Does multi-vessel off-pump coronary artery bypass grafting reduce post operative morbidity compared to on-pump CABG ?

Lokeswara Rao Sajja*, M.Ch, Gopichand Mannam*, FRCS, Sriramulu Sompali***, MD, Karri Venkata Reddy*, M.Ch, Bala Raju Ravirala***, DNB, Bhupathiraju Soma Raju**, DM, Penmetcha Krishnam Raju**, DM

**Divisions of Cardiothoracic Surgery, **Cardiology & ***Cardiothoracic Anesthesiology, Care Hospital, The Institute of Medical Sciences, Road No. 1, Banjara Hills, Hyderabad*

Abstract

Background: Cardiopulmonary bypass (CPB) may contribute to the complications and it is assumed that eliminating cardiopulmonary bypass has the potential of reducing post operative morbidity after coronary artery bypass grafting (CABG). The study was carried out to compare mortality and morbidity in the off-pump and on-pump CABG groups.

Methods: We prospectively analysed 200 patients undergoing CABG. Group A consists of 100 patients underwent multi-vessel off-pump CABG and group B consists of 100 patients underwent CABG with CPB. The incidence of complications (mortality, re-exploration for bleeding, myocardial infarction, atrial fibrillation, neurological events, new onset renal failure (s. creatinine >1.6 mg/dL) pulmonary complications, length of ICU stay and hospital stay were recorded, analysed and compared.

Results: OPCAB patients received 2.73±0.61 grafts /patient and on-pump CABG patients received 3.39±0.75 grafts/patient (*p* value <0.00001). There was no significant statistical difference in mortality, incidence of stroke between OPCAB and CABG with CPB patients. Length of ICU stay was 32.84±4.22 vs 44.85±7.18 hrs (*p* value <0.00001) and hospital stay was 6.52±0.69 vs 7.94±0.92 days (*p* value <0.00001) between group A and group B respectively. Incidence of atrial fibrillation was less in OPCAB group 7% vs 12% although it was statistically not significant (*p* value 0.33). It was observed in our study that there was no significant deference in worsening of existing renal failure between on-pump CABG and OPCAB 6% vs 2% (*P* value 0.28). Blood utilization was significantly less in OPCAB group (*p* value <0.001).

Conclusion: There was no statistically significant difference in terms of mortality, incidence of stroke and new onset renal failure in both groups. But there was lesser incidence of post operative atrial fibrillation, worsening of existing renal failure in off-pump group though statistically not significant. There was significant reduction in blood utilization, length of ICU and hospital stay in OPCAB group.

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Key words: Off-pump coronary artery bypass, Cardiopulmonary bypass, OPCAB

Introduction

Beating heart surgery was originally the only approach to myocardial revascularization[1]. In 1967, Kolessov reported left internal thoracic artery (LITA) to left anterior descending (LAD) coronary artery anastomosis through a left thoracotomy on a beating heart as a method of treatment of angina pectoris[2]. However, this was quickly abandoned in favor of coronary artery bypass grafting (CABG) through median sternotomy and with the use of cardiopulmonary bypass (CPB) techniques because of improved safety and ease of anastomosis on a still heart and a bloodless operative field. Recently, off-pump coronary artery bypass grafting (OPCAB) has enjoyed resurgence in the interest and popularity among the cardiac surgeons of South America[3,4] in the beginning

Address for correspondence:
Dr. G.C. Mannam,
Care Hospital, The Institute of Medical Sciences,
Road No 1, Banjara Hills,
Hyderabad - 500 004
Phone : 91-40-55668888
Fax : 91-40-55625003
E mail- gmannam@yahoo.com
@IJTCVS 097091342041204/035

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and world wide later on[5,6]. This has been also as a sequelae to the increasing awareness of morbidity attributable to CPB. A variety of innovative techniques and refinement of instrumentation have facilitated the applicability of off-pump coronary artery bypass grafting to many of the patients with multi-vessel coronary artery disease. Although OPCAB accounts for approximately 18% of coronary artery bypass grafting procedures performed in the United States, as reported by the National Society of Thoracic Surgeons Adult Cardiac Database Fall 2001 report, concern has been raised about the difficulty of this rediscovered procedure and the possibility that incomplete revascularization may compromise patient outcomes[1,7].

During this period, off-pump CABG has been audited against conventional technique by many observational, case-matched and prospective randomized studies[7,8,9,10]. There is significant evidence in the literature suggesting that off-pump coronary artery bypass grafting reduce postoperative morbidity, organ dysfunction and cost without compromising mid term outcomes compared to the conventional coronary bypass operations. The available evidence also supports the view that high risk patients might benefit the most from revascularization on the beating heart. High quality follow-up data are still needed to assess the impact of off-pump coronary artery bypass operations on long-term clinical outcomes.

Patients and Methods

This prospective study was conducted to compare completeness of revascularization, clinical outcomes, blood utilization in unselected consecutive patients of two groups of A and B (group A and group B each comprising of hundred patients) who underwent elective primary CABG. These patients were assigned to one group or the other based on the surgeons' choice and diffuse nature of the coronary artery disease. Patients with diffuse disease were assigned to CPB group B. In group A OPCAB was performed with the use of an Octopus tissue stabilizer (Medtronic Inc. Minneapolis, MN, USA) in all patients and Starfish cardiac positioner (Medtronic Inc. Minneapolis, MN, USA) was used whenever necessary to access posterior and lateral targets arteries. The group B consisted of 100 patients who underwent CABG with CPB and using intermittent ischemic fibrillatory arrest technique or cold blood cardioplegic arrest technique. The technique of myocardial protection was chosen according to the choice of the surgeon. In an attempt to minimize variability, all procedures were performed by single group of surgeons and all patient management was carried out by a single team according to strict, unbiased, criteria-driven protocols during the year 2003. All the data of the patients were entered into our coronary artery bypass grafting database on the day of surgery, at the time of discharge from the hospital and later on at the time of first follow-up visit. The demographic characters were similar between the two groups (Table 1).

Table 1. Patient characteristics

Variables	OPCAB (n=100)	CABG with CPB (n=100)	*p* Value
Age (y, mean ± SD)	57.82±8.61	57.67±9.09	0.9
Gender (no. of females)	18	22	
Baseline EF			
>55%	42	44	0.89
45%-54%	36	34	0.88
35%-44%	15	12	0.48
25%-34%	6	8	0.78
<25%	1	2	
Previous MI	28	24	
0-7 d	2	6	
8-20 d	3	4	
>21 d	23	14	
Previous CVA	6	3	0.49
Previous TIA	4	1	0.37
COPD	16	10	0.29
Smoking	21	24	0.73
Diabetes	42	39	0.77
Insulin	2	3	1
Oral agent	40	36	0.66
Hypertension	21	23	0.86
Previous coronary	4	5	1
angioplasty		3	1
Prior stent	4		
Hypercholesterolemia	16	20	0.58
Previous peripheral vascular	2	3	1
surgery/stent	11	9	0.81
Renal failure	1	2	1
(s. creatinine >1.6 mg)			
CCS class III or IV	26	28	0.87
Dialysis dependence			
Preoperative medications			
Aspirin	100	100	
ACE inhibitors	26	32	0.44
b-Blockers	44	36	0.31
Calcium-channel blockers	18	16	0.85
Diuretics	4	6	0.75
Stains	46	40	0.48

Data analysis and statistical methods

The data was gathered prospectively and recorded by one of the assistant surgeons assigned in the management of the study. The data was obtained from a database developed in Microsoft Access by Dr Satyanarayana (Dusk Database) Discrete data was

expressed as a percentage and continuous data was expressed as mean ± standard deviation. The statistical significance of difference between mean values assessed using the student's *t* test and the difference between proportions by the Chi-square test.

Surgical techniques

General: Surgical access to the heart was through a standard median sternotomy in all patients. All incision and closure technique were the same in both groups. No cell saver was used during these procedures. Patients in whom complete revascularization considered was not possible with OPCAB technique, those patients were converted to on-pump technique of CABG. The distal anastomoses for LITA graft was constructed using 8-0 polypropylene continues suture and for the saphenous vein grafts and radial artery grafts 7-0 polypropylene suture was used. All the proximal anastomoses of radial artery grafts were constructed using 7-0 polypropylene suture and of the saphenous vein grafts were constructed using 6-0 polypropylene suture.

OPCAB Technique

OPCAB was performed with Medtronic Octopus 3 or 4 (Medtronic Inc. Minneapolis MN, USA) stabilizing devices for target coronary artery stabilization. Target arteries were accessed by deep pericardial traction sutures and also with the use of Medtronic Starfish cardiac positioner (Medtronic Inc. Minneapolis, MN, USA) to access the posterior and lateral coronary arteries. A mean systemic arterial pressure was maintained around 65 to 70 mmHg through out the procedure. Intra coronary shunts were used while constructing the coronary anastomoses for all the vessels. A humidified carbon-dioxide blower/mister (Medtronic Inc, Grand Rapids, MI, USA) was used to disperse the blood from the anastomotic site while constructing the distal anastomosis.

CABG with CPB technique

While doing coronary artery bypass grafting with CPB, every effort to minimize the effect of CPB was made. All diabetic patients received infusion of Insulin Glucose Potassium solution through out the procedure. Myocardial protection was achieved either with intermittent ischemic fibrillatory arrest technique or with cold blood cardioplegic arrest technique.

The patients were cooled to 32° Celsius. Myotherm (Medtronic Inc, Minneapolis, MN, USA) was used to deliver cold (4°C-8°C) intermittent high potassium 4:1 blood cardioplegia.

Results

The complications in the hospital or within 30 days of the operation were comparable in two groups (Table 2). There was one death in OPCAB group and two deaths in CABG with CPB group. The patient who died in the OPCAB group was re-intubated on 2nd post operative day for unsatisfactory arterial blood gases and later developed septicemia and multi organ failure. The two patients who died in CABG with CPB group, one died of low cardiac output syndrome followed by septicemia and the other patient developed respiratory failure and later on septicemia with multi organ failure. None of these patients underwent an autopsy. The re-exploration for bleeding was similar in both groups but the chest tube drainage was significantly low in OPCAB group compared to CABG with CPB group (*P* value <0.001). Thirty percent of the patients in OCPAB group received no transfusion of homologous blood or blood products where as every patient in CPB group received blood transfusion. The patients of OPCAB group

Table 2. Complications in hospital or within 30 days

Variables	OPCAB (n=100)	CABG with CPB (n=100)	*p* Value
Operative mortality			
In operating room	Nil	Nil	
In hospital <30 d	1	2	1
In hospital >30 d	Nil	Nil	—
Cardiac			
Reoperation for bleeding	1	1	0.48
Reoperation for graft occlusion	0	0	—
Myocardial infarction, new Q wave	Nil	1	1
Angina	Nil	1	1
Arrhythmia, atrial fibrillation	7	12	0.33
Arrhythmia, ventricular	2	3	1
Arrhythmia, permanent pacemaker	Nil	Nil	—
Neurologic			
Transient ischemic attack	Nil	Nil	1
Permanent stroke	Nil	1	—
Renal			
New failure	2	3	1
Worsening of existing renal failure	2	6	0.28
Pulmonary			
Pleural effusion, thoracocentesis	2	3	1
Pneumonitis	1	3	0.61
Infection			
Deep sternal	Nil	Nil	—
Superficial sternal	Nil	2	0.48
Conduit harvest site	1	2	1

received fewer units of blood compared to the conventional CABG group (*p* value 0.001). Both groups had similar hemotocrits 31.0±3.91 for OPCAB, vs 30.1±4.01 for CABG with CPB at day 4 post operatively (*p* value 0.11) and at discharge (29.0±4.01 for OPCAB, vs 28.10±3.74) for CABG with CPB (*p* value 0.07). No patient was re-explored for graft occlusion in any of the groups. Incidence atrial fibrillation was insignificantly higher in CPB group compared to OPCAB group (*p* value <0.33). There was no difference in the incidence of ventricular arrhythmias, stroke or transient ischemic attacks between the groups. There was no statistically significant difference in the incidence of new onset renal failure (s.creatinine = 2.0 mg/dL) between the groups but the worsening of preexisting renal failure was higher in CABG with CPB group though it was statistically not significant (*p* value 0.28). Infection rate of sternotomy wound and conduit harvest sites was similar in both the groups (Table 2). The number of grafts per patient was higher in CABG with CPB group (2.73±0.61 for OPCAB group vs 3.39±0.75 for CABG with CPB group) (*p* value <0.00001). Index of completeness of revascularization (number of grafts performed/number of grafts intended) (1.00±0.14 for OPCAB vs 1.00±0.08 for CABG with CPB) were similar between groups. The use of more than one arterial conduit was higher in patients of CABG with CPB group compared to OPCAB group (*p* value <0.0009). More patients in the OPCAB group met extubation criteria in the first 4 hours (58% for OPCAB group and 38% for CABG with CPB group) (*p* value 0.007). All patients in OPCAB group were extubated with in 24 hours where as 4 patients in CABG with CPB group did not meet the criteria for extubation until more than 24 hours after operation. One patient in OPCAB group and three patients in CABG with CPB group were reintubated either for unsatisfactory blood gases or unstable hemodynamics. With uniform, unbiased protocols the post operative ICU stay (38.2±6.2 hrs for OPCAB group vs 48.6±12.6 hours for CABG with CPB group, *p* value <0.00001) and hospital stay (from surgery to discharge) was 6.83±0.69 days for OPCAB group vs 7.94±0.92 days for the conventional CABG group (*p* value <0.00001).

Discussion

Many non randomized comparisons of OPCAB and CABG with CPB groups applying sophisticated statistical methods have reported significant reduction in risk-adjusted mortality, stroke, acute renal failure, prolonged ventilator dependence, reexploration for bleeding with OPCAB[11,12]. However, the criticism of conclusions of these studies has been centered on the inherent bias of patient selection and non randomization. Cleveland and his colleagues analyzed information available on the database of The Society of Thoracic Surgeons[12] and showed that CABG with CPB had greater proportions of patients with triple vessel disease and needed urgent or emergency revascularization than the OPCAB group. In a prospectively randomized comparative study of two hundreds unselected patients undergoing off-pump CABG versus conventional coronary artery bypass Puskas and co-workers found that there was reduced myocardial injury, transfusion requirements and length of hospital stay in OPCAB group[10]. They also opined that even larger randomized studies so far published[9,10,13] have limited statistical power to detect differences between groups in end points that occur infrequently. No differences were found in mortality rate and incidence of stroke, perioperative myocardial infarction or acute renal failure in the above mentioned randomized studies[9,10,13]. In our study, though not randomized, we found similar observations. Our study correlates well with the previously published non randomized studies in terms of shorter hospital stay. A reduction in blood transfusion requirement has been consistently reported across multiple studies including this study[9,14,15]. However, the postoperative day 4 and discharge hematocrit did not show any significant difference between the groups unlike significant increase of discharge and postoperative day 3 hematocrit values of OPCAB group[14]. Our study differs from the study of Cheng et al[16] who reported that OPCAB group had incomplete revascularization nearly twice as much as in the CPB group. In the present study, the index of completeness of revascularization (number of grafts performed/number of grafts intended) between the two groups were comparable and correlates with the study of Puskas et al[10]. There are several published series addressing arterial graft patency in OPCAB surgery, although excellent short term patency for arterial conduits to the anterior wall [17,18] has been reported but angiographic documentation of successful lateral and inferior wall was lacking.

Conclusions

In conclusion, our study found that there was no significant difference in mortality rate, incidence of stroke and perioperative MI but the chest tube drainage and blood transfusion requirement were significantly lower in OPCAB group compared to CABG with CPB group. Although there was no significant difference in

the incidence of new onset renal failure, worsening of existing renal failure was higher, but not statistically significant, in CABG with CPB group. Index of completeness of revascularization was comparable between the two groups. The ICU and hospital stay were longer in CABG with CPB group.

References

1. Cooley DA. Con. beating heart surgery for coronary revascularization : is it the most important development since the introduction of heart-lung machine ? *Ann Thorac Surg* 2000; 70: 1779–81.
2. Kolessov VI. Mammary artery - coronary artery anastomosis as a method of treatment for angina pectons. *J Thorac Cardiovasc Surg* 1967; 54: 535–44.
3. *Bene*tti FJ. Direct coronary surgery with saphenous vein bypass without either cardiopulmonary bypass or cardiac arrest. *J Cardiovasc Surg* 1985; 26: 217–22.
4. Buffalo E, de Andrade JC, Braco JN, Teles CA, Aguiar LF, Gomes WJ. Coronary artery bypass grafting without cardiopulmonary bypass. *Ann Thorac Surg* 1996; 61: 63-66.
5. Puskas JD, Wright CE, Ronson RS, Brown WM, Gott JP, Guyton RA. Off-pump multivessel coronary bypass via sternotomy in safe and effective. *Ann Thorac Surg* 1998; 66: 1068–72.
6. Hart JC, Spooner TH, Pym J, Flavin TF, Edgerton JR, Mach MJ, et al. A review of 1582 consecutive Octopus off-pump coronary bypass patients. *Ann Thorac Surg* 2000; 70: 1017–20.
7. Bonchek LI, Ullyot DJ. Minimally invasive coronary bypass : a dissenting opinion. *Circulation* 1998; 98: 495–97.
8. Angeline GD, Taylor FC, Reeves BC, Ascione R. Early and midterm outcome after off-pump and on-pump surgery in Beating Heart Against cardioplegic Arrest Studies (BHACAS 1 and 2): a pooled analysis of two randomized controlled trials. *Lancet* 2002; 359: 1194–99.
9. Van Dijk D, Nierich AP, Jansen EW, Nathoe HM, Suyker WJ, Diephuis JC, et al. Early outcome after off-pump versus on-pump coronary bypass surgery. Results from a randomized study. *Circulation* 2001; 104: 1761–66.
10. Puskas JD, Williams WH, Duke PG, Staples JR, Glas KE, Marshall JJ, et al. Off-pump coronary artery bypass grafting provides complete revascularization with reduced myocardial injury, transfusion requirements and length of stay. A prospective randomized comparison of two hundred unselected patients undergoing off-pump versus conventional coronary artery bypass grafting. *J Thorac Cardiovasc Surg* 2003; 125: 797–08.
11. Plomondon ME, Cleveland JC, Ludwig ST, Grunwald GK, Kiefe CI, Grover FL, et al. Off-pump coronary artery bypass is associated with improved risk-adjusted outcomes. *Ann Thorac Surg* 2001; 72: 114–49.
12. Cleveland JC, Shroyer AL, Chen AY, Peterson E, Grover FL. Off-pump coronary artery bypass grafting decreases risk-adjusted mortality and morbidity. *Ann Thorac Surg* 2001; 72: 1282–89.
13. Jones EL, Weintraub WS. The importance of completeness of revascularization during long-term follow-up after coronary artery operations. *J Thorac Cardiovasc Surg* 1996; 112: 227–37.
14. Puskas JD, Thourani VH, Marshell JJ, Dempsey SJ, Steiner MA, Sammons BH, et al. Clinical outcomes angiographic patency and resource utilization in 200 consecutive off-pump coronary bypass patients. *Ann Thorac Surg* 2001; 71: 1477–84.
15. Ascione R, Williams S, Lloyd G, Sundaramoorthy T, Pitsis AA, Angeline GD. Reduced postoperative blood loss and transfusion requirement after beating-heart coronary operations : a prospective randomized study. *J Thorac Cardiovasc Surg* 2001; 121: 689–96.
16. Cheng W, Denton TA, Fontana GP, Raissi S, Blanche C, Kass RM, et al. Off-pump coronary surgery : Effect on early mortality and stroke. *J Thorac Cardiovasc Surg* 2002; 124: 313–20
17. Mack MJ, Magovern JA, Shennib H. Arterial graft patency in coronary artery bypass grafting. What do we really know ? *Ann Thorac Surg* 1998; 66: 1055–59.
18. Mack MJ, Magovern JA, Acutt TA, Landreneau RJ, Tennison DM, Tinnerman EJ, et al. Results of graft patency by immediate angiography in minimally invasive coronary after surgery. *Ann Thorac Surg* 1999; 68: 383–90.