Off Pump Coronary Artery Bypass (OPCAB) is Safe & Cost Effective in High Risk Patients

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ABSTRACT

Background: Cardiopulmonary bypass (CPB) is associated with diffuse systemic inflammatory responses during and after cardiac surgery and is associated with increased morbidity & mortality associated with Coronary Artery Bypass Grafting CABG, particularly in high risk sub set of patients i.e., advanced age, severe left ventricular dysfunction, renal failure, etc. The purpose of this study is to analyze the results of OPCAB in high-risk patients and compared them with results of CABG on-pump (ie, conventional CABG) in a similar group of patients

Methods: Over a 3-year period the 51 high risk patients were operated at social security hospital These patients underwent coronary revascularization were divided in 2 groups, group A CABG & group B without cardiopulmonary bypass OPCABG. Data were prospectively collected on patients who were undergoing off-pump coronary artery bypass surgery (OPCAB group) and who had one or more of the following risks factors: poor left ventricular ejection fraction (EF ≤30%), significant left main coronary artery stenosis (≥70%), redo surgery, and acute coronary syndrome operated within 48 hours.. Preoperative risk factors, intraoperative variables, and postoperative results were analyzed and compared between the two groups

Results: Between June 2006 and November 2008, coronary revascularization was done in 51 high risk patients with average parsonett score 15.4 ±2.8. These patients were divided in 2 groups OPCAB & CABG groups with the demographic profile of the patients and the risk factors were fully matched and balanced. The severity of coronary artery disease was comparable in the two groups, with the incidence of triple vessel disease in OPCAB 70.1% versus 78.2% in CABG (p=0.546). Similarly incidence of left main is the same between 2 groups (p=0.099). . Hospital mortality was 3.3% and 4.5% in the OPCAB and CABG groups, respectively (p = 0.001).The requirement of intraaortic balloon pump postoperatively was also less in the OPCAB(2 patients) versus CABG(5 patients)(p <0.001 group). The incidence of postoperative MI, stroke, renal dysfunction, pulmonary infection, and sternal infection was significantly less in OPCAB group as shown in Table 4. The mechanical ventilation time, blood transfusion requirement was significantly less in OPCAB group. The length of intensive care unit stay & hospital stay were significantly less in the OPCAB group

Conclusions: off-pump coronary artery bypass grafting in high-risk patients is safe and is associated with reduced mortality & morbidity in high-risk patients & is also cost effective, when compared with conventional on-pump coronary artery revascularization.

Key words: Off Pump Coronary Artery Bypass, Coronary Artery Bypass Grafting, Cardiopulmonary Bypass

INTRODUCTION

Cardiopulmonary bypass (CPB) is associated with diffuse systemic inflammatory responses during and after cardiac surgery[1,2] and is associated with increased morbidity & mortality associated with Coronary Artery Bypass Grafting CABG[3], particularly in high risk sub set of patients i.e., advanced age, severe left ventricular dysfunction, renal failure, etc[4,5]. The OPCAB approach has been shown to reduce the overall systemic inflammatory response, including cytokine-mediated response[6,7,8]. With the development of various tools and techniques, including several stabilizers and intracoreonary shunts, have made OPCAB a safe procedure that is now being employed for treating multivessel coronary artery disease, even in patients who are at high risk.

The important concerns in OPCAB surgery are that of patient selection and benefit, long-term graft patency, and safety of beating heart coronary revascularization for multivessel coronary artery disease. The purpose of this study is to analyze the results of OPCAB in high-risk patients and compared them with results of CABG on-pump (ie, conventional CABG) in a similar group of patients.

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MATERIAL AND METHODS

Over a 3-year period the 51 high risk patients were operated at social security hospital These patients underwent coronary revascularization were divided in 2 groups, group A CABG & group B without cardiopulmonary bypass OPCABG. The age of the patients ranged from 52 to 85 years in a predominantly male population (Table 1). Data were prospectively collected on patients who were undergoing off-pump coronary artery bypass surgery (OPCAB group) and who had one or more of the following risks factors: poor left ventricular ejection fraction (EF ≤30%), significant left main coronary artery stenosis (≥70%), redo surgery, and acute coronary syndrome operated within 48 hours. The decision for a patient to undergo operation on pump or off pump was made by the operating surgeon. Preoperative risk factors, intraoperative variables, and postoperative results were analyzed and compared between the two groups.

Anticoagulation protocol: Heparin was injected in a dose of 3 mg/kg in patients who underwent operation without CPB and 3 mg/kg in patients with CPB. Activated clotting time was measured initially and then every 30 minutes; it was maintained for more than 400 seconds in patients who underwent surgery off pump and more than 400 seconds in those who had their surgery on pump. Protamine sulfate was used in 1:1 ratio to reverse the heparin effect after the procedure.

Surgical technique for off-pump coronary artery bypass surgery: All patients underwent operation through a median sternotomy. The left internal mammary artery (LIMA) was harvested by standard technique using hemoclips. The other conduits (saphenous veins and radial artery) were harvested simultaneously. and Octopus 3 (Octopus tissue stabilization system) platform and stabilizer was used to stabilize the target coronary vessel. Intracoronary shunts (Baxter AnastaFLO Intravascular shunt, Irvine, CA) were used for distal anastomosis.

The sequence of grafting was individualized for a particular patient, depending on the severity of the lesions in different coronary arteries and patient's hemodynamics. Both the left anterior descending and right coronary arteries could be grafted without much displacement of the heart. For exposure of the circumflex vessels, three pericardial traction sutures were used to pull the heart vertically. The right pleura was opened wide and a vertical pericardiotomy was performed to herniate the heart to the right chest under the sternum. Other maneuvers such as the Trendlenberg position and tilting the table were performed as required. Inotropic agents were used as and when necessary during surgery. The distal anastomosis was performed using 7-0 suture.

Proximal anastomosis was performed using standard techniques. The aorta was palpated before applying partial occlusion clamp for proximal anastomosis The proximal anastomosis was performed using 6-0 Prolene suture.

Surgical technique for on-pump coronary artery bypass surgery: Conventional coronary artery bypass procedures were performed using standard CPB, which was established using ascending aortic and two-stage venous cannulation. The LIMA, radial artery, and saphenous veins were harvested by standard techniques. Moderate hypothermia & antegrade blood cardioplegia was used for myocardial protection. Cardioplegia was repeated after every 20 minutes

Study definitions: Perioperative MI was defined as development of new Q waves on postoperative electrocardiography or loss of R wave progression, new left bundle branch block, or new ST and T wave changes in association with an increase in creatine kinase (CK) level of more than 40 U/L or CK-MB/CK ratio of more than 5%. Blood loss was defined as total chest tube drainage until chest tubes were removed. Prolonged ventilation was defined as ventilation for more than 48 hours. Mediastinisis was defined as mediastinal collection with positive culture. Acute renal failure was defined as requirement of peritoneal or hemodialysis. Total operative time was defined as time from skin incision to closure of skin.

Urgent surgery was defined as surgery within 24 hours of angiography. Surgery was considered as emergency surgery when the patient was shifted directly to the operating theater from the catheterization laboratory or the surgery was required within a few hours of admission or of performing angiography.

Statistical analysis: Data are reported as mean ± SD. Variables considered for univariate and multivariate analysis were as follows: patient age and gender, primary symptoms (angina or heart failure symptoms), , LVEF, diabetes, NYHA Class, use of left internal mammary artery (LIMA), , blood transfusion requirement, number of distal anastomosis, Intensive care unit and hospital stay, low cardiac output syndrome, etc.. SPSS version 10.0 was used for all analyses. A *p* value of less than 0.05 was accepted as significant.

RESULTS

Between June 2006 and November 2008, coronary revascularization was done in 51 high risk patients with average parsonett score 15.4 ±2.8. These patients were divided in 2 groups OPCAB & CABG

groups with the demographic profile of the patients and the risk factors were fully matched and balanced. The preoperative variables of the patients are shown in Table 1. Two patients in OPCAB group had to be converted to CPB resulting the number of patients in OPCAB (n=23) & CABG(n=28).. There were almost 82% males, two thirds of the patients had diabetes mellitus. Mean left ventricular ejection fraction was present in 30.2 ±3.5in the OPCAB versus 29.7±2.8 in the CABG group (p=0.904). Previous history of stroke or cerebrovascular disease was present in 8.6% in the OPCAB group and 7.1% in the CABG group (p=0.660). Incidence of COPD & CRF 21.1% & 8.6% in OPCAB versus whereas 21.4% & 7.1% in CABG respectively (p=0.995) & (p=0.323).

The results of coronary angiography are shown in Table 2. The severity of coronary artery disease was comparable in the two groups, with the incidence of triple vessel disease in OPCAB 70.1% versus 78.2% in CABG (p=0.546). Similarly incidence of left main is the same between 2 groups (p=0.099). The operative characteristics of the patients are displayed in Table 3.The LIMA was used in 100% patients in the OPCAB(p=0.235), & all territories were revascularized in off pump surgery & thus complete revascularization was achieved in all cases. Intraoperatively, more patients in the OPCAB group required inotropic agents than those in the CABG group. Average operating time was significantly less in the OPCAB group (p<0.001).

Table 4 shows postoperative outcome data for the two groups of patients. Hospital mortality was 3.3% and 4.5% in the OPCAB and CABG groups, respectively (p = 0.001). The requirement of intraaortic balloon pump postoperatively was also less in the OPCAB(2 patients) versus CABG(5 patients)(p <0.001 group). The incidence of postoperative MI, stroke, renal dysfunction, pulmonary infection, and sternal infection was significantly less in OPCAB group as shown in Table 4. The mechanical ventilation time, blood transfusion requirement was significantly less in OPCAB group. The incidence of low cardiac output syndrome and atrial fibrillation were significantly less in the OPCAB group. The length of intensive care unit stay & hospital stay were significantly less in the OPCAB group. Overall cost of the operation was less in OPCAB group as compared to CABG group. This cost was further reduced by the repeated use of stabilizers & shunts after ETO sterilization.

Table1 Demographic Profile

Variable	**OPCAB Group (*n* =23)**	**CABG Group (*n* = 28)**	***p* Value**
Age (y)	58.9 ± 11.0	60.3 ± 9.9	0.118
Male (%)	19 (82.6)	23 (82.14)	0.232
Female (%)	4 (17.4)	5(17.16)	0.112
Diabetes	17 (73.9)	19(67.8)	0.403
Hypertension (%)	11(47.8)	10(35.7)	0.832
Smoker (%)	15 (65.3)	18 (64.2)	0.669
COPD (%)	5 (21.1)	6 (21.4)	0.995
History of CVA (%)	2 (8.6)	2 (7.1)	0.660
NYHA class III or IV (%)	12 (52.1)	11(39.2)	0.360
Unstable angina (%)	6 (26.0)	8 (28.57)	0.838
Chronic renal failure	2(8.6)	2(7.1)	0.323
CHF (%)	3(13.0)	4(14.2)	0.352
Parsonnet score	15.4 ± 2.8	14.9± 2.5	0.443

CVA = cerebrovascular accident; NYHA = New York Heart Association; CABG = coronary artery bypass grafting; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease;

Table 2. Coronary Angiography Findings

Variable	**OPCAB Group (*n* =23)**	**CABG Group (*n* = 28)**	***p* Value**
Single-vessel disease (%)	2 (8.6)	2(7.1)	0.560
Double-vessel disease (%)	3 (13.1)	4 (14.2)	0.721
Triple-vessel disease (%)	16(70.1)	22(78.2)	0.546
Left main stenosis (%)	5 (21.5)	6(21.3)	0.099
LVEF	30.2±3.5	29.7 ±2.8	0.904

Table 3. Intraoperative Variables

Variable	**OPCAB Group (*n* = 23)**	**CABGGroup (*n* = 28)**	***p* Value**
LIMA (%)	23 (100)	26(92.85)	0.235
No. of grafts	3.0 ± 0.4	3.2 ± 0.3	0.066
Total operating time (min)	176 ± 41	242 ± 47	<0.001
Intraoperative IABP (%)	2 (8.6)	5 (17.16)	<0.001

Table 4. Postoperative Results

Variable	OPCAB Group (*n* =23)	CABG Group (*n*=28)	*p* Value
Intubation time (h)	19 ± 5	24 ± 6	<0.001
Postoperative inotropes (%)	17(73.5)	26 (92.8)	<0.001
Blood loss (mL)	362 ± 53	580 ± 66	<0.001
Blood transfusion (%)	10 (43.4)	26 (92.8)	<0.001
Postoperative IABP (%)	2(8.6)	5 (17.6)	0.001
Perioperative MI (%)	2 (8.6)	3 (10.2)	0.879
Reoperation for bleeding (%)	1 (4)	6(21.9)	<0.001
low cardiac output syndrome	2 (8.6)	6 (21.7)	<0.001
Stroke (%)	(0)	1 (0.97)	<0.001
Prolonged ventilation (%)	1 (4)	4 14.2)	0.002
Renal dysfunction (%)	2 (3.9)	5(17.1)	<0.001
ICU stay (h)	18	33	<0.001
Pulmonary infection (%)	1 (2.9)	7(3.6)	<0.001
Sternal infection (%)	2(1.1)	3 (1.4)	0.633
Operative mortality (%)	1 (3.3)	3 (4.5)	<0.001

DISCUSSION

CPB and cardioplegic arrest can cause myocardial dysfunction, negative central nervous system effects, neuropsychiatric phenomena, severe systemic inflammatory response, and coagulopathy associated with end-organ injury[9,10,11,12]. A number of studies have demonstrated that advanced age, urgent operation, impaired left ventricular function, cerebrovascular disease, female sex, New York Heart Association class III or IV status, and left main coronary artery stenosis were independent predictors of operative risk .[13] Patients with these described comorbid conditions may have cumulative risk score reached an average of 24 points using Parsonnet's operative predicted risk stratification. The development of new mechanical stabilizers & refinements in off-pump technology has led to the widespread application of coronary revascularization without CPB. Recent studies demonstrate the success of complete revascularization in beating heart surgery[14]. OPCAB surgery has been shown to be a feasible, safe alternative to on-pump coronary artery surgery. Complete revascularization can now be accomplished in the majority of patients with excellent short-term results[15]. This technique is now being used for high-risk patients including patients with poor ventricular function, advanced age, renal dysfunction, and previous history of stroke; morbidity and mortality have be en reported to be lower than in patients undergoing operation on CPB[16,17].

OPCAB surgery is more cost effective, is associated with less mortality & morbidity, accelerates postoperative recovery, and shortens the time to return to work compared with the conventional approach. In our study, the mortality of OPCAB was significantly less as compared to that of CABG patients. The OPCAB approach has been shown to reduce perioperative complications and resource use in patients[18]. The incidence of postoperative complications was less in the OPCAB than in the CABG group in our study also. The stroke rate in our study was less in the OPCAB than in the CABG group, Ricci and colleagues [19] have also shown reduced incidence of stroke in octogenarians undergoing OPCAB. A possible mechanism may be the significantly higher rate of arteriosclerosis of the ascending aorta in octogenarians, which may potentiate migration of atheromatous microemboli to the brain during aortic cannulation and result in neurologic injury after on-pump CABG. The largest benefits were observed for the variables transfusion, length of stay in the ICU and the HDU, and total length of stay.

Many studies[16,22] have reported excellent results for OPCAB group of patients with relatively low mortality and morbidity & reported better preservation of interventricular septal contractility after OPCAB [21], and the avoidance of damaging effects of CPB and aortic crossclamping.

Exposure and stabilization of the vessels on the posterior and lateral walls present an occasional challenge in these patients, especially in the presence of significant cardiomegaly. Deep pericardial sutures, deep vertical right pericardiotomy, and extensive right pleurotomy help in maintaining hemodynamic stability during anastomosis on these vessels in these patients.

. During off-pump coronary revascularization in these patients, myocardial perfusion starts as soon as first distal anastomosis has been completed. This helps to stabilize the patient, and the other anastomosis can be performed in a relatively stable patient.

In conclusion, this study suggests that off-pump coronary artery bypass grafting in high-risk patients is safe and is associated with reduced mortality & morbidity in high-risk patients & is also cost effective,

when compared with conventional on-pump coronary artery revascularization.

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