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A Comparison of Off-Pump and On-Pump Coronary Artery Bypass Graft Surgery in Terms of Perioperative Bleeding and Associated Complications – A Prospective Analytical Study

Dr. Krishnendu Chakrabarti[1], Dr. Sayar Kumar Munshi[2], Dr. Pares Bandyopadhyay[3]

Department of Cardiothoracic & Vascular Surgery (CTVS), Nilratan Sircar Medical College & Hospital [NRSMCH], Kolkata, under West Bengal University of Health Sciences

Abstract: ***The relative benefits and risks of performing coronary artery bypass grafting(CABG) with a beating heart technique (off-pump CABG), as compared with cardiopulmonary bypass (on-pump CABG), are not clearly established. Many studies have been carried out regarding its different aspects. We performed a prospective study among the patients who have undergone CABG in Nilratan sircar medical college and hospital, CTVS department in the time period of June,2012 to March,2015. Among them 172 patients have been operated for off-pump CABG and 31 patients have been operated under CPB. 5 patients needed conversion from off-pump to on-pump during operation. The use of off-pump CABG resulted in reduced rates of allogenic blood transfusion and reoperation for perioperative bleeding. So off-pump CABG may be considered as superior to on-pump CABG in terms of perioperative bleeding and related complications.***

Keywords: coronary artery bypass grafting, cardiopulmonary bypass, perioperative bleeding, allogenic blood transfusion

1. Introduction

The first Coronary artery bypass grafting (CABG) procedure was performed in 1960 on a beating heart. But after the advent and refinement of cardiopulmonary bypass (CPB) it has been instituted during grafting procedure for technical ease and more chance of complete revascularization [1]. So the on pump CABG started from the year of 1968. But the various complications mostly caused by the CPB like increased perioperative bleeding [15,17], perioperative renal dysfunction [4,5], adverse cerebral outcomes [2,3], myocardial dysfunction [6] and systemic inflammatory response [7,8,9] lead to increased mortality and morbidity following on-pump CABG . Off-pump CABG surgery has been safely performed for many years in two centers of South-America [8,9] and in Netherlands [10,11,12] afterwards. The major concern with off-pump surgery is wether the need to contend with heart motion and more blood in the operative field compromises the quality of distal coronary graft anastomoses and in a less durable or less complete revascularization (25-32).

Among the various adverse effects of CPB, excessive bleeding is an important cause of morbidity and mortality after on-pump CABG than off-pump [13,14,17,18]. The exposure of blood to synthetic, nonendothelial surfaces causes severe hemostatic defects that inhibit or alter many components of the thrombotic and fibrinolytic systems [7,12,15,17]. Because of the altered hemostatic function and increased perioperative blood loss, patients undergoing CPB are often given allogenic blood transfusions [15,17]. The transfused allogenic blood products exposes the patients to additional risks like transfusion reactions, viral transmissions, immunosuppresion and increased mortality rates [7,12,15,16,17]. Also morbidity and mortality rates increases substantially when the patient needs reexploration due to bleeding [17,30]. So the increased perioperative bleeding due to CPB is supposed to be a significant factor that increases the mortality and morbidity after on-pump CABG than off-pump (25-30).

The purpose of this study is to investigate and compare the short-term outcomes and complications associated with increased perioperative bleeding between all patients undergoing on-pump CABG surgery with sternotomy and all patients undergoing off-pump CABG surgery with sternotomy in the NilRatan Sarkar Medical College & Hospital, CTVS Department from the year of June, 2012 to March,2015.

2. Materials and Methods

This is a prospective study where all the patients who have been operated for CABG in the time period from June,2012 to March,2015 has been considered. All the patients of both sexes have been considered. The patients were decided to undergo off-pump or on-pump CABG depending upon type of lesion in coronary arteries, ejection fractions and other parameters like preexisting arrhythmia, recent myocardial infarction etc. The on-pump group excludes the patients who were previously planned for off-pump CABG but required intraoperative cardiopulmonary bypass for on-table adverse events.

Inclusion criterias are Left main coronary artery stenosis >50% with or without symptoms,Triple vessel disease with LVEF < 50% , Two-vessel disease with proximal LAD and either LVEF <50 or objective evidence of ischemia on noninvasive testing, Unstable angina not remitting by medical therapy t

Exclusion criterias are Previous heart surgery, Poor left ventricular function (LVEF<30%) Patient's undergone off pump surgery converted to on pump surgery, Unstable preoperative condition (eg. patient receiving continuous infusion of inotropes on the day of surgery, or on IABP)

Postoperatively the patients were shifted to a dedicated ITU and monitored for all hemodynamic parameters. The bleeding amount and urine output were recorded on hourly basis. The re-exploration was decided according to standard guidelines depending upon amount of bleeding within a specific time period, development of imminent signs of cardiac tamponade and report of arterial blood gas analysis. The blood products (whole blood) were transfused according to Hb% by ABG report to maintain Hb% above 10gm/dl and hematocrit >30%. The patients were kept under mechanical ventilation till all the hemodynamic parameters are stable, neurological, cardiovascular and kidney functions were within normal limits. The patients were routinely kept in ITU for three days postoperatively or as long as the patients are stable without any inotropic support.

The data collected from both the groups are compared using standard methods of statistical analysis. The baseline characteristics are compared and the perioperative bleeding and associated parameters are analysed and compared in details. The results are presented in chart. The p-value is calculated for the parameters of interest and the difference is considered significant at p-value <0.05.

3. Results

This is a prospective study where the patients undergoing CABG (on-pump or off-pump) between June,2012 to March,2015 has been considered and compared. Most baseline characteristics were similar in both groups. The mean age is 56.31 yrs in off-pump group and 54.96 yrs in on-pump group. 28.48% of off pump patients and 32.25% of on-pump patients had diabetes. 9.88% of off-pump patients and 6.45% of on-pump patients had myocardial infarction. Five number of patients who were assigned to off-pump surgery were switched to on-pump intraoperatively due to hemodynamic instability. There was no significant difference in the quality of native vessels between the two groups.

No significant differences occurred in major in-hospital complications between two groups. The same results were observed in relation to myocardial infarction and the need for in-hospital reoperation.

Variable	*OffPump(n=172)*	*On-Pump(n=31)*	*P value*
Crossover, n (%)		5 (excluded)	
Operation time, mean (SD), min	245.5	290.4	
Cross-clamp, mean (SD), min		55.8	
Grafts per patient, mean (SD)	2.65±1.02	2.68±1.02	
LIMA to LAD, %	31.39%	36.36%	
Amount of blood loss	577.21	662.9	The result is significant at $p < .05$.
Postoperative need for inotropics	155(90.11%)	26(83.87%)	
Need of intra-aortic balloon pump	2	1	
Need for w.blood bag consumed /pt	4.2 per pt.	4.55 per pt.	The result is significant at $p < .05$.
Need for pacing >24 h	5	1	
New onset of atrial fibrillation	3	1	
Renal complication			
Hemodialysis	1	0	
Reoperation during index admission			
i)Reoperation for bleeding	7	3	
ii)Reoperation for other causes	0	0	
Pneumonia	9	2	
Time to extubation, h	5.62	12.16	The result is significant at $p < .05$.
Length of stay in ICU >1 d	2.65	2.90	
Post. Op. Hb%	9.11	9.07	
Length of stay in hospital, median (IQR), d	8.62	8.64	

Operative data

The operation time is significantly shorter in off-pump patients (245.5 minutes) than in on-pump patients (290.4 minutes). The number of grafts per patient is higher in on-pump group than the off-pump group (2.68+/- 1.02 versus 2.65+/- 1.02). Number of internal mammary artery anastomoses per patient (LIMA to LAD) is also higher in on-pump patients (36.36%) in comparison to off-pump group (31.39%).

Complications due to bleeding

Post-operative bleeding and subsequent requirement of whole blood transfusion is significantly higher in on-pump patients than in off-pump patients. Amount of blood loss per patient in on-pump group is 662.9 ml and in off-pump group is 577.21 ml. The difference is statistically significant with p value of 0.03 (p<0.05) . Need for whole blood bag consumed per patient is higher in on-pump patients than in off-pump group (4.55 per patient versus 4.2 per patient) which is also statistically significant (p value 0.02). However this is not true for FFP and platelet transfusion. The requirement of FFP is 2.01 bags per patient in off-pump group and 2.19 bags per patient in on-pump group. The need for platelet is 2.12 per patient and 2.23 per patient in off-pump and on-pump patients respectively. In both the cases the difference is not significant. However the hemodynamic

alteration is more pronounced in off-pump group than on-pump. Post-operative need for inotropic support is 90.11% in case of off-pump patients and 83.87% in case of on-pump group. Two patients in off-pump group and one patient in on-pump group required intra-aortic balloon pump for low BP. Also five patients from off-pump group and one patient from on-pump group needed pacing for >24 hrs. New onset atrial fibrillation is detected in three patients from off-pump group and one patient from on-pump group. In both the cases the p-value is >0.05 indicating that the difference is not statistically significant. Finally, seven patients from off-pump and three patients from on-pump group required re-exploration due to bleeding (p value 0.18). On average on-pump patients required post-operative ventillatory support for 12.16 hrs in comparison to 5.62 hrs for off-pump patients. The average Hb% on third post-operative day is 9.11gm/dl in off pump patients in compare to 9.07 gm/dl in on-pump patients. The length of hospital stay is also higher in on-pump patients (8.64 days) in compare to off-pump patients (8.62 days).

4. Discussion

In our study, we have compared the off-pump CABG patients (172) with the on-pump CABG patients (31) who have been operated in Nil Ratan Sarkar Medical College & Hospital in the time period between June,2012 to March,2015. The primary objective of our study is to compare and analysis the perioperative bleeding related complications in both the study groups. We found no significant difference in the rate of the first coprimary composite outcome of death, nonfatal stroke, nonfatal myocardial infarction or nonfatal new renal failure requiring dialysis during post-operative hospital stay. But we found significant differences between the two groups regarding perioperative bleeding and related complications like requirement of blood products transfusion, amount of bleeding, ionotropic support requirement, rate of re-exploration due to bleeding, post-operative Hb% and post-operative ITU stay. While all these complications are more frequently encountered in on-pump patients and hence far our off-pump groups, but it is also noticeable that fewer grafts were performed per procedure in off-pump patients than in on-pump group and hence incomplete revascularization [18,19,20,21,22,23,24,25]. So it may be stated that the off-pump group would benefit in the short term from deleterious effects of perioperative bleeding and transfusion related complications which may be counterbalanced by the risk of lower rates of long-term graft patency and revascularization.

As previously stated that cardiopulmonary bypass itself causes significant alteration of blood coagulation pathway rendering the patients to be at increased rate of perioperative bleeding related complications. That in turn increases the risk of allogenic blood component transfusion related complications and rate of reexploration due to bleeding which again increases the mortality and morbidity in on-pump CABG patients in compare to off-pump CABG patients. Randomized trials, matched cohort and retrospective studies [17,28,30] consistently demonstrate reduced blood loss, reoperation for bleeding and requirements of allogenic blood products in off-pump patients than in on-pump. Ascione et al [17], in their study shows that transfusion requirements were higher in the on-pump group and this reflected the significantly higher mean transfusion costs, reentry for bleeding occurred infrequently in off-pump patients.

Puskas et al [33] in a prospective randomized study, included 51 off-pump patients who were seen from November 1996 through December 1997 and underwent off-pump CABG by single surgeon at Craoswford Long Hospital, Emroy University. The control group included 245 patients, for a total sample of 296 patients. More than half of the patients in the control group required transfusion of one blood product or more during hospitalization, whereas less than a quarter of the off-pump group received any blood products. Puskas et al [33] in retrospective study included 200 undergoing off-pump CABG by a single surgeon at Emroy University. A statistically significant difference was found in favour of off-pump group as compared to on-pump groupin regards of requirement of perioperative transfusion. Cleveland et al [28] using the society of Thoracic surgeons (STS) National Adult Cardiac Surgery Database, procedural outcomes were compared for conventional and off-pump CABG procedures from January 1,1998 through December 31, 1999. A total of 126 experienced centers performed 118,140 total CABG procedures. The number of off-pump patients were11,717 cases (9.9% of total cases). Importantly their data suggests that an off-pump strategy reduces the likelihood of reoperation due to bleeding. Their conclusion agrees with others [17,28,29,30,31,32,33] who have documented less perioperative blood loss with off-pump CABG. The need for transfusion was significantly less in the beating heart group.

In our study we also found that the amount of perioperative blood loss and requirement of whole blood transfusion is significantly less in off-pump group than on-pump group. Also the rate of reexploration due to bleeding, the post operative inotropic support requirement are higher in on-pump group while the Hemoglobin percentage at 3rd post operative day is higher in off-pump patients. All these data clearly establish the off-pump CABG to be superior than on-pump CABG in terms of perioperative bleeding related complications.

5. Conclusion

Our study revealed no significant difference in mortality or morbidity in the immediate post operative period between off-pump and on-pump CABG patients. But the perioperative bleeding and associated complications are more prevalent when the patients required cardiopulmonary bypass during CABG procedure. The amount of blood loss, requirement of whole blood transfusion and reexploration due to bleeding are significantly higher in on-pump patients. The only significant drawback in off-pump group is less number of grafts anastomoses due to technical difficulty and hence more chance of incomplete revascularization than on-pump patients. However there was no evidence in short term follow up of any difference of revascularization in both the groups that may become apparent in long term follow up. Hence, we can clearly conclude that the off-pump CABG is

superior than on-pump CABG in terms of perioperative bleeding and associated complications.

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