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A retrospective assessment of the early and medium outcomes of on-pump beating-heart versus off-pump CABG in patients with moderate left ventricular dysfunction (LVEF)

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***Abstract*---**Aim: To compare the early and medium outcomes of on-pump beating-heart (OPBH) coronary artery bypass grafting (CABG) and off-pump CABG (OPCABG) in patients with left ventricular ejection fraction (LVEF) between 30% and 40%. Material & Methods: This study was conducted as a retrospective observation over a period of 1 year at the Department of Cardiothoracic and Vascular Surgery, Indira Gandhi Institute of medical Sciences, Patna, Bihar, India.130 patients were selected for this study. All patients were divided into 2 groups, according to the revascularization method: OPCABG group and OPBH group. Results: LVEF before discharge significantly improved from 34.39 ± 4.21 to 44.27 ± 7.29 in the OPBH group and from 34.27±4.61 to 42.66 ± 8.20in the OPCABG group ($P<0.001$). All survival patients have been echocardiographically examined after 6 months which showed a significant higher early postoperative LVEF in the OPBH group than in the OPCABG group (45.28 ± 6.10 versus 44.42 ± 7.08%, respectively; $P=0.002$). Conclusion: The OPBH technique was a safe and an acceptable alternative for surgical

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revascularization in patients with moderate left ventricular dysfunction which provided better midterm MACE-free survival compared with OPCABG.

***Keywords*---**Coronary Artery Bypass, Off-Pump, Ventricular Dysfunction, Left Coronary Artery Bypass, Myocardial Revascularization.

Introduction

Because of developments in equipments, myocardial protection, and surgical technique, both the immediate and long-term outcomes of surgical revascularization are becoming better. This indicates that surgical revascularization will be used in the treatment of an increasing number of high-risk patients who suffer from coronary artery disease [1–5]. Off-pump coronary artery bypass grafting (CABG) is gaining popularity among cardiac surgeons and patients who are scheduled for surgical revascularization. This kind of CABG does not need cardiopulmonary bypass, cardioplegic arrest, or aortic cross-clamping [6, 7].

Off-pump CABG surgery has been widely accepted as a viable option for revascularization of the heart; however, the risk of intra-operative hemodynamic decompensation and insufficient revascularization in patients with severely impaired left ventricular function increases the risk of postoperative morbidity and mortality [8]. This is despite the fact that it has been widely accepted that off-pump CABG surgery is a viable option for revascularization of the heart.

In patients with severe left ventricular dysfunction, post-off-pump CABG surgery morbidity and mortality may remain high due to intra-operative hemodynamic deterioration as a result of insufficient circulatory support. The support provided by an intra-aortic balloon pump (IABP) increases cardiac output by approximately 17 percent in the case of severe pump failure [9-10]. On-pump beating-heart CABG, which includes cardiopulmonary bypass without cardioplegic arrest or aortic cross-clamping, has recently been used to treat high-risk patients [11–12]. This procedure involves beating the patient's heart while the pump is attached to it.

These high-risk patients have recently been treated with a novel hybrid approach, the on-pump beating-heart (OPBH) CABG [13]. By reducing the preload and afterload and maintaining coronary blood flow, this procedure might prevent myocardial damage and the subsequent need for oxygen. An aortic cross-clamp and cardioplegic arrest were averted as a result of this strategy. Even more importantly, it has been shown to minimise inflammation and myocardial edoema [16] by keeping the heart beating.

It was still debatable whether this hybrid procedure was the most effective course of action for the patients [17-19], particularly those who’s left ventricular ejection fraction (LVEF) ranged from 30 to 40 percent. The purpose of this research was to compare the early and medium-term success rates of OPCABG with OPBH CABG.

Material & Methods

This study was conducted as a retrospective observation over a period of 1year and was approved by the Ethics Committee. All operations were performed by the same surgeons. A total of 1005 patients went to the Department of Cardiothoracic and Vascular Surgery, Indira Gandhi Institute of medical Sciences, Patna, Bihar, India, 735 patients underwent OPCABG surgery and 175 patients underwent CABG surgery with CPB assist.

Inclusion criteria comprised patients with: 1, an ejection fraction (EF) value evaluated by pre-operation transthoracic echocardiography (TTE) between 30% and 40%; 2, ischemic heart disease that met surgical revascularization criteria; 3, no other cardiac disease, such as ventricular septal defect, medium to severe mitral regurgitation, and left ventricle aneurysm, that needed to be intervened at the same time.

Finally, 875 patients with LVEF above 40% and 56 patients with other cardiac disease treated at the same time were excluded and 130 patients were selected for this study. All patients were divided into 2 groups, according to the revascularization method: OPCABG group and OPBH group.

Surgical Procedures

Intraoperative trans esophageal echocardiography (TEE) was introduced into the esophagus after general anesthesia. The surgery was operated through a median full sternotomy. Left and right internal thoracic arteries (LITA and RITA) and saphenous vein grafts (SVG) were harvested at the same time using "no touch" technique. Deep pericardial sutures were performed after incision of the pericardium. Surgical revascularization was always started from the LITA going to the left anterior descending coronary territory. Then a sequential technique, right coronary, left circumflex and diagonal, was followed using one SVG. Sideto-side anti-parallel anastomoses were performed with Prolene 7-0 for the sequential bypasses. End-to-side anastomoses were performed with Prolene 6-0 for the proximal aortic connections with the saphenous vein. The anastomosis quality was assessed by transit-time flow probe (Medistim Butterfly Flow Meter, Oslo, Norway). All the target vessels were exposed and controlled with silastic sling. A CO_2-blower mister device was used to visualize the operative field. After the anastomosis, heparin was neutralised with protamine to return the activated clotting time (ACT) to the preoperative level. A cell salvage device was used during surgery and the salvaged blood was rein fused into the patient after bleeding.

In OPBH CABG patients: systemic heparinization was implemented by 3 mg/kg and after the ACT was longer than 480 seconds, CPB was established through ascending aorta and right atrium without cardioplegic arrest or an aortic cross-clamp. Stabilization devices were the Medtronic Octopus apical suction positioning device and the Starfish apical suction positioning device (Medtronic, Inc., Minneapolis, MN, USA). The patients' systemic temperature was approximately 36°C.

In OPCABG patients: heparin was implemented by 1 mg/ kg. Stabilization devices were the Medtronic Octopus apical suction positioning device and the Starfish apical suction positioning device (Medtronic, Inc., Minneapolis, MN, USA). To avoid hypothermia-induced arrhythmia, central temperature was maintained above 36°C.

Baseline clinical data included age, sex, obesity, smoking, NYHA class, PCI, DM, chronic renal dysfunction (CRD), previous MI, recent MI, congestive heart failure, hypertension, hyperlipemia, COPD, stroke, prior cerebrovascular accident, abnormal motion of the segmental cardiac wall, LVEF, LVEDD, enlarged left ventricles, anatomical severity of CAD, and Euro SCORE. Operative data included operation time, number of distal anastomosis, CPB time, SVG, LITA and RITA use, composite graft, urgent switch to on-pump, and prophylactic intra-aortic balloon pump (IABP) support. Bivariate analyses were used to examine differences in baseline characteristics between the two groups.

The primary endpoints studied overall death, including in hospital mortality and death after 30 days or after discharge. The secondary endpoints were the mid-term death and the major adverse cardiovascular events (MACE) rates, such as low cardiac output symptom (LCOS), the need for repeated revascularization, new onset of acute MI, and other cardiac-related complications. Follow-up information was obtained by visit or telephone calls and was agreed by all patients before discharge by informed consent. All surviving patients underwent postoperative echocardiographic re-examination. The mean follow-up time was 6-62 months.

Definitions

Mortality rate due to surgery is defined as the number of deaths that occur during hospitalization and within 30 days following the operation. Resternotomy is defined as a second procedure performed during the first 36 hours after first surgery in order to stop bleeding; Postoperative myocardial infarction is defined as the emergence of new Q waves on the electrocardiogram (ECG) in two or more contiguous leads; Postoperative low cardiac output syndrome equals the need for inotropic support and/or IABP for more than 30 minutes; After OPCABG surgery, atrial or ventricular arrhythmia is defined as any episode of atrial or ventricular fibrillation that was recorded by the monitoring equipment on a rhythm strip or the 12-lead electrocardiogram; Failure of the lungs to recover after surgery is defined as requiring artificial breathing for longer than 72 hours or reintubation. Following heart surgery, a positive result in a sputum culture that indicates the need for anti-infective therapy denotes a postoperative diagnosis of pneumonia; A new persistent neurological event that lasts for more than 24 hours is defined as a stroke. Infection of a deep sternal incision is connected to the bones; any leakage of purulent material from the sternotomy hole and instability of the sternum are symptoms of this infection. Definition and classification of acute kidney injury (AKI) according to the criteria provided by the Acute Kidney Injury (AKI) Working Group.

Results

There were 49 (75.3%) males in the OPBH group and 51 (78.4%) males in the OPCABG group. The mean age was 60.42 ± 10.51 and 60.53 ± 10.70 years old, respectively, in the OPBH and the OPCABG group. Detailed baseline characteristics are shown in Table 1. There were no significant differences in age, gender, obesity, smoking, previous myocardial infarction (MI), previous percutaneous coronary intervention (PCI), hypertension, diabetes mellitus (DM), chronic renal failure (CRF), recent MI, congestive heart failure, hyperlipemia, chronic obstructive pulmonary disease (COPD), prior cerebrovascular accident, abnormal motion of the segmental cardiac wall, LVEF, left ventricular end-diastolic dimension (LVEDD), extent of coronary artery disease (CAD), and Euro SCORE between the 2 groups.

Operation time was 260 ± 47 min in the OPBH group and 222 ± 57 min in the OPCABG group (P<0.0001). The number of distal anastomosis ranged from 2 to 6 and it was 3.82 ± 0.80 in the OPBH group and 3.51 ±0.89 in the OPCABG group (P<0.0001). The internal thoracic artery was used in all patients and SVG number was 60 in the OPBH group and 62 in the OPCABG group. Prophylactic IABP support was used in 7 (10.7%) patients in the OPBH group and 11 (16.9%) in the OPCABG group (P=0.601). More detailed data are shown in Table 2.

LVEF before discharge significantly improved from 34.39±4.21 to 44.27±7.29 in the OPBH group and from 34.27±4.61 to 42.66±8.20in the OPCABG group (P<0.001). All survival patients have been echocardiographically examined after 6 months which showed a significant higher early postoperative LVEF in the OPBH group than in the OPCABG group (45.28 ± 6.10 versus 44.42 ± 7.08%, respectively; P=0.002) (Table 3).

Table 1. Baseline and procedural characteristics after matching

	OPBH group(n=65)	%	OPCABG group(n=65)	%	P value
Age (years old)	60.48±9.44		61.22±9.59	32.31	0.661
Older age (>65 years old)	15	23.08	21	78.46	0.819
Male	49	75.38	51	63.08	0.521
Obesity (BMI >30 kg/m^2)	37	56.92	41	53.85	0.317
Smoking	30	46.15	35	67.69	0.518
NYHA class III-IV	49	75.38	44	76.92	0.748
Previous MI	37	56.92	50	15.38	0.882
Previous PCI	14	21.54	10	72.31	0.902
Hypertension	31	47.69	47	23.08	0.772
Diabetes mellitus	11	16.92	15	9.231	0.990
Chronic renal dysfunction	5	7.692	6	26.15	0.618
Recent MI	8	12.31	17	29.23	0.843
Congestive heart failure	13	20	19	80	0.980
Hyperlipemia	44	67.69	52	16.92	0.952
COPD	9	13.85	11	60	0.789
Prior cerebrovascular	33	50.77	39	61.54	0.721

accident					
Abnormal motion of the segmental cardiac wall	27	41.54	40	32.31	0.417
LVEF	34.39 ± 5.71		35.81 ± 5.80		0.551
LVEDD	62.37 ± 6.61		60.39 ±6.88		0.518
Enlarged left ventricles (LVEDD >65 mm)	20 (33.3%)		17 (26.1%)		0.271
Extent of CAD	Left main stem disease		19(29.2%)	21 (32.3%)	0.661
	Three vessels		54 (83.0%)	56 (90.7%)	0.618
	Two vessels		13 (27.6%)	9 (13.8%)	0.720
	Logistic EuroSCORE		7.61 ± 2.80	7.44 ± 2.61	0.618

Table 2. Intra-operative data after matching

	OPBH group (n=65)	%	OPCABG group (n=65)	%	P value
Operation time (minutes)	260 ± 47		222 ± 57		0.0001
Number of distal anastomosis	3.82 ± 0.80		3.51 ±0.89		<0.0001
SVG use	60	92.31	62	95.38	0.821
LITA use	59	90.77	57	87.69	0.610
RITA use	4	6.154	4	6.154	0.661
Composite grafting	62	95.38	63	96.92	0.890
Prophylactic IABP support	7	10.77	11	16.92	0.601

Table 3. Postoperative data

	OPBH group (n=65)	%	OPCABG group (n=65)	%	P value
Surgical mortality	6 (4.55%)	9.2	8 (4.41%)	12.3	0.618
Resternotomy for bleeding	__		__		__
ICU stay (days)	2.38 ± 0.66		3.52 ± 1.10		0.662
Hospital stay (days)	8.77 ±1.45		9.37 ±2.12		0.362
Ventricular arrhythmia	4	6.154	6	9.231	0.729
Low-output syndrome	1	1.538	2	3.077	0.859
Drainage during the first 12 hours (ml)	430 ± 126		371 ± 149		0.882
Stroke	2	3.077	5	7.692	0.549
Myocardial infarction	1	1.538	3	4.615	0.318
Atrial fibrillation	18	27.69	32	49.23	0.520
AKI requiring dialysis	3	4.615	7	10.77	0.551
Respiratory failure	__	__	1	1.538	0.472
Pneumonia	2	3.077	5	7.692	0.702
DSWI	1	1.538	2	3.077	0.783
LVEF before discharge	44.27 ± 7.29		42.66 ± 8.20		0.001*
LVEF after 6 months	45.28 ± 6.10		44.42 ± 7.08		0.002*

Discussion

The long-term results of off-pump and on-pump CABG were published by certain big randomised studies (ROOBY and CORONARY) [19]. However, only a limited number of individuals who were diagnosed with left ventricular dysfunction participated in these studies.

Therefore, the most effective way of surgical revascularization is still up for debate for patients who have moderate left ventricular failure (EF between 30 and 40 percent). Reports have demonstrated that manipulation and hemodynamic worsening during OPCABG might result in the immediate conversion to conventional CPB, which leads to a poor prognosis and dramatically increased in-hospital mortality. This is particularly true in patients who have left ventricular dysfunction [20-21]. The conversion rate was significant in light of the multiple risk factors, including inexperienced surgeons [22], risk factors posed by patients, and the absence of any significant technological benefits.

Patients who presented with high risk, such as those with poor cardiac function[23], poor-quality coronary targets[24], prior MI, redo or salvage revascularization[25], or COPD[26], accounted for the majority of conversions, and their presence was predictive of a several fold increase in the risk of conversion, according to a meta-analysis of recent reports. Therefore, the rapid conversion during OPCABG surgery may not be necessary in individuals who have OPBH CABG surgery. These patients have moderate left ventricular dysfunction.

Some critics might argue that low EF patients treated with off pump technique would undergo incomplete revascularization because during OPCABG, low blood pressure and arrhythmia always appeared, especially if the position changed during circumflex anastomosis[27]. Some surgeons would give up continuing revascularization to avoid ventricular arrhythmia. Although incomplete revascularization would not increase early risk, the long-term outcomes, such as recurrent angina and other ischemia symptoms, decreased the late survival rate and required reintervention. Previous studies have investigated the on-pump beating-heart technique for surgical revascularization. Even by 2005, Rastan and colleagues [28] had prospectively examined randomized data of markers of myocardial injury in 20 patients with a normal ejection fraction who underwent off-pump CABG compared to 20 patients with a normal ejection fraction who underwent on-pump beating-heart CABG, and they showed off pump CABG had less myocardial injury than on-pump beating-heart CABG. The reason for this difference may have been the study population because the current study focused on high-risk patients with left ventricular ejection fraction of 35% or less. Gulcan and colleagues [29] evaluated myocardial function and clinical outcomes of 46 high-risk patients with an ejection fraction <30% who received on-pump beating-heart CABG and associated procedures, and they found that the on-pump beating-heart CABG technique was effective for protecting myocardial functions in patients with severe left ventricular dysfunction and was associated with low postoperative morbidity and mortality. This evidence agreed with the outcomes of the current study. Another study [30], including patients with a high-risk Euro-SCORE and with a mean EF of 0.37, revealed that the on-pump beating-heart method seemed to be safe, secure and effective for this population of very high-risk patients and conducive to complete revascularization, reducing early complications and multi-organ failure compared to off pump CABG.

According to our research, the percentage of urgent switches was 7.35 percent. When compared with OPBH patients, urgent switch patients had significantly higher rates of low cardiac output, the need for IABP support, acute kidney injury requiring dialysis, longer durations of mechanical ventilation, and longer stays in the intensive care unit. This highlighted the disadvantage of urgent switch. If they discovered that it was difficult to anastomose during OPCABG before revascularization, some surgeons would prefer to have the option to select the CPB assist, often known as an elective conversion. This voluntary conversion often occurred in patients with an enlarged left ventricle, which was not related with worse results, as a study demonstrated [31].

Conclusion

The OPBH technique was a safe and an acceptable alternative for surgical revascularization in patients with moderate left ventricular dysfunction which provided better midterm MACE-free survival compared with OPCABG.

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