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Original Research Article

RETROSPECTIVE OBSERVATIONAL ANALYSIS OF A CORONARY ARTERY BYPASS GRAFTING SURGERY PATIENT COHORT: OFF PUMP VS ON PUMP

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Abstract

Introduction: Cardiovascular disease has emerged as a major health burden worldwide. Ischemic heart disease contributes to a major chunk of deaths of which the majority is from developing countries . Coronary artery bypass grafting is one of the treatment options for a patient with ischemic heart disease and the debate between the superiority of surgical procedure, On Pump CABG vs Off pump CABG goes on. This study attempts to evaluate the outcome of On Pump CABG (ONCAB) vs Off Pump CABG(OPCAB) in a tier 2 city.

Materials and Methods This study is a retrospective, nonrandomized observational study, based on coronary artery disease patients admitted to the Dept of Cardiothoracic Surgery, Sri Jayadeva Institute of Cardiovascular Science and Research Gulbarga, in between June 2022 and May 2023.

Results Of the 134 patients who underwent surgery, a total of 114 OPCAB surgeries were done and 20 ONCAB surgeries were done. Male patients had more incidence of coronary artery disease. Triple vessel disease is more common than double and single vessel disease. Diabetes is one of the most common comorbid condition. Ventilation time and icu stay was almost the same in both the groups. CNS and renal complications were more in onpump group than off pump group. Mortality was more in on pump group

Conclusion The result of this analysis indicates that off-pump surgery is associated with less operative mortality and morbidity than on-pump surgery and that the use of cardiopulmonary bypass is an independent risk factor for mortality.

Keywords: Cardiovascular disease, Bypass, off-pump surgery

Introduction

Cardiovascular disease has emerged as a major health burden worldwide. It is the number killer among all the diseases. Heart disease contributed to a major chunk of deaths of which the majority is from developing countries (1). A rise in the prevalence of cardiovascular diseases in the early twentieth century and a subsequent decline in the latter half has been well documentedin the industrialized countries. However the scenario is reversed in developing countries especially India with a steady escalation in the prevalence of cardiovascular diseases (2). It has been consistently observed that Indians have premature CAD and that their risk for CAD is two to four times higher than European population (3) and ten times higher than that reported 40 years ago. The emerging trend of CAD in India shows that there is an increase of the disease in the young population. And occurring in younger patients, the disease pattern is

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severe. Within the Indian subcontinent also, there has been a rapid rise in CAD prevalence (4,5) .CAD has a multifactorial etiology with many of the risk factors being influenced by lifestyle, prominent factors being dietary and smoking, diabetes mellitus, hypertension, obesity, COPD.One of the most debated and polarizing issues in cardiac surgery has been whether coronary artery bypass grafting without the use of cardiopulmonary bypass that is off pump CABG or on-pump CABG with use of cardiopulmonary bypass is superior to that performed with the heart-lung machine and the heart being chemically arrested (standard CABG) (6). Beating heart coronary artery bypass grafting is a technique developed to reduce usage of cardiopulmonary bypass. Until recently, CPB was considered to be the most important factor for creating a perfect vascular anastomosis in a quiet, motionless and bloodless field. Because of the many deleterious effects of CPB, recognized to be particularly important in the emerging scenario of an increasing number ofelderly and high risk patients being taken up for CABG, off-pump bypass has gained importance. Many of the technical difficulties of the off-pump technique have been overcome by the development of devices such as stabilizers, snares, shunts, suction cones, etc (7).

Materials and Methods

This study is a retrospective, nonrandomized observational study, based on coronary artery disease patients admitted Dept of Cardiothoracic Surgery, Sri Jayadeva Institute of Cardiovascular Science and Research Gulbarga ,in between June 2022 and May 2023, who underwent surgical intervention for coronary artery disease. Patients with diagnosis of coronary artery disease admitted in the cardiology were followed up and those patients who were suitable for surgery were taken up for surgical treatment and were included in the study list. Of all 134 patients who underwent surgical procedure, treatment was based on prior review of coronary angiograms of the respective patients. Patients who were operated on an emergency basis and patients who had previous cardiac surgery were excluded from this study. Patients were taken up for surgical management after obtaining informed consent; either on-pump or off-pump coronary artery bypass surgery. Decision was based on the opinions of the operating surgeons after reviewing the coronary angiograms of the patients. Triple, double and Single vessel diseases were included in the study list.

Statistical analysis was done by collecting preoperative clinical features, operative data and postoperative data and expressed as percentages, mean and standard deviations wherever applicable.

Interpretation of Results

Sex Distribution

In the OPCAB group , 97 were male patients, the remaining 17 being female patients. Of the 17 On Pump CABG patients, 12 were male, remaining 5 being female patients. Including the converted group of patients, the total number of male patients in the on-pump group were 14 and the female patients 6.

	ONCAB	OPCAB	CONVERTED
Males	12	97	2
Females	5	17	1

On calculation of the percentage of the patients, 70 % of the on-pump group were males, while 85.08% of the off pump group were males.

	ONCAB	**OPCAB**

Males	70%	85.08%
Females	30%	14.91%

DISTRIBUTION OF CORONARY ARTERY DISEASE

Among the distribution of the coronary artery disease, of the 134 patients, 73.13% had triple vessel disease, 15.67% had double vessel disease, and 11.19 % had single vessel disease. Of the 98 triple vessel disease patients, 79.59% had off pump CABG and the remaining 20.4% had on-pump CABG including the converted surgeries . In the Double vessel patients group, all had off pump CABG, and in the SVD group , all patients had off pump CABG.
25% of the cases were having left main disease . Out of which 23 were done off pump CABG and 10 were done on pump CABG.

	TVD	DVD	SVD
CABG	17	0	0
OPCAB	78	21	15
CONVERTED	3	0	0

AGE DISTRIBUTION

The majority of patients in the present study belonged to the 41 to 60 years age groups.The mean age in the on-pump patients was 56.76 ±8.22 years, while in the off-pump group it was 46.40 ± 8.03 years. The percentage of patients in the 41 to 50 years age group in the on-pump patients was 29.41% of on-pump patients, while in the off-pump group it was 46.49%. Patients between the ages of 51 to 60 years formed 58.82% of on-pump patients and 31.57% of the off-pump patients.

	31-40yrs	**41-50yrs**	**51-60yrs**	**61-70yrs**	**71-80yrs**
CABG	**0**	**2**	**10**	**5**	**0**
OPCAB	**17**	**53**	**36**	**6**	**2**
CONVERTED	**0**	**3**	**0**	**0**	**0**

CO-MORBID FACTORS

Among the most common comorbid diseases that have been analyzed, it was found that 52.23% of the 134 patients had diabetes mellitus, 33.58% had hypertension, 39.55% had hyperlipidemia, 11.1% had COPD.
Calculating for the operative groups separately, it was found that 50% had diabetes mellitus, 30% had hypertension, 45% had hyperlipidemia,10% had COPD in ONCAB patients. While for the off pump group, 52.63% had diabetes, 35.29% had hypertension, 38.5% had hyperlipidemia, 11.4 % had COPD.

	DM	HTN	DYSLIPIDEMIA	COPD	SMOKING
CABG	7	6	9	2	6
OPCAB	60	39	44	13	40
CONVERTED	3	0	0	0	0

CARDIOPULMONARY BYPASS CONDUCTION

Cardiopulmonary bypass was utilized in 20 patients for CABG. In 17 patients CPB was used electively and in 3 patients it was used as a bail out. The mean cardiopulmonary bypass

conduction time was 47 minutes.

	Present Study
CPB Time	47 ± 10.44 mins

NUMBER OF GRAFTS

In the patients who had on-pump CABG, 65 % had 3 vessel grafts, 30% had 2 grafts .Of the patients who had off- pump surgery, 64.91% had 3 grafts, 28.07% had 2 vessel grafts and the remaining 6.14% had single vessel graft.

	THREE	TWO	ONE
CABG	13	6	0
OPCAB	74	32	7
CONVERTED	3	0	0

LV FUNCTION

Pre operative LV function is one of the determinants in deciding whether to take a patient electively for off pump CABG or on pump CABG. Usually severe LV dysfunction patients will not tolerate off pump procedures.

Normal LV function >55%
Mild LV dysfunction 45-54%
Moderate LV dysfunction 36-44%
Severe LV dysfunction <35%

	EF >55%	EF 45-54%	EF 36-44%	EF <35%
ONCAB	0	3	10	7
OPCAB	70	20	14	10

TYPES OF CONDUITS

In the present study, two types of vascular conduits were used. The left internal mammary artery graft and the great saphenous vein graft. In majority of the cases both LIMA and SVG were used as conduits, 18 patients in the on- pump group and 109 in the off-pump group. Next in strength were SVG alone grafts, i.e.2 patients in the on-pump group, and 2 in the off-pump group. While LIMA alone was used in 3 patients who underwent off pump bypass surgery.

	LIMA+SVG	ONLY LIMA	ONLY SVG
ONCAB	15	0	2
OPCAB	109	3	2
CONVERTED	3	0	0

Usage of IABP

5 patients needed IABP support postoperatively. 3 patients who had undergone OPCAB procedure and 2 who had undergone on pump procedure

OPCAB	ONCAB
3	2

DURATION OF CARE

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During the postoperative period, the duration of ventilation, intensive care and total hospital stay were noted. It was observed that the mean ventilation time was 1.58 ± 1.13 days in the on-pump group, while it was 1.41 ± 0.98 days in the off-pump group of patients. The duration of mean intensive care was 4.6 ± 2.8 days in the on-pump group, while it was 3.85 ± 1.9 days in the off-pump group. And the average hospital stay period was 9.21 ± 1.03 in patients in the on-pump group , while it was 9 ± 0.42 days in the off-pump group.

	Ventilation	**ICU**	**Hospital**
CABG	1.58 days	4.6 days	9.21 days
OPCAB	1.41 days	3.85 days	9 days

POSTOPERATIVE COMPLICATIONS

The most common postoperative complication was excess drainage. The mean quantity of postoperative bleeding was 479.60 ml in the on-pump bypass group with a standard deviation of 291.69 ml, while in the off-pump group it was 335.58ml with a standard deviation of 220.58 ml. While the range extended from 150 ml to 1500ml for the on- pump group, it was 150 to 1350 ml for the off-pump group , with only one patient in the off-pump group having more than 1000 ml drainage. Although 10 patients had significant bleeding, reopening for excess drainage as the primary cause was done for only 2 patients in the on- pump group, the remaining done for other various causes causing hemodynamic instability. In the off-pump group, reopening for bleeding as the primary cause was done in only 1 patient, the other reopening done for hemodynamic instability due to VT.

	Excess drain	**Renal**	**CNS**	**Arrythmia**	**Re ex**	**Stern inf**	**Lung infection**
CABG	**3**	**2**	**1**	**2**	**3**	**3**	**1**
OPCAB	**6**	**6**	**2**	**4**	**3**	**2**	**6**
CONVERTED	**1**	**0**	**1**	**0**	**0**	**0**	**2**

DISTRIBUTION OF COMPLICATIONS

	Excess Drain	Renal	CNS	Arrhythmia	Re-exploraton	Sternal Inf	Lung inf
CABG	20%	10%	10%	10%	15%	15%	15%
OPCAB	5.2%	5.2%	1.7%	3.5%	2.62%	1.7%	5.2%

Other important primary complications studied were CNS and renal complications.

CNS COMPLICATIONS

With reference to neurological complications, among the 134 total patients, 4 patients developed neurological complications.

Among these patients, 2 belonged to the on-pump group, 2 to the off-pump group and 1 belonged to the converted group. Approximately, 10% of the on-pump patients developed neurological complications, whereas it was 1.7% in the off-pump group. The range of neurological complications varied from cerebrovascular accident like monoplegia, hemiplegia

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to Hypoxic encephalopathy. Among the 4 patients who developed neurological complications, 3 patients developed monoplegia and hemiplegia, while the remaining 1 patient developed hypoxic encephalopathy.

All neurological complications were referred to expert neurological opinion and guidance for management. Neurological impairment after bypass surgery may be attributable to hypoxia, emboli, hemorrhage, and/or metabolic abnormalities. Postoperative neurological deficits have been divided into type 1 (associated with major focal neurological deficits, stupor, or coma) and type 2 (in which deterioration in intellectual function is evident). Adverse cerebral outcomes are observed in approximately 6% of patients after bypass surgery, divided equally between type 1 and type 2 deficits. Predictors of type 1 deficits include proximal aortic atherosclerosis (defined by the surgeon at operation), prior neurological disease, use of an intra aortic balloon pump (IABP), diabetes, hypertension, unstable angina, and increased age. Predictors of type 2 deficits include history of excess alcohol consumption, arrhythmias including atrial fibrillation, hypertension, prior bypass surgery, peripheral vascular disease, and congestive heart failure.

POSTOPERATIVE RENAL FAILURE – MANAGEMENT

Of the 20 patients who underwent on-pump bypass surgery, 3 patients developed postoperative complication of renal failure, while in the off- pump group, 6 patients developed renal failure postoperatively. Of these total 6 patients, 5 in the on-pump group were treated medically successfully, while the remaining 1 in the off-pump group had undergone dialysis treatment for renal failure. 2 patients in the on-pump group were treated medically and 1 required dialysis.

	medical	Dialysis
ONCAB	2	1
OPCAB	5	1

MORTALITY

There were 2 mortalities in the on-pump group, i.e. 10% of 20 patients, and 4 deaths, i.e. 3.5% of the 114 patients who underwent OPCAB surgery.

PATIENTS	ONCAB	OPCAB
TOTAL	20	114
DEATHS	2	4

The deaths were due to low cardiac output syndrome with prolonged ventilator support and multiorgan failure in 4 patients and arrhythmia not amenable to medical management in 2 patients

DISCUSSION

For decades the use of cardiopulmonary bypass has been recognized as the main cause of a complex systemic inflammatory response, which significantly contributes to several adverse postoperative outcomes, including renal, pulmonary, or neurological complications, bleeding, and even multiple organ dysfunction (8). Coronary artery bypass graft (CABG) surgery is among the most common operations performed in the world and accounts for more resources expended in cardiovascular medicine than any other single procedure (9).Beating heart operations were reintroduced to routine clinical practice 30 years ago as a last-resort technique limited to patients at high- risk of cardiopulmonary bypass–induced complications. The pioneering off-pump procedures, in which anastomoses were performed on moving and bloody coronary vessels, were technically demanding, and the revascularization of the lateral wall of

the left ventricle was often not feasible. After the recent development of effective devices for target vessel exposure and stabilization, off-pump coronary artery bypass grafting (OPCAB) has gained widespread use as an alternative technique and is now challenging conventional on-pumpgrafting as the standard for surgical therapy in multivessel disease (8). Seven core variables are the most consistent predictors of mortality after coronary artery surgery (9):

- Priority of operation
- Prior heart surgery
- Left ventricular ejection fraction (LVEF)
- Number of major coronary arteries with significant stenoses
- Advanced age
- Gender
- Percent stenosis of left main coronary artery

The present study being a retrospective non-randomized study, the total number of patients were 134, 20 belonging to the on-pump group and 114 belonging to the off-pump group. Among the other studies used for comparison, Mack et al studied on 10118 on-pump patients and 7283 off- pump patients, while Cleveland Clinic study involved 406 each of on- pump and off-pump patients, Nathoe et al study involved 139 on-pump and 142 off-pump patients. A more relevant study with regard to local population, Raghuram et al involved 53 on-pump and 48 off-pump patients (10,11,6,12). Mean age in the on-pump group was 50.51 while it was 49.02 in the off-pump patient group, when compared to Raghuram et al , which was 57.4 and 59.6 respectively. One western study by Hasse et al had a mean age of 64.7 and 65.9 respectively, indicating the earlier occurrence of coronary artery disease in the Indian population (10,6,13). As per Raghuram et al, the sex distribution was 46:7 in the on- pump group and 48:0 in the off-pump group. In this study it was 97:17 and 14:6 respectively, compared with Hasse et al who showed a distribution of 66:24 and 56:34 respectively. This distribution indicates that when compared to the west, coronary artery disease is less prevalent in the Indian female population (10,6,13).In the analysis of the co morbid factors, diabetes, hypertension, chronic obstructive pulmonary disease and hyperlipidemia were given particular attention. In this study, there was a 50% incidence of diabetes in the on-pump group , while it was 52.63% in the off-pump group. As per Raghuram et al , it was 60.4% and 52.1% respectively and 32.2% and 20% respectively in Hasse et al study. The picture shows more prevalence of Diabetes in the Indian population (10,6,13). Hypertension was present in 47.2% and 52.1% respectively in the on-pump and off-pump groups in the Raghuram et al study, while it was 30% and 52.63% respectively in this study. Chronic obstructive pulmonary disease was another co morbid risk factor analyzed in this study which was present in 10% of the on-pump patients and 11.4% of the off-pump patients, while it was 9.4% and 16.7% in Raghuram etal study and 11.1% and 11.1% respectively in the Hasse study (10,6,13).Hyperlipidemia was present in 45% of on-pump patients and 38.59% of off-pump patients in this study, while it was 52.8% and 58.3% respectively in Raghuram et al study and 57% and 77.8% respectively in Hasse et al study (10,6,13).The mean preoperative Left ventricular Ejection Fraction was 55.09% and 57.17% in the Present study, compared to 44.5 and 39.5% respectively in the Raghuram et al study. With regard to Hasse et al, there was a finding of 35.6% and 32.2% of patients who had LVEF < 50% in the on-pump and off-pump groups respectively (10,6,13). With regard to the operative particulars, the left internal mammary artery was used in 96.2% and 93.8% respectively in the on-pump and off- pump group in the Raghuram et al study, compared to 90% and 95.61% respectively in the present study. The average number of grafts used in this study was 2.25 in the On-pump group compared to 2.29 in the off- pump group, while it was 3.2 and 3.0 respectively in the Raghuram et al study.

CONCLUSION

The result of this analysis indicates that off-pump surgery is associated with less operative mortality and morbidity than on-pump surgery and that the use of cardiopulmonary bypass is an independent risk factor for mortality. Certain
results are worthy of note. The first is that the use of cardiopulmonary bypass is an independent risk factor for mortality. Second, there appears to be a particular benefit of avoiding CPB in those subgroups generally considered high risk for CABG surgery, including the elderly, women, and fragile patients.

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