Bangabandhu Sheikh Mujib Med. Coll. J. 2022;1(1):04-08

Original Article

Comparison of Early Outcome of Off-pump and Conventional Coronary Artery Bypass Graft Surgery in Patients with Left Main Coronary Artery Disease with Left Ventricular Dysfunction

SK Raha[1], S Hossain[2], SK Biswas[3], S Rahman[4], MK Hasan[5]

Abstract:

Left Main (LM) coronary artery disease and left ventricular dysfunction both are important predictors of in-hospital mortality. To avoid the harmful effects of cardio pulmonary bypass (CPB), many cardiac surgeons are using Off-pump Coronary Artery Bypass (OPCAB) as an effective alternative to conventional CABG (CCAB) even in these sub-groups of patients. This study performed in the National Institute of Cardiovascular Diseases (NICVD) evaluated the early outcomes of OPCAB in terms of mortality and major post-operative morbidities and compared them with that of CCAB in patients with left main coronary artery diseases with left ventricular (LV) dysfunction. Total 120 patients with left main coronary artery disease with reduced left ventricular ejection fraction (≤40%) were allocated into two groups: a) 60 patients who underwent OPCAB and b) another 60 patients who underwent conventional CABG between January 2012 and December 2017. All risk factors and co-morbidities were homogenously distributed between the two groups. Majority of the patients had triple vessel disease. Nearly three-quarters (73.3%) of patients in OPCAB group and 80% in CCAB group received 3 grafts (p=0.470). The mean total operative time (p< 0.001), intubation times (p<0.001), blood losses (p < 0.001); requirements for blood and blood products (p < 0.0010), intensive care unit stays (p<0.001) and hospital stays (p< 0.001) were all significantly lower in the OPCAB group. OPCAB is a safe and effective operative revascularization procedure for patients with left main coronary artery disease with left ventricular dysfunction and is associated with reduced morbidity.

Key words: OPCAB, CCAB, Left Main Coronary Artery Disease, Left Ventricular Dysfunction.

Introduction:

Jones et al after examining seven large datasets, with more than 172,000 patients undergoing isolated CABG found seven variables to be predictive of mortality - urgency of operation, age, prior heart surgery, gender, left ventricular ejection fraction (LVEF), and percentage of stenosis of the left main coronary artery and number of major coronary arteries with 70% stenosis.[1]

CABG with cardioplegia has been considered the gold standard operation for coronary revascularization[2]. However, high risk patients are extremely sensitive to cardioplegic arrest and have higher intra-operative and post-operative risk[3].

Atrial fibrillation occurs in 20-40% of patients who had CABG with cardiopulmonary bypass and is associated with higher risk of cerebrovascular accidents[4]. The higher incidence of post-operative IABP insertion, renal hemodialysis, mechanical ventilation and/or re-intubation or tracheostomy could be responsible for the significant higher rate of readmission for CPB patients[5].

In the mid-1990s interest in beating-heart techniques experienced resurgence in an attempt to decrease the morbidity associated with CABG without jeopardizing the benefits[6]. Although the initial experience with OPCAB was limited to single or double vessel disease with preserved left ventricular function[7-8], the availability of modern retractor-stabilizers, heart positioning devices, techniques of exposure of all surfaces of heart, intracoronary shunts, and adequate surgeon experience, similar completeness of revascularization and graft patency can be achieved with OPCAB even in patients with left main disease

1. Dr. Sanjay Kumar Raha, MBBS, MS (Cardiovascular and Thoracic Surgery), Associate Professor, Department of Cardiac Surgery, NICVD

2. Dr. Sorower Hossain, MBBS, FCPS (Cardiovascular and Thoracic Surgery), Assistant Registrar, Department of Cardiac Surgery, NICVD

3. Dr. Smriti Kana Biswas, MBBS, FCPS (Gynaecology and Obstetrics), Medical Officer, 250 Bedded TB Hospital, Shyamoli, Dhaka.

4. Dr. Salauddin Rahman, MBBS, MS (Cardiovascular and Thoracic Surgery), Assistant Registrar, Department of Cardiac Surgery, NICVD

5. Dr. Md. Kamrul Hasan, MBBS, MS (Cardiovascular and Thoracic Surgery), Professor, Department of Cardiac Surgery, NICVD

Address of correspondence :
Dr. Sanjay Kumar Raha, Department of Cardiac Surgery, National Institute of Cardiovascular Diseases, Dhaka-1207, Bangladesh.
Phone: +8801720988629,
E-mail: drsanjayraha77yahoo.com

with reduced left ventricular function[9-11]. Now OPCAB is widely accepted and considered to be safe for myocardial revascularization specially for high risk patients[12].

The rapidly increasing incidence of diabetes mellitus, hypertension, and hypercholesterolemia in most communities has given rise to more severe and diffuse coronary artery disease[13]. As a result of improvement in invasive cardiology most patients referred for CABG have diffuse disease and poor ventricles. The global ischemia caused by conventional CABG (CCAB) could be detrimental to them. The OPCAB technique was developed with specific purpose of reducing mortality and morbidity in high risk patients[6].

Methodology:

This prospective non-randomized clinical study was done in National Institute of Cardiovascular Diseases (NICVD) from January 2012 and December 2017. Among the 120 patients with left main coronary artery disease with reduced left ventricular ejection fraction (≤40%) 60 patients underwent OPCAB (Group: A) and the rest 60 underwent conventional CABG (Group: B).

Anesthesia and Monitoring

Premedication, induction, maintenance and monitoring were done according to local protocol. Femoral artery canulation was performed in patients with poor ventricular function (left ventricular ejection fraction <35%) in the event that urgent institution of an intra-aortic balloon pump (IABP) was required. The patient's temperature was maintained close to 36^{o}C for OPCAB and 32-34^{o}C for CCAB.

Technique of CABG

All patients were operated through a median sternotomy. Intravenous heparin (100 IU/kg and 300 IU/kg) was given to maintain an activated clotting time (ACT) of 300 second for OPCAB and 450 second for CCAB. Proximal anastomoses were performed on the partially clamped ascending aorta using 6-0 continuous polypropylene suture. Distal anastomoses were performed with continuous 7-0 or 8-0 polypropylene (Prolene) monofilament suture. After the procedure, heparin therapy was reversed with protamine sulfate in a 1:1 ratio. The leg, forearm, and chest wounds were closed and the patients were shifted to ICU.

Postoperative Management in ICU

Cardiac, respiratory, renal function and hourly blood loss were monitored meticulously. Extubation was done as early as possible while the patients fulfilled the extubation criteria. Arterial blood gas, serum electrolytes and hematocrit estimation were done as per standard protocol. Haemodynamic and other parameters were managed according to standard protocol.

Results:

Patient characteristics are shown in the Table-1. The mean ages of the study sample of OPCAB group and CCAB group were similar (p=0.2986; >0.05). Both sexes were homogenously distributed between the two groups but with clear male predominance (90% in OPCAB vs. 91.17%). Overweight and obese patients were higher among CCAB group than that in OPCAB group (43.3% vs. 33.3%). However, the mean BMI were almost similar (p = 0.5885; >0.05). Both groups had similarly distributed co-morbidities (p values >0.05). In the study the mean left ventricular ejection fraction (LVEF) was almost similar in both groups (p = 0.3414). Five (8.33%) patients of OPCAB group and 10% of CCAB group were in NYHA class II or III (p=0.75173, >0.05). However, most of the patients of both groups were in NYHA class I. Similarly, 43.33% patients of OPCAB group and 53.33% of CCAB group were in CCS angina class III or IV (p=0.757, >0.05). Most of the patients of both groups were in CCS angina class I. Pre-operative angiographic study demonstrated that majority of the left main patients had triple vessel disease (TVD) in each group (p=0.5315). The rest had double vessel disease (DVD) (p=0.6091) and left main only (p=1.0). So, all pre-operative parameters were almost identically distributed between the groups (p > 0.05).

The operating time was significantly higher in CCAB group (p< 0.001). Left internal mammary artery (LIMA) was anastomosed to left anterior descending artery (LAD) in all the patients. Radial artery was used similarly in both the groups (p=0.6091). Most of the patients of both groups (p = 0.470) required 3 grafts.

Among the post-operative variables the mean ventilation time was significantly higher in the CCAB group than those in OPCAB group (p<0.001). Four CCAB patients required prolonged inotropic support. Among them 2 required IABP support. On the other hand, one of the OPCAB patients received prolonged inotropic support and one required IABP. Total post-operative bleeding and blood product requirement were significantly lower in OPCAB (p < 0.001) group. The average ICU-stay and total postoperative hospital stay were also shorter in OPCAB group (p< 0.001).

One patient of each group (p=1.000) died within 30 days of operation. In the immediate postoperative period, 2 of the CCAB patients and 1 of the OPCAB patients developed new Q-wave myocardial infarction (MI) but all of them recovered with conservative management. The only death of OPCAB group was due to cardiac temponade from mediastinal bleeding. Re-exploration was done and bleeding was secured. But he died later due to multi-organ dysfunction from prolonged low output syndrome. The other patient of CCAB group died of pneumonia requiring re-intubation. Three patients of CCAB group and one of OPCAB group required re-exploration for bleeding (p=0.6186). Two of CCAB patients and one of OPCAB group developed stroke (p=1.000). New postoperative arrhythmias developed in 12 CCAB and 6 OPCAB patients (p=0.236). Most (14 patients) of them had atrial arrhythmia and the remaining (4 patients) had ventricular tachycardia. LOS, pulmonary complications, infective complications, and renal dysfunction, were also more common in CCAB group. Thus, postoperative complications were relatively less common in OPCAB group although statistically not significant.

Table-1: Patient characteristics of multi vessel coronary artery disease

Variables	OPCAB group (n=60)	CCAB group (n=60)	*p* Value
Age, years#	60.3±7.86*	58.9±6.79*	0.29 *ns*
Male, n (%)¥	54(90)	55(91.17)	0.7517*ns*
BMI(kg/m²)#	27.2±2.14*	26.98±2.3*	0.5885*ns*
Hypertension, n (%)¥	32(53.3)	30(50.0)	0.796*ns*
Diabetes mellitus, n (%)¥	23(38.33)	24(40.0)	0.8412*ns*
Smoking, n (%)¥	33(55.0)	32(53.33)	0.8546*ns*
Dyslipidemia, n (%)¥	31(51.67)	35(58.33)	0.5820*ns*
Family H/O CAD, n (%)¥	6(10.0)	8(13.3)	0.500*ns*
Past H/O CVA, n (%)¶	3(5.0)	1(1.67)	0.6173*ns*
COPD, n (%)¥	7(11.67)	5(8.33)	0.54282*ns*
History of MI, n (%)¥	24(40.0)	22(36.67)	0.688209*ns*
PVD, n (%)¥	6(10.0)	5(8.33)	0.75173*ns*
Renal dysfunction, n (%)¶	6(10.0)	3(5.0)	0.4906*ns*
Arrhythmia, n (%)¶	6(10.0)	4(6.67)	0.743*ns*
LVEF (%)#	37.4± 2.2*	36.98± 2.6*	0.3414*ns*
NYHA class II or III, n (%)¥	5(8.33)	6(10.0)	0.75173*ns*
CCS angina class III or IV, n (%)¥	26(43.33%)	32(53.33)	0.757*ns*
LM only¥	6(10.0)	7(11.67)	1.0ns
LM + DVD¥	8(13.33)	10(16.67)	0.6091*ns*
LM + TVD¥	46(76.67)	43(71.67)	0.5315*ns*

***Data are presented as the mean SD for continuous variable.**
 # Student's t-Test, ¥ Chi-square (χ^2) Test, Fisher's Exact Test, ns= Non-significant

OPCAB: Off-Pump Coronary Artery Bypass; CCAB: Conventional Coronary Artery Bypass; COPD: Chronic Obstructive Pulmonary Disease; CVA:Cerebrovascular Accident; MI: Myocardial Infarction; NYHA: New York Heart Association; CCS: Canadian Cardiovascular Society Angina Class; PVD: Peripheral Vascular Disease.

Table 2: Intraoperative Variables

Variables	OPCAB group (n=60)	CCAB group (n=60)	*p* Value
Conversion to CPB, n (%)	2(3.33%)		
CPB time, minutes		106.3 ± 22.9	
Total operating time, minutes#	276.6 ± 29.5*	312.3 ± 31.8*	<0.0001*s*
Conduit used¥			
LIMA, n (%)	60(100%)	60(100%)	0.694 *ns*
Radial artery, n (%)	10(16.67%)	8(13.33%)	0.6091 *ns*
SVG, n (%)	60(100%)	60(100%)	0.694 *ns*
Graft distribution¥			
LAD territory, n (%)	60(100%)	60(100%)	0.694 *ns*
Circumflex territory, n (%)	56(93.33%)	60(100%)	0.246 *ns*
RCA territory, n (%)	51(85%)	50(83.33%)	0.7725 *ns*
Intraoperative IABP¶	0(0%)	2(3.3%)	0.500 *ns*

***Data are presented as the mean SD for continuous variable.**
 # Student's t-Test, ¥ Chi-square (χ^2) Test, Fisher's Exact Test, ns= Non-significant; s = Significant

Table 3: Comparison of post-operative outcome between groups

Variables	OPCAB group (n=60)	CCAB group (n=60)	*p* Value
30 days mortality, n (%)¶	1(1.67)	1(1.67)	1.000 *ns*
Ventilation time, hours#	7.92±0.4*	11.35±0.5*	<0.0001*s*
LOS or Prolonged inotropic support¶	2(3.33)	4(6.7)	0.6794 *ns*
Postoperative IABP¶	1(1.67)	2(3.33)	1.000 *ns*
Total bleeding (ml) #	405 ± 38*	620 ± 42*	<0.0001 *s*
Amount of blood products needed (ml) #	710 ± 35*	1090 ± 45*	<0.0001 *s*
Length of ICU stay(hours) #	72 ± 2.6*	90 ± 2.0*	<0.0001 *s*
Length of post-operative hospital stay(days) #	8.2 ± 0.2*	10.3 ± 0.3*	<0.0001 *s*
Re-exploration for bleeding¶	1(1.67)	3(5.0)	0.6186 *ns*
Stroke¶	1(1.67)	1(1.67)	1.000 *ns*
Pulmonary complication	5(8.33)	6(10.0)	0.7517 *ns*
Perioperative MI¶	1(1.67)	2(3.3)	1.000 *ns*
Arrhythmia¥	5(8.33)	11(18.33)	0.1071 *ns*
Surgical site infection¶	4(6.7)	3(5.0)	1.000 *ns*
Renal dysfunction¶	5(8.33)	7(11.67)	0.5428 *ns*

OPCAB: Off-Pump Coronary Artery Bypass; CCAB: Conventional Coronary Artery Bypass; CPB: Cardiopulmonary Bypass; IABP: Intra-AorticBalloon Pump; LAD: Left Anterior Descending Artery; RCA: Right Coronary Artery; LIMA: Left Internal Mammary Artery; RIMA: Right Internal Mammary Artery; SVG: Saphenous Vein Graft.

***Data are presented as the mean SD for continuous variable.**
 # Student's t-Test, ¥ Chi-square (χ^2) Test, Fisher's Exact Test, ns= Non-significant; s = Significant; LOS= Low Output Syndrome

Discussion:

In the present study, we analyzed our experience with OPCAB in patients having left main disease with reduced left ventricular ejection fraction (≤40%). Although OPCAB approach has fewer short-term complications than on-pump CABG, incomplete revascularization is more common with off-pump approach, which led to more complications and repeat revascularization[14]. Complete revascularization is believed to be important in producing a re-intervention-free result following OPCAB[15]. Meharwal et al[16]. showed the average numbers of grafts 3.0±0.7 for OPCAB group and 3.2±0.8 for on-pump group. Shroyer et al[17]. showed the average numbers of grafts 2.9±0.9 for OPCAB group and 3.0±1.0 for on-pump group. Youn et al[18]. demonstrated in their study that patients with on-pump CABG tended to have more grafts, but there was no significant difference in number of distal anastomoses and complete revascularization between the groups. Technical improvement and experience have led some surgeons to perform off-pump total arterial grafting using two internal thoracic arteries (ITA) or one ITA and radial artery for multivessel coronary artery disease in regular basis[19]. We have used intracoronary shunts in all patients during distal coronary anastomoses. Positioning and stabilization of the heart in OPCAB, specially during circumflex and posterior descending artery anastomosis, are associated with significant haemodynamic changes[20]. These changes may be further exacerbated by the snaring of the coronary arteries. Several studies have shown the effectiveness of intracoronary shunts for maintaining myocardial perfusion to avoid ischemia of target vessels during OPCAB, although the use of shunts is not widespread and remains controversial[21]. We have found intracoronary shunts useful.

The mean period of mechanical ventilation, amount of blood products needed, length of ICU stay and hospital stay during the early post-operative period- all were significantly lower in OPCAB group. All these reflect definite clinical advantage as well as favorable economic outcome associated with OPCAB group of patients. Transmission of viral infections, induction of immunologic transfusion reactions, and suppression of the immune system remain important risks related to the transfusion of blood and blood products despite improvements in donor-screening methods[22].

OPCAB has been shown to be associated with decreased morbidity and mortality in high-risk patients, including the elderly, patients with poor left ventricular function, renal dysfunction, left main stenosis, or chronic obstructive pulmonary disease, and patients with prior neurologic dysfunction[23]. As in many studies, our hospital mortalities for OPCAB and CCAB done on patients with multivessel disease with reduced left ventricular ejection fraction (≤40%)were comparable. Meharwal et al. reported that the operative mortality was higher in CCAB group (1.86% vs. 0.97%, p<.001)[16]. Ruzzeh et al[24]. in a multi-centre comparative analysis showed similar result (1.4% vs. 2.9%)[5]. But, Sajja et al. (2.8% vs.3.9%, p=0.746) showed different results.

Study Limitations:

The present study has several limitations and those are as follows:

1. Sample size was small and patients were selected purposefully.
2. They were not randomly assigned to either group.
3. The surgical procedure either OPCAB or CCAB was determined by the surgeon. Therefore selection bias may affect our findings.
4. The duration of follow up of this study was limited. Clinical outcomes were restricted to 30-days mortality. No data beyond three months follow-up were available. Nothing was mentioned about the quality of life after CABG.
5. As a single institutional study the conclusions may not be applicable in general because of differences in practice patterns of other centres.
6. Other factors such as variations in surgical skill, patient difference in extent or distribution of coronary artery disease and echocardiography reports although unavoidable should also be considered.

Recommendations:

We recommend OPCAB as a safe and effective surgical strategy for the patients with left main disease with reduced left ventricular ejection fraction (≤40%). A prospective large scale multi-institutional randomized trial along with long term follow up and evaluation of graft patency is necessary to confirm our findings and to define the long term clinical and functional results of both on-pump and off-pump CABG.

Acknowledgements:

I owe my heartfelt gratitude and indebtedness to Professor Dr. Md. Kamrul Hasan, Professor, Department of Cardiac Surgery, NICVD for his active help, guidance and valuable suggestions.

Disclosure of Interests:

I have no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

References:

1. Jones RH, Hannan EL, Hammermeister KE, Delong ER, O'Connor GT, Luepker RV, et al. Identification of preoperative variables needed for risk adjustment of short-term mortality after coronary artery bypass graft surgery: The Working Group Panel on the Cooperative CABG Database Project. J AmCollCardiol. 1996; 28:1478-87.

2. Favaloro RG, Effler DB, Groves LK, Shelton WC, Sones FM. Direct myocardial revascularization by saphenous vein graft: Present operative techniques and indications. Ann Thorac Surg. 1970; 10:97-111.

3. Wan YP, Arifi A, Wan S, Wong ES, Yip J, Thung KH, et al. Beating heart revascularization with or without cardiopulmonary bypass: Evaluation of inflammatory response in a prospective randomized study. J ThoracCardiovasc Surg. 2004; 127:1624-33.

4. Altarabsheh SE. Outcomes of Off-pump Coronary Artery Bypass Surgery. Bahrain Medical Bulletin2009; 31:3-12.

5. Ruzzeh SA, Ambler G, AsimakopoulosG,Omar RZ, Hasan R, Fabri A,et al.Off-pump Coronary Artery Bypass (OPCAB) Surgery Reduces Risk-Stratified Morbidity and Mortality: A United Kingdom Multi-Centre Comparative Analysis of Early Clinical Outcome. Circulation 2003; 108:1-8.

6. Mack MJ, Pfister A, Bachand D, Emery R, Magee MJ, Connolly M, et al.Comparison of coronary artery bypass surgery with and without cardiopulmonary bypass in patients with multivessel disease. J ThoracCardiovasc Surg. 2004; 127:167-73.

7. Arom KV, Flavin TF, Emery RW,Kshettry VR, Janey PA, Petersen RJ, et al.Safety and efficacy of off-pumpcoronary artery bypass grafting. Ann Thorac Surg. 2006; 669:704 -10.

8. Puskas JD, Wright CE, RonsonRS,Brown WM, Gott JP, GuytonRA, et al. Off-pump multivessel coronary bypass via sternotomy is safe and effective. Ann Thorac Surg. 1998; 66:1068-72.

9. Cohn L. Myocardial Revascularization without Cardiopulmonary Bypass.In:Cohn L, editor. Cardiac Surgery in the Adult. 3rd ed. New York: McGraw Hill Medical; 2008.p. 633-52.

10. Hernandez F, Cohn WE, Baribeau Y. In-Hospital Outcomes of Off-pump Versus On-pump Coronary Artery Bypass Procedure: A Multicenter Experience. Ann Thorac Surg. 2001; 72:1528-34.

11. Roy A, Stanbridge RL, O'Regan D. Progression to 100% offpump coronary artery bypass with the Octopus-1 dual holder. Heart Surg Forum. 2001; 4:174-78.

12. Takai H, Kobayashi J, Tagusari O. Off-pump coronary artery bypass grafting for acute myocardial infarction. Circulation. 2006; 70:1303-06.

13. Royse CF, Royse AG, Wong CT. Assessment of left ventricular function during off-pump coronary artery bypass surgery. Ann Thorac Cardiovasc Surg. 2003; 19:371-77.

14. Hu S, Zheng Z, Yuan X. Increasing long-term major vascular events and resource consumption in patients receiving off-pump coronary artery bypass grafting: A single-center prospective observational study. Circulation. 2010; 121:1800-08.

15. Gundry SR, Romano MA, Shattuck OH, Razzouk AJ, Bailey LL. Seven-year follow-up of coronary artery bypasses performed with and without cardiopulmonary bypass. J Thorac Cardiovasc Surg. 1998; 115:1273-78.

16. Meharwal ZS, Mishra YK, KohliV,Singh N, Bapna RK, Mehta Y, et al. Multivessel Off-Pump Coronary Artery Bypass: Analysis of 4953 Cases.The Heart Surgery Forum. 2003; 6(3):153-59.

17. Shroyer AL, Grover FL, Hattler B,Collins JF, McDonald GO, Kozora E, et al. On-Pump versus Off-Pump Coronary-Artery Bypass Surgery. N Eng J Med.2009; 361(19):1827-37.

18. Youn YN, Chang BC, Hong YS, Kwak YL, Yoo KJ. Early and mid-term impacts of cardiopulmonary bypass on coronary artery bypass grafting in patients with poor left ventricular dysfunction: A propensity score analysis. Circulation. 2007; 71:1387-94.

19. Raja SG, Siddiqui H, Ilsley CD, Armani M. In-Hospital Outcomes of Off-pump Multivessel Total Arterial and Conventional Coronary Artery Bypass Grafting: Single Surgeon, Single Center Experience. Ann Thorac Surg. 2009; 88:47-53.

20. Mathison M, Edgerton JR, Horswell JL, Akin JJ, Mack MJ. Analysis of hemodynamic changes during beating heart surgical procedures. Ann Thorac Surg.2000; 70:1355-61.

21. Lucchetti V, Capasso F, Caputo M. Intracoronary shunt prevents left ventricular function impairment during beating heart coronary revascularization. Eur J Cardiothorac Surg.1999; 15:255-59.

22. Consten EC, Henny CP, Eijsman L, Dongelmans DA, van Oers MH. The routine use of fresh frozen plasma in operations with cardiopulmonary bypass is not justified. J Thorac Cardiovasc Surg. 1996; 112:162-67.

23. Boyd WD, Desai ND, Del Rizo DF, Novick R, McKenzi FN, Menkis AH. Off-pump surgery decreases post-operative complications and resource utilization in the elderly. Ann Thorac Surg. 1999; 68:1490 -93.

24. Sajja LR, Mannam G, Dandu SBR. Off-pump coronary artery bypass grafting in patients with significant left ventricular dysfunction. Ind J Thorac Cadiovasc Surg. 2008; 24:110-15.