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Original Article

ON PUMP BEATING HEART CABG IS SUPERIOR TO CONVENTIONAL CABG IN POOR LEFT VENTRICULAR FUNCTION

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Abstract

Coronary artery bypass graft (CABG) surgery is one of the treatment modalities of coronary artery disease (CAD) patients. There are multiple selection criteria for CABG and multiple procedures like conventional CABG, on pump beating heart CABG and off pump beating heart CABG (OPCAB). This study was intended to compare between conventional CABG and on pump beating heart CABG. Total 60 patients were selected for the study, of which 30 patients had undergone conventional CABG and 30 had undergone on pump beating heart CABG. Different preoperative and postoperative variables shows clear and significant superiority of on pump beating heart CABG. So it may be an alternative surgical procedure where OPCAB is not feasible in poor left ventricular (LV) function.

Key words: Coronary Artery Bypass Graft (CABG), Coronary Artery Disease (CAD), On-Pump beating heart CABG (OnP-BH CABG), Off pump beating heart CABG (OPCAB), Cardiopulmonary bypass (CPB).

Introduction

Coronary Artery Bypass Graft (CABG) surgery is well established treatment modalities in patients with Coronary Artery Diseases (CAD) refractory to medical therapy or when intervention cardiologic procedures (PTCA) are not feasible[1].

In 1950s, before the Cardiopulmonary Bypass (CPB) era, the concept of myocardial revascularization was propounded by Demikhov [2]. In the same decade, Murray and Longmire performed CABG using segmental excision with saphenous vein or internal mammary artery grafts [3]. The first reported successful CABG operation took place in 1964 in Leningrad, where Kolesov grafted a LIMA to the LAD without CBP [4].

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After 1968, CABG with Cardiopulmonary Bypass (CPB) was widely adopted and has become well-established treatment modalities for patients with CAD[5]. However, there has been increasing evidence that CPB may be responsible for some of the morbidities associated with CABG surgery. Thus, it has been proposed that CABG surgery would be safer if CPB would be avoided [6]. The development of new cardiac stabilization devices has allowed for the creation of safe and reproducible anastomoses on beating heart [7]. Several large, nonrandomized, retrospective case series comparing CABG surgery performed on the beating heart (Off pump) and conventional CABG (CCAB) surgery performed with CPB (on pump) have indicated an advantage to CABG surgery without CPB (OPCAB); however, selection bias towards lower-risk cases in OPCAB remains an issue [6]. Furthermore, the potential pitfalls of OPCAB surgery are technically demanding with steep learning, incomplete revascularization, intraoperative ischaemia and sub-optimal anastomoses[2].

Enormous development of medical therapy and intervention cardiology resulted to reduced number of

CABG and the end stage coronary artery diseases (ESCAD) are being submitted for CABG surgery.

ESCAD patients with bypassable vessels to two or more regions of reversible ischaemia can undergo safe CABG with acceptable hospital survival and mortality and morbidity. In high-risk ESCAD patients, who may poorly tolerate cardioplegic arrest, on-pump beating heart (OnP-BH) CABG may be an acceptable alternative associated with lower postoperative mortality and morbidity. Such a technique offers better myocardial and renal protections associated with lower postoperative complications [7, 8].

Furthermore, in high-risk patients (Poor LV function- EF <25%, evolving MI or infarct and advanced age- mean 79.5) OPCAB is not technically feasible. So, an intermediate approach based on maintenance of beating heart with CPB support but without aortic cross clumping and cardioplegic arrest might be an acceptable alternative [9]. It is still associated with the potentially detrimental effects of CPB but eliminates intraoperative global myocardial ischaemia due to avoidance of cross-clumping and cardioplegic arrest [9, 10].

The special emphasis may be projected to CAD with poor LV function (EF <35%). OnP-BH CABG can be done safely in patients with a low ejection fraction [11, 12, 13]. The main advantage of OnP-BH technique is the ability it provides one to perform complete revascularization and intracavity procedures with low morbidity and mortality [12, 13]. It avoids myocardial injury associated with aortic cross clamping in conventional CABG (CCAB) [12].

In Bangladesh, several studies were conducted regarding the outcome of conventional CABG [14, 15, 16] but no previous study on OnP-BH CABG surgery has been carried out till date. We introduced it first time in NICVD. So, it will be beneficial to evaluate the efficacy, safety and applicability of OnP-BH CABG surgery in patients with CAD having impaired LV function. Our study was to identify the CABG procedure that is better for patients with impaired left ventricular function.

Materials and Methods

The study was conducted at National Institute of Cardiovascular Diseases, Dhaka during the period of May 2006 to April 2007. It was a Randomized Control Trial (RCT). Patients undergoing CABG for CAD with impaired left ventricular function (EF < 45%) were selected for the study. Total 60 patients were selected for the study and were divided into two groups: Group I: 30 patients who underwent Conventional CABG (Control group) and Group II: 30 patients who underwent On-Pump Beating Heart CABG (Study group). The patients were explained about the purpose and importance of the study. Informed and written consents were taken from the participants. Inclusion criteria was patients who underwent on-pump beating heart CABG & conventional CABG having CAD with impaired left ventricular function (EF <45%). Exclusion criteria were patients having EF >45%, history of previous cardiac surgery, concomitant procedures including valvular operation, congenital or ventricular aneurysm, reoperation and had history of renal, respiratory or hepatic failure, stroke/TIA or coagulopathy.

Peroperative variables were Total operation time in minutes, Extracorporeal circulation time in minutes, Aortic cross-clamp time in minutes (CCAB), Number of distal anastomoses (LAD, LCX, Diagonal, RCA), Postoperative MI, Ventilation time in hours, ICU stay in hours, Low cardiac output syndrome, Total length of hospital stay in days, Neurological complications, Mortality etc. Assessment of LV function at 3rd month by Echo was done in each patient. Patients were followed up for 3 months. All patients were attended 1 month after discharge and at 3 months following operation. All relevant data was collected from each patient by a predesigned questionnaire.

Result

The mean age was found 62±7 in group-I and 57±11 in group-II (Table-I). The value of unpaired t-test was 1.67 and it was insignificant ($p>0.1$). So there was no age variation between two groups. The Chi-Square test of the preoperative data between two groups was 0.58 with df (c-1) (r-1) =1 (Table-II). The p value was >0.5 and was insignificant. So there was no difference of preoperative data between two groups. The mean operation time in group-I was 276±20.24 minutes and in group-II was 227±15.85 minutes (Table-III). The unpaired t-test value is 10.65 ($p<0.001$) and was highly significant. So, the total operation time was significantly less in group-II than in group-I. The Mean Extracorporeal Circulation Time was 126.4 ± 12.3 min in Group-I and 107±4.5 min in Group-II (Table-IV). Unpaired t-test value was 1.48 ($p>0.1$) and was insignificant. So the Extracorporeal Circulation Time had no difference between two Groups. The mean XCT in Group-I was 61.3 ± 4.42 (Table-V). As there was no Cross Clamp in Group-II, it was 0. The unpaired t-test value was 13.8 ($p<0.001$) and was highly significant. Table-VI shows the Bypass Graft conduits of two Groups. The χ^2 test reveals p value>0.5 and was insignificant. So Graft Conduits are not predictor variables between two Groups. Table-VII shows the name and number of distal anastomosis. The Mean Distal Anastomosis in Group-I was 2.7 ± 1.2 and in Group-II was 3.1 ± 1.3. The unpaired t-test was done with t= 0.22 (p>0.1) and insignificant. So the numbers of distal anastomosis did not vary significantly between two Groups. Table-VIII shows postoperative predictor variables as follows: ICU Stay in Hours: G-I Mean=67.32±5.4, G-II Mean=35.2±4.8, t=4.44 (p<0.05), significant; Ventilation Time in Hours: G-I Mean=18.2±3.5, G-II Mean=10.2±2.4, t=1.88(p<0.05), Significant; Postoperative MI: χ^2 = 0.22(p>.05), Insignificant; Blood Loss in ml: G-I=625.54 ±10.42, G-II=630.4±8.7, t=0.38(p>0.1), Insignificant; Arrhythmia: G-I=13(43%), G-II=5(16%), χ^2 = 3.78(p<0.05), Significant; Inotropic Support in Hours: G-I=62.8±6.4, G-II=30.6±4.7, t=4.05(p<0.001), Significant; Low cardiac output syndrome: G-I=9(30%), G-II=3(10%), $\div^2$ = 3.74 (p=0.05), Significant; Respiratory Complications: G-I=7(23%), G-II= 6(20%), p>0.01 with $\div^2$ test, Insignificant; Renal Complications: G-I=4(13%), G-II=2(6%), p>0.1 with $\div^2$ test, Insignificant; Neurological Complications: G-I=9(30%), G-II=2(6%), $\div^2$ =5.44(p<0.02), Significant; Mortality: G-I= 2(6%), G-II= 1(3%), p>0.5 with $\div^2$ test, Insignificant. So the significant difference was observed in ICU stay, Ventilation time, Development of Arrhythmia, Inotropic support, Low output syndrome and Neurological complications. No significant difference found in Postoperative MI, Blood loss, Respiratory complications and Mortality between two groups.

Table-IX shows LVEF Improvement between two groups. The Unpaired t-test value was 2.47(p<0.02) and was significant. So, the improvement of LVEF in Group-II was more significant than in Group-I.

Table-I

Age and Sex Distribution.

Age		Group-I (30)			Group-I (30)		p value
	Male	Female	Total(%)	Male	Female	Total(%)	>0.1
41-50	5	0	5(16%)	7	0	7(23%)	
51-60	17	1	18(60%)	13	0	13(43%)	
61-70	7	0	7(23%)	10	0	10(33%)	
Mean±SD		62±7			57±11		

The values are numbers with percentage within parenthesis.

Table-II

Preoperative Data

Variables	Group-I	Group-II	p value
HTN	18(60%)	15(50%)	>0.5
DM	11(36%)	9(30%)	>0.5
Creatinine Level >2mg/dl	02(6%)	1(3%)	>0.5
Family History	7(23%)	11(36%)	>0.5
Smoking History	21(70%)	22(73%)	>0.5

The values are numbers with percentage within parenthesis.

Table-III

Total Operation Time

Time	Group-I	Group-II	p value
Range in minutes	230-370	180-295	t- Test= 10.65. p<0.001
Mean ± SE	276±20.24	227±15.85	

Table-IV

Extracorporeal Circulation Time (ECCT)

Time	Group-I	Group-II	p value
Range	80-220	60-175	t= 1.48 p>0.1
Mean ± SE	126.4 ± 12.3	107 ± 4.5	

Table-V

Aortic Cross Clamp Time (XCT) in minutes

Time	Group-I	Group-II	p value
Range	40-84	00	t= 13.8 p<0.001
Mean ± SE	61.3 ± 4.42	00	

Table-VI

Bypass Graft Conduits

Grafts	Group-I	Group-II	p value
LIMA	30(100%)	30(100%)	p>0.5 with ?2 test.
RIMA	0	1(3%)	
RA	1(3%)	1(3%)	
RSVG	30(100%)	30(100%)	

The values are numbers with percentage within parenthesis.

LIMA= Left Internal Mammary Artery; RIMA= Right Internal Mammary Artery; RA= Radial Artery; RSVG= Reverse Saphenous Vein Graft.

Table-VII

Numbers of Distal Anastomosis

Target Vessel	Group-I	Group-II	p value
LAD	30(100%)	30(100%)	
Diagonal	11(36%)	13(43%)	
OM	17(56%)	27(90%)	Unpaired t= 0.22, p>0.1
RI	1(3%)	1(3%)	
RCA	14(46%)	14(46%)	
PDA	9(30%)	11(36%)	
Total	82	95	
Mean ± SE	2.7 ± 1.2	3.1 ± 1.3	

The values are numbers with percentage within parenthesis.
LAD= Left Anterior Descending; OM= Obtuse Marginal; RI= Ramous Intermedius; RCA= Right Coronary Artery; PDA= Posterior Descending Artery.

Table-VIII

Postoperative Predictor Variables in ICU

Variables	Group-I	Group-II	p value
ICU Stay in hours	67.32±5.4	35.2±4.8	t=4.44
Mean ± SE			p<0.05
Ventilation time in hours.	18.2±3.5	10.2±2.4	t=1.88
Mean ± SE			p<0.05
Postoperative MI	3(10%)	2(6%)	$\chi^2$2= 0.22
(Total Affected)			p>.05
Blood Loss in ml	625.54 ±10.42	630.4±8.7	t=0.38
Mean ± SE			p>0.1
Arrhythmia	13(47%)	5(16%)	χ^2 3.78
(Total Affected)			p<0.05
Inotropic support in hours.	62.8±6.4	30.6±4.7	t=4.05
Mean ± SE			p<0.001
Low Output Syndrome	9(30%)	3(10%)	$\chi^2$2 = 3.74
(Total affected)			p=0.05
Respiratory Complications (affected)	7(23%)	6(20%)	p>0.01 with ?2 test
Renal Dysfunction (Affected)	4(13%)	2(6%	p>0.1 with ?2 test
Neurological Complications	9(30%)	2(6%)	χ^2 =5.44
(affected)			p<0.02
Mortality (n)	2(6%)	1(3%)	p>0.5 with ?2 test

The values are numbers with percentage within parenthesis.

Table-IX

Late in Hospital Complications

Complications	Group-I	Group-II	p value
Wound Infection (Affected)	6(20%)	4(13%)	χ^2 test reveals p>0.5, Insignificant
Hospital Stay(days) Mean ± SE	16±7	14±6	t-test, p>0.01, insignificant.
Mortality (n)	0	0	Insignificant

The values are numbers with percentage within parenthesis.

Table- X

Improvement of LV Function (LVEF) between Groups

LVEF	Group-I	Group-II	p value
=30	1	0	Unpaired t= 2.47,
31-35	5	0	p<0.02,
36-40	6	4	Significant
41-45	10	7	
=46	8	19	

Discussion

This study included total 60 patients of coronary artery diseases with LVEFd"45% who underwent CABG surgery in NICVD, Dhaka, Bangladesh. Out of 60 patients, 30 underwent conventional CABG (Group-I) and 30 underwent On Pump Beating Heart (OnP-BH) CABG (Group-II). Data from 60 patients were included for final analysis. The mean age was found 62±7 in group-I and 57±11 in group-II and no significant variation of age between two groups. Age of the majority of patients was 51 to 60. In another study [13] , the mean patient age was 57.9 ± 9.5 and were similar to this study. There was only one female patient in G-I (3%) in our series. In another study [16] the male to female ratio was 22:1. The selection of LVEF 45% may be the cause of having minimal female patients in this series.

The mean operation time (minutes) in group-I was 276±20.24 and in group-II was 227±15.85. The total operation time was significantly less in group-II than in group-I. In the study of Gulcan et al[13], the total operation time was 275 ± 63 min. This was similar to Group- I. So, total operation time was reduced significantly in Group-II. The Mean Extracorporeal Circulation Time (ECCT or CPB time) was 126.4 ± 12.3 min in Group-I and 107±4.5 min in Group-II. The difference between two groups was insignificant. In another study [7] CPB time was 116±20 min and was similar to this study. The mean XCT (Cross clamp time) in Group-I was 61.3 ± 4.42. As there was no Cross Clamp in Group-II, and it was 0. The unpaired t-test value was 13.8 (p<0.001) and was highly significant. The XCT was 84±23 min in the study carried out by Prifti et al [8] and 64.2±26.2 min in the study of Folliguet et al [12] and was nearly similar to this study.

The Bypass Graft conduits of two Groups were as follows: in G-I, LIMA 100%, RIMA 0%, Radial Artery 3% and RSVG 100% and in G-II, LIMA 100%, RIMA 3%, RA 3% and RSVG 100%. Graft Conduits are not predictor variables between two Groups. In other study[13], LIMA use was 97.8%, RA 21% and RSVG 84.8% and was nearly similar to our study. The Mean number of Distal Anastomosis in Group-I was 2.7 ± 1.2 and in Group-II was 3.1 ± 1.3. The target vessel in G-I were LAD 100%, Diagonal 36%, Obtuse marginal 56%, Ramous Intermedius 3%, RCA 46% and PDA 30%. In G-II, the target vessel were LAD 100%, Diagonal 13%, Obtuse Marginal 27%, Ramous Intermedius 3%, RCA 46% and PDA 36%. The number of distal anastomosis did not vary significantly between two Groups. The number of distal anastomosis was 2.6±0.9 [7] and 3.06 ± 1.04 [13] in other studies. In the study of Gulcan et al [13] the target vessel was: LAD 93.1%, Diagonal 60.8%, OM 76.1% and RCA 73.9%. The number and target vessel of our study was similar to other study.

ICU Stay in Hours: G-I Mean=67.32±5.4, G-II Mean=35.2±4.8 was significantly less in G-II. In another study [13] ICU stay was 2.56±1.7 days and was similar to this study. Ventilation Time in Hours: G-I Mean=18.2±3.5, G-II Mean=10.2±2.4 and was significantly less in G-II. Ventilation time was 9.2 ± 22.6 in another study [12] and was similar to the Group-II of this study. Postoperative MI: 10% in G-I and 6% in G-II and the difference was insignificant. Perioperative MI were 2.8% [17]and 1.3% [8] in other studies. The rate of MI is relatively higher in Group-I of this study. Blood Loss in ml (Postoperative): G-I=625.54 ±10.42, G-II=630.4±8.7, t=0.38(p>0.1) and the variation was insignificant. In other studies it was 500.15±303.55ml [13] and 614±22.6ml [12]. These findings are similar to our study. Postoperative Arrhythmia: G-I= 43%, G-II= 16% and it was significantly less in G-II. Arrhythmia was 19.1% [17] and 15.2% [13] in other studies. These findings are similar to the Group-II of our study and signify that the rate of arrhythmia is higher in Group-I. Postoperative Inotropic Support in Hours in ICU: G-I=62.8±6.4, G-II=30.6±4.7 and was significantly less in G-II. Inotropic support was 19.2 hours in the study of Legare et al [6]. Postoperative Low output syndrome: G-I=30%, G-II=10% and was significantly less in G-II. In the study of Prifti et al [7] it was 24% and 11% respectively. Postoperative Respiratory Complications: G-I=23%, G-II= 20% and the difference between two Groups was insignificant. In the study of Prifti et al [7] respiratory complications were 3.7%. The higher incidence of respiratory complications in this study was due to inadequate isolation and poor restriction of visitors in the ICU. Postoperative Renal Complications: G-I=13%, G-II=6% the difference was statistically insignificant. Renal complications were 2.2% [13] and 13.3% [10] in other study and are similar to this study. Acute renal failure was found in 3.6% [18] and 3.5% [17] of patients undergoing CABG with poor LV function. Postoperative Neurological Complications: G-I=30%, G-II=6% and was significantly less in G-II. In another study [7], the neurological complications were 8.4% and 7.5% respectively. The incidence was similar to Group-II of this study but there are higher rate of neurological complications in Group-I. ICU Mortality: G-I= 6%, G-II= 3% and was statistically insignificant. Hospital mortality was 2% [12] and 7.7% [8] in other study. The rate of mortality was similar in our study.

So the significant difference was observed in ICU stay, Ventilation time, Development of Arrhythmia, Inotropic support, Low output syndrome and Neurological complications. These parameters are significantly less in Group-II and favors OnP-BH CABG than Conventional CABG in patients with poor LV function (LVEF<45%). No significant difference found in Postoperative MI, Blood loss, Respiratory complications and Mortality between two groups.

The late in hospital complications of wound infections (20% and 13%), total length of hospital stay (16±7 days and 14±6 days) and mortality (00%) was statistically insignificant between two groups. In the study of Folliguet et al [12], hospital stay was 9.4±5.8 days. A wound infection was 8% in the study of Prifti et al [7]. These findings were nearly similar to our study.

Pre- and postoperative EF analysis with improvement of LVEF was statistically significant in both group-I and G-II. The numbers of Subgroup Migration (LVEF Improvement) in Group-II was significantly more than in Group-I. In Group-I, the mean preoperative and postoperative (at 3rd month) LVEF were 39.8±1.2 and 42.9 ± 1.7 respectively. In Group-II, the mean preoperative and postoperative LVEF were 41.6±1.3 and 46.26 ± 2.01 respectively and was significant statistically at p>0.05 level.

Table-XI shows the preoperative and postoperative LVEF in different previous studies undergoing CABG. From these table values, it can be realized that the LVEF had improved significantly in the patients undergoing OnP-BH CABG than conventional CABG in patients with poor LV function. Our study also showed that significant improvement of LV function can be achieved by using OnP-BH CABG in patients with poor LV function.

Several limitations of this study should be addressed. First, Echocardiography is an observer dependent investigation and it was possible for an observer to distinguish between two groups. So there may be chance of biasness. Second, all surgery were not performed by one surgical team but same protocol of NICVD was followed by all teams.

Table- XI

Improvement of LVEF in different previous studies

Study	OnP-BH CABG			Conventional CABG		
	Preoperative	Postoperative	p	Preoperative	postoperative	p
Prifti et al.[7]	24.8±4	26.4±4	0.035	26.2± 4.3	27±6	NS
Prifti et al.[8]	24.8±0.4	27.2±4	0.001	25±5	26.6±7	0.125
Folligurt et al.[12]	24.8% ± 11.2%	30.5%±10.8%	0.003.	-	-	-
Gulcan et al.[13]	25.6±2.8	33.64±4.69	-	-	-	-

Conclusion

On-pump beating-heart (OnP-BH) CABG is safe for patients with severely depressed LV function. The OnP-BH technique offers surgeons complete revascularization without technical and hemodynamic difficulties along with low morbidity and mortality. In highest risk patients, who may poorly tolerate cardioplegic arrest, and in situations where off pump surgery may increase the operative risk, the on-pump beating-heart CABG may be an acceptable alternative associated with lower postoperative mortality and morbidity. Such a technique offers better myocardial and renal protection associated with lower postoperative complications resulting from intraoperative hypoperfusion. LV function had also improved significantly after surgery. These benefits suggest that OnP-BH CABG should be the method used in cases of severe LV dysfunction.

List of Abbreviations

CABG- Coronary Artery Bypass Graft, OPCAB- Off-Pump Coronary Artery Bypass, CCAB- Conventional Coronary Artery Bypass, OnP-BH- On-Pump Beating Heart, CAD- Coronary Artery Diseases, CPB-Cardiopulmonary Bypass, PTCA- Percutaneous Coronary Angioplasty, IMA- Internal Mammary Artery, LMCA- Left Main Coronary Artery, LAD- Left Anterior Descending, LCX- Left Circumflex Artery, RCA- Right Coronary Artery, OM- Obtuse Marginal, LV- Left Ventricle, EF- Ejection Fraction, LVIDd- Left Ventricular Internal Diameter in Diastole, LVIDs- Left Ventricular Internal Diameter in Systole, ESCAD- End Stage Coronary Artery Diseases, VSD- Ventricular Septal Defect.

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