronary blood flow, especially in the circumflex system, is greatly affected by vertical displacement<sup>24</sup>. We observed that grafting of ramus intermedius was also associated with hemodynamic deterioration probably due to compression of left ventricular outflow tract when the anastomosis was made quite proximally because the mid and distal parts of ramus intermedius were intra myocardial. Several maneuvers might be needed to minimize hemodynamic instability including putting the patient in Trendelenburg position and deep pericardial traction sutures. In two patients who continued to have deterioration of hemodynamics after completion of all distal anastomoses off-pump needed institution of cardiopulmonary bypass temporarily to stabilize hemodynamics and subsequently were weaned off CPB after initiating intra aortic balloon pump support. In our study we did not observe any significant difference in the number of grafts per patient between OPCAB and on-pump groups ( $p=0.07$ ) in contrast to other published series<sup>21,25</sup>. We had also observed that index of completeness of revascularization (IOCR) is comparable between OPCAB and CCAB groups ( $p=0.52$ ). We did not observe any statistically significant difference in the incidence of atrial fibrillation between the two groups which is in concurrence with the findings of Darwazah et al<sup>22</sup>. The decreased use of inotropic support and intra aortic balloon support in the OPCAB group was similar to other published series<sup>5,11,21</sup>. We also have found no difference in the incidence of perioperative myocardial infarction between the two groups as others had<sup>21</sup>. There was a significant reduction in transfusion of homologous blood in OPCAB group in our series as it was also observed by Ascione and colleagues<sup>11</sup>. There was worsening of pre-existing renal dysfunction, when patients with compromised left ventricular function had undergone on-pump revascularization ( $p < 0.05$ ).

In conclusion off-pump coronary artery bypass grafting is feasible and safe even in patients with depressed left ventricular function and is associated with improved early outcomes in terms of reduced usage of inotropes and intra aortic balloon support, and better preservation of renal function in patients with pre existing renal insufficiency.

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