ORIGINAL ARTICLE

POSTOPERATIVE ARRHYTHMIAS AFTER CORONARY ARTERY BYPASS GRAFTING A COMPARISON BETWEEN 'OFF PUMP' AND 'ON PUMP' CABG

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Background: Coronary artery bypass without cardiopulmonary bypass (CPB) has gained popularity recently with the development of devices that allow for improved exposure and standardization in off pump coronary artery bypass surgery. Off pump coronary artery bypass surgery reduces some of the morbidities traditionally attributed to CPB. The primary goal of off pump coronary artery bypass surgery is to provide an equally comprehensive operational result as the conventional operation. The purpose of the study was to compare intra operative and postoperative arrhythmias in off pump coronary artery bypass (OPCAB) verses conventional CABG. **Methods:** This study was a sub-group as part of a randomised control trial and was conducted from January 2006 to March 2007 at Punjab Institute of Cardiology. One hundred patients were included in 'on pump' group-A, and 100 patients in 'off pump' group-B. **Results:** Thirty-three patients in group-A and 22 in group-B developed arrhythmias. Twenty-six patients developed atrial fibrillation in group-A and 16 patients in group-B. Mortality due to arrhythmias was 5, three were in on pump group, and 2 were in off pump group. **Conclusion:** There is non-significant tendency towards less frequency of postoperative arrhythmias in the off pump patients as compared to on pump coronary artery bypass surgery patients.

Keyword: CABG, Coronary Artery Bypass Grafting, off pump, on pump, cardiopulmonary bypass

INTRODUCTION

Coronary artery bypass surgery with cardiopulmonary bypass is a standard procedure for treatment of coronary artery disease. Workload of Coronary artery bypass surgery is decreased because of modern way of treating coronary artery disease especially with percutaneous coronary intervention (PCI). CABG is reserved for patients with significant stenosis of left main stem, diffuse coronary artery disease, diabetic patients in which 'In stent' restenosis is very high, and for patients with stenosis at coronary bifurcation.[1]

Cardiopulmonary bypass provides controlled haemodynamics blood less and motion less surgical field intra operatively allowing surgeons to bypass multiple coronary arteries with great precision and control.[2] Cardiopulmonary bypass is a major intervention with multiple involved risks. This resulted in renewed interest in off pump coronary artery bypass grafting.[3] Off pump is equally safe as the on pump[4], there are some advantages of off pump compared to conventional on pump coronary artery surgery.[5,6] Controversies still exist whether off pump coronary artery by pass surgery provides better, immediate and long term results over conventional on pump coronary artery surgery.[7–10]

It was observed in earlier experience with off pump coronary artery bypass surgery that this technique can provide similar results to conventional coronary artery bypass surgery in patients with additive Euro Score 6 or greater.[11] Up to 30% of patients following CABG will have at least one episode of atrial fibrillation post operatively.

Most frequent postoperative rhythm disturbances occur usually two to three days after surgery, mostly benign and self terminating. Postoperative arrhythmias are associated with prolonged hospital stay, haemodynamics instability and thrombo embolism. Stroke risk is increased three folds in patients with post operative arterial fibrillation.[12] The primary goal of off pump coronary artery bypass surgery is to provide an equally comprehensive operation as the conventional operation. Patient selection plays an important role in success of OPCAB. Patient with poor ejection fraction, cardiomegaly, shock or with malignant arrhythmias are high risk for OPCAB, vessel quality and size play a significant role in post operative out come.

Ascione *et al* demonstrated decreased incident of arrhythmias and decrease inotropic support following OPCAB, although this did not reach the statistical significance.[13–16] Supra-ventricular specifically atrial fibrillation is the most common in the cardiac per operative surgery. Arrhythmias can complicate up to 50% of the procedure and is associated with increased length of intensive care unit, hospital stay, increased morbidity and mortality.[17,18]

The objective of the study was to compare the off pump and on pump coronary artery by pass surgery with reference to arrhythmias which included atrial fibrillation, supra-ventricular tachycardia, bradycardia, and atrial fibrillation/ventricular tachycardia.

MATERIAL AND METHODS

This prospective randomised control trial was conducted at Punjab Institute of Cardiology from January 2006 to March 2007. Patients were randomised in two groups A and B. Group A, included patients in whom on pump coronary artery by pass surgery was done by using on pump technique. In group B off pump coronary artery by pass surgery was carried out. All patients were assessed preoperatively by using Euro Score for standardising the risk and expected outcome. Inclusion criteria for the patients were elective coronary artery by pass grafting, age over 18 years, willingness to be randomly assigned, provision of informed consent. Exclusion criteria for the patients were, associated heart surgery, emergency surgery, cardiogenic shock, preoperative intra-aortic balloon pump, recent MI with in one month, history of supra-ventricular tachycardia, atrial fibrillation, renal, respiratory impairment, previous stroke, TIA and coagulopathy.

Operative techniques for on pump and off pump were adopted as standard. For exposure and stabilization after exposing the target vessel and stabilisation octopus Medtronic suction device was used in off pump patients. Vessel size >1.5 mm, quality were considered for satisfactory anastomosis. Keys to optimisation of intra-operative patient haemodynamics were heart rate, rhythm, BP, cardiac filling pressure, electrolytes, body temperature (prior to cardiac manipulation). This provided stable platform and allowed us to stabilize the heart during the anastomosis period. Monitoring radial artery catheterisation, central venous pressure, mixed oxygen saturation (Mv_{O2}, Pulmonary Artery pressure was considered in all OPCAB cases. Heart rate was kept between 50 and 100. Pulmonary artery diastolic pressure was maintained between 11–15 mm Hg. After median sternotomy and harvesting of conduits heparin sulphate was given 300 IU/Kg to achieve Activated clotting time of 400 seconds or greater, repeated every 20 minutes. Full protamine for reversal after completion of procedure. First anastomosis performed was in the order of Internal mammary artery to left anterior descending artery (LAD). Because it is easiest to complete, minimal cardiac manipulation and provided revascularisation of the most critical area which confirmed added protection from haemodynamic instability and arrhythmias, during the remaining procedure. Deep pericardial sutures were placed for stabilisation of heart and rolling of heart into midline position. We used sponge in the most dependent position of the pericardium and rotated this sponge around to position the heart. After stabilisation of the heart by octopus device the anastomosis were performed. Intra coronary shunt was used to achieve the bloodless field and allow distal perfusion.

The data was analysed using PASW 18.0 and STATA 8.2, Mean±SD is given quantitative variables. Frequencies and percentages are given for qualitative variables. Two-independent sample *t*-test was applied to observe group mean differences. Pearson Chi-square and Fisher Exact test were applied to observe associations between qualitative variables. A *p*-value of <0.05 was considered as statistically significant.

RESULTS

Study population was divided into two groups with 100 patients in each group. Group-A consists of patients who underwent On-Pump coronary artery by pass grafting and group-B consists of the patients who underwent off-pump CABG. Both groups were matched for preoperative and postoperative variables with no significant difference in each group.

The mean haemoglobin level in group A was 13.23±1.67 g/dl and in group B it was 12.34±1.80 g/dl, no significant difference was observed in the mean Hb levels of both groups (p=0.773). The mean ESR in group A was 19.51±12.70% and in group B it was 19.36±12.89%, no significant difference was observed in the mean ESR of two groups (p=0.930). The mean platelet count in group A was $221.62\pm69.97\times10^9$/L and in group B it was $223.66\pm68.94\times10^9$/L, no significant difference in platelet count was observed in both groups (p=0.845). The mean Haematocrit in group A was 38.31±5.38 ρg and in group B it was 38.19±4.65 ρg, no significant difference was observed in the mean HCT between groups (p=0.887).

Similarly, the mean levels of blood urea, creatinine, bilirubin, prothrombin time, INR, APTT, serum cholesterol, triglycerides and cardiac enzymes showed no significant different levels in both groups.

Table-1: Preoperative laboratory investigations in patients

Variables	ON-PUMP (Mean±SD)	OFF-PUMP (Mean±SD)	*p*
N	100	100	
Haemoglobin in gm/dl	13.23±1.67	12.34±1.80	0.773
Erythrocyte Sedimentation Rate	19.51±12.70	19.36±12.89	0.930
Platelets	221.62±69.97	223.66±68.94	0.845
Haematocrit (%)	38.31±5.38	38.19±4.65	0.887
Blood Urea	31.11±14.41	28.24±10.28	0.098
Blood Creatinine	1.06±0.64	1.07±0.73	0.878
Serum Bilirubin	0.64±.227	0.63±.25	0.826
Prothrombin Time	13.63±2.28	13.45±1.202	0.513
International Normalised Ratio	1.08±.11	1.07±0.09	0.522
Activated Partial Thromboplastin Time	38.81±10.53	39.36±14.90	0.761
Serum Cholesterol	155.6±35.431	151.87±39.4	0.654
Serum Triglyceride	169.3±131.97	174.49±132.05	0.435

In Table-2 demographics of the study groups are presented. The mean age of the patients in group A was 53.51±9.96 years and in group B it was 51.59±10.30 years, no significant difference was observed in the mean age of patients in both groups (*p*=0.765). Similarly, no significant difference was observed in the mean height, weight, pulse, systolic blood pressure, diastolic blood pressure and respiratory rate of patients in group-A and group-B.

Table-2: Demographics of the study group

Variables	On-Pump	Off-Pump	*p*
n	100	100	
Age of the patient	53.51±9.96	51.59±10.30	0.765
Height of the patient	167.9±9.57	168.97±6.49	0.512
Weight of the patient	71.80±12.6	74.90±12.13	0.070
Pulse	81.19±9.98	78.70±8.39	0.052
Systolic Blood Pressure	119.20±13.8	121.70±12.85	0.941
Diastolic Blood Pressure	77.42±9.13	75.87±8.32	0.209
Respiratory Rate	20.46±2.21	20.16±2.49	0.470

There is no significant difference in risk factor distribution in both groups. In Table-3 there is no significant association was observed between hypertension and groups (54.0% vs 53.0%, *p*=0.8873). In group-A 38 (38.0%) patients were diabetic and in group-B 42 (42.0%) patients were diabetic with *p*-value being 0.5637. In group-A 34 (34.0%) patients had a positive family history of IHD whereas in group-B 39 (39.0%) patients had family history of IHD, the association was statistically non-significant (*p*=0.4637). Eighteen (18.0%) patients in group-A were hyperlipidemic whereas 10 (10.0%) patients in group-B were hyperlipedemic (*p*=0.1030). Renal failure, Hepatitis B, Hepatitis C and IABP had no significant associations in groups, *p*-value being 0.3124, 0.4071 and 0.3476 respectively. Significant association was observed between endartrectomised vessels between groups, in group-A 29 (29.0%) vessels were endartrectomised whereas in group-B 16 (16.0%) vessels were endartrectomised (*p*=0.027).

Table-3: Distribution of risk factors

Variables	On-pump n (%)	Off-pump n (%)	*p*
N	100	100	
Hypertension	54 (54.0)	53 (53.0)	0.8873
Diabetes Mellitus	38 (38.0)	42 (42.0)	0.5637
Family History	34 (34.0)	39 (39.0)	0.4637
Hyperlipidemia	18 (18.0)	10 (10.0)	0.1030
Smoking	42 (42.0)	33 (33.0)	0.1887
Renal Failure	0 (0.0)	1 (1.0)	---
Hepatitis B	1 (1.0)	3 (3.0)	0.3124
Hepatitis C	2 (2.0)	4 (4.0)	0.4071
Endartrectomy	29 (29.0)	16 (16.0)	0.0277
IABP	3 (3.0)	4 (4.0)	0.3476

Table-4 shows that LAD was grafted in 100% patients of both groups. In group-A D1 was grafted in 29 (29.0%) patients whereas in group-B it was grafted in 35 (35.0%) patients showing no significant association *p*=0.3631. D2 was grafted in 4 (4.0%) patients in group-A, and in group-B it was grafted in 3 (3.0%) patients, the results showed insignificant association (*p*=0.7004). In group-A OM1 was grafted in 60 (60.0%) patients whereas in group-B it was grafted in 43 (43.0%) patients with a non-significant *p*=0.3181. Similarly no significant association was observed in the number of grafts applied on OM2 in group-A and group-B (12.0% vs 9.0% *p*=0.4889), on CX in group-A and group-B (7.0% vs 10.0% *p*=0.4469), on RI in group-A and group-B (12.0% vs 18.0% *p*=0.234), on PDA in group-A and group-B (19.0% vs 18.0% *p*=0.8555) and on RCA group-A and group-B (51.0% vs 50.0% *p*=0.8875) respectively.

Table-4: Application of Per-op Grafts in both groups

	ON-PUMP n (%)	OFF-PUMP n (%)	*p*
n	100	100	
LAD	100 (100.0)	100 (100.0)	---
D1	29 (29.0)	35 (35.0)	0.3631
D2	4 (4.0)	3 (3.0)	0.7004
OM1	60 (60.0)	43 (53.0)	0.3181
OM2	12 (12.0)	9 (9.0)	0.4889
CX	7 (7.0)	10 (10.0)	0.4469
RI	12 (12.0)	18 (18.0)	0.2348
PLV	1 (1.0)	1 (1.0)	---
PDA	19 (19.0)	18 (18.0)	0.8555
RCA	51 (51.0)	50 (50.0)	0.8875

Table-5 shows that 24 (24.0%) single vessels were endartrectomised in group-A and 14 (14.0%) were endartrectomized in group-B. Similarly 4 (4.0%) double vessel endartrectomy was performed in group-A and 2 (2.0%) was performed in group-B. Triple vessel endartrectomy was performed in 1 (1.0%) patient in group-A and no triple vessel endartrectomy was involved in group-B.

Table-5: Coronary Endarterectomy performed

Variables	On-pump n (%)	Off-pump n (%)
Single Vessel Coronary Endarterectomy	24 (24.0)	14 (14.0)
Double Vessel coronary Endarterectomy	4 (4.0)	2 (2.0)
Triple Vessel coronary Endarterectomy	1 (1.0)	0 (0.0)

In Table-6 post operative graft application is compared in both groups. The average grafts applied in group A was 2.99±0.882 and in group B the average grafts applied was 2.96±0.942, no significant difference was observed in terms of grafts applied in both groups *p*=0.234.

Table-6: Post Grafts application and Comparison

Variables	On-pump Mean±SD	Off-pump Mean±SD	*p*-value
n	100	100	
Post-op Grafts	2.99±0.882	2.96±0.942	0.234

Table-7 shows that mean ICU stay in group-A was 5.32±2.15 and in group-B it was 4.47±1.83, *p*=0.051. Similarly no significant difference was

observed in the mean hours ventilated, hospital stay and drain in group-A and group-B *p*=0.070, 0.074 and 0.468 respectively.

Table-7: Post-operative Findings

Variables	On-pump Mean±SD	Off-pump Mean±SD	*p*
N	100	100	
ICU Stay	5.32 ± 2.15	4.47 ± 1.83	0.051
Hours Ventilated	10.69±8.53	8.12 ± 5.23	0.070
Hospital stay	13.43±7.11	11.69 ± 6.01	0.074
Drain	526.24±265.73	558.61±242.60	0.468

Table-8 describing post operative complications in both groups including arrhythmias .in this table renal failure and Acute Myocardial Infarction were significantly associated in group-A and group-B (21.0% vs 10.0% *p*=0.0316) and (2.0% vs 11.0% *p*=0.0098) respectively. Neurological complications were observed only in group-B patients 3 (3.0%).

In group-A 33 (33.0%) patients developed arrhythmias whereas in group-B 22 (22.0%) patients developed arrhythmias *p*=0.3467 with no significant difference in both groups in mortality and morbidity (*p*-vale >0.05).

In both groups, no significant association was observed between low output syndrome, respiratory infections, wound infections, Intra-aortic balloon pump and mortality *p*-value being 0.3660, 0.3465, 0.1489 and 0.3465 respectively.

Mean Euro score was 3.0±2.07 in group-A and 1.8±1.9 in group-B. Actual mortality due to arrhythmias was 5, 2 patients died due to AF, One patient died due to AF/VT, One due to AF, SVT, VT, VF, other one mortality resulted from Atrial Fibrillation/Supra ventricular tachycardia, Bradycardia and Heart Block .

Over all mortality in on pump patients were 3, 2 due to AF/ one due to AF/ T. Total patients died in off pump group were 2. One due to Atrial Fibrillation/Supraventricular tachycardia/Ventricular Tachycardia/Ventricular Fibrillation, other one due to AF, SVT, Bradycardia , Heart Block. Mortality in A, was higher (1.673%) than group-B (0.75%), (*p*=0.3332).

Table-8: Comparison of Post-operative Complications

Complications	On-pump n (%)	Off-pump n (%)	*p*
N	100	100	
Conversion to On-pump	1 (1.0)	---	---
Neurological	0 (0.0)	3 (3.0)	---
Arrhythmias	33 (33.0)	22 (22.0)	0.0815
Low Output Syndrome	2 (2.0)	1 (1.0)	0.3467
Respiratory	9 (9.0)	13 (13.0)	0.3660
Wound Infection	3 (3.0)	4 (4.0)	0.3465
IABP	6 (6.0)	2 (2.0)	0.1489
Renal Failure	21 (21.0)	10 (10.0)	**0.0316***
Mortality	3 (3.0)	2 (3.0)	0.3465
AMI	2 (2.0)	11 (11.0)	**0.0098***

DISCUSSION

This study was carried out with the aims that the development of off pump coronary artery surgery decreases the incidence/adverse outcome due to extra corporeal circulation. Clinically off pump has shown improved out come in patients who are otherwise at risk for cardiopulmonary by pass and aortic cross clamping.

Cardiologist, suggest off pump surgery while patient's profile yet remained the determining factor for on or off pump coronary surgery. Decision ultimately lies with the surgeon as they are working with preoperative work up and intra operative findings. The theoretical advantage of off pump coronary artery surgery leads us to expect lower mortality and morbidity, less blood transfusion, faster recovery, shorter hospital stay and lower cost. However the evidence is short of proof.

To date six large randomised trial (150 patients) of on pump versus off pump surgery have been completed and have shown no out come differences or only small difference. Straka *et al*[19] in their study of 400 non selected patients (mean age 63 years), found that OPCAB patient had significantly fewer distal anastomosis (2.3 verses 2.7). Less blood loss (560 verses 2.7) lower post operative creatinine kinase MB (0.15 versus 0.56 microkat/L) and lower total hospital cost. They concluded that an off pump technique is applicable in 85% of non selected patient and is at loss as clinically safe and effective as on pump surgery. The study by Karolak *et al*[20] is a trial of 300 selected good risk patients (out of 933 eligible for randomisation). The outcome were excellent for both groups, and no significant difference in morbid events were noted, including such end points as transfusion requirement, Intubation time, intensive care time and hospital stay: Buffalo and Gerola *et al*[21], in their multi centre preoperative study of 160 patient with lesion in LAD alone or associated with the right coronary artery, did not find any statistical difference on hospital mortality and morbidity between the two myocardial revascularisation techniques.[21]

In a single surgeon study Puskas *et al*[22,23] recorded similar low mortality stroke rates for on pump and off pump patients, but found the off pump groups had lower transfusion rates and less enzyme release. A randomized trial from UK documented lower hospital stay and a decreased risk of atrial fibrillations and blood transfusion for the off pump group but equivalent mortality and stroke risk. Van Dijk *et al*[24] randomised 28% low risk patients and found blood utilisation slightly higher in the on pump group, as was enzyme release follow up at 1 year after operation showed no neurocognitive difference. The randomised trials that exist have involved good risk patient, and have documented low procedure related risk for both

treatments. They have also shown equivalent revascularisation rates in terms of mean number of graphs performed per patient.

Other studies of on pump versus off pump surgery have lacked randomised controls have included different types of patients and have yielded different conclusions. Al-Ruzzeh *et al*[25] reviewed UK data base from 1997–2001 and found significant difference in mortality and neurological, pulmonary and renal complications, all in favour of off pump surgery. A report from the society of thoracic surgeons national data base by Cleveland *et al*[26] noted a decreased neurological, renal, respiratory and bleeding complications in their off pump group. Similarly Mack *et al*[27] in their retrospection analysis of all coronary artery by pass grafting in a three year period in four centres with off pump coronary surgery experience showed that CPB was predictive of mortality in high risk patients including re-operation, female patients and patient aged 75 years, off pump coronary bypass grafting on the other hand, was associated with less mortality including significantly lower rate of blood transfusion 32.6% versus 40.6%, stroke 1.4% versus 2%, renal failure 2.6% versus 5.2%, pulmonary complications 4.1% versus 9.5%, re-operation 1.2% versus 3.2% atrial fibrillation 21.1% versus 24.99% and GIT complications 3.6% versus 4.8%.

All studies showed a non significant trend towards arrhythmias after off pump surgery.[28–32] One hypothesizes that advantage in turns of risk of arrhythmias after off pump surgery if present may be a little, insufficient statistical power and further to adjust for confounding factor may be reason for lack of statistical significance. Controlled randomised investigation of off pump versus on pump coronary surgery have inducted CPB plus cardioplegia arrest on the main procedure of new onset arrhythmias. The reduction in the likelihood of arrhythmias especially AF after off pump surgery was more evident in the elderly surgical candidates who are inherently more prone to arrhythmias and in high risk individual with multiple preoperative co- morbidities.

Finally in a comprehensive review and Meta analysis of studies comparing off pump versus on pump surgery it was confirmed that the off pump strategy associated with a significantly decreased chances of arrhythmias.

CONCLUSION

The conclusion emerged that there is a non significant tendency and less frequency of post operative Arrhythmias in the off pump patients. Keeping in view with conclusions of other meta analysis. Our study of recent controlled trials have the occurrence of post operative arrhythmias as study end point confirm these results indicating statistically significant advantage in terms of new onset arrhythmias incidence, if the pump is avoided.

REFERENCES

1. Adams DH, Filsoufi F, Antman EM. Medical management of the patient undergoing cardiac surgery. In: Zies DP, Libby P, Borow RO, Braun Wald E, editors. Braun Wald's Heart Disease. A text book of cardiovascular medicine Philadelphia: Elsevier Saunders; 2005.p.1993–2019
2. Subodh V, Paul WM, Fedak RD, Wiesel PE, Szmitko MV, Badiwala DB. Off pump Coronary Artery bypass Surgery. Fundamentals for the clinical cardiologist. Circulation 2004;109:1206–11.
3. Duminda NW, Beatie WS, Djaiani G, Rao V, Michael AB, Keyvan K., *et al.* Off Pump Coronary Artery Surgery for reducing mortality and morbidity. J Am Col Cardiol 2005;46:872–82.
4. Kobayashi J, Tashiro T, Ochi M, Yaku H, Watanabe G, Satoh T, *et al.* Japanese Off-Pump Coronary Revascularization Investigation (JOCRI) Study Group. Early outcome of a randomized comparison of off-pump and on-pump multiple arterial coronary revascularization. Circulation 2005;112(9 Suppl):I338–43.
5. Salzberg SP, Adams DH, Filsoufi F. Coronary artery surgery: conventional coronary artery bypass grafting versus off-pump coronary artery bypass grafting. Curr Opin Cardiol 2005;20:509–16.
6. Wildhirt SM, Schulze C, Conrad N, Sreejayan N, Reichenspurner H, von Ritter C, *et al*. Reduced myocardial cellular damage and lipid per oxidation in off pump versus conventional coronary artery bypass grafting. Eu J Med Res 2000;5:222–3.
7. Hanan EL, Wu C, Smith CR, Higgins RS, Carlson RE, Culliford AT, *et al*. Off pump versus on pump coronary artery bypass graft surgery. Differences in short term outcome and in long term mortality and need for subsequent revascularization Circulation 2007;116:1145–52.
8. Oo AY, Grayson AD, Patel NC, Pullan DM, Dihmis WC, Falri BM. Is off pump coronary surgery justified in Euro score high-risk cases? A propensity score analysis. Interact Cardiovasc Thorac Surg 2003;2:660–4.
9. Darwazah AK, Abu shama'a RA, Hussain E, Hawari MH, Ismail H. Myocardial revascularization in patients with low EF <or =35%: effect of pump techniques on early morbidity and mortality. J Card Surg 2006;21(1):22–7.
10. Rastan AJ, Eckenstein JI, Hent Schel B, Funkat AK, Gummert JF, Doll N, *et al.* Emergency Coronary artery bypass graft surgery for acute coronary artery syndrome: Beating heart versus conventional cardioplegia cardiac arrest strategies. Circulation 2006;114(I Supp):1477–85.
11. Lahhnen J, Brancari F, Rimpilanen J, Kytökorpi R, Mosorin M, Rainio P, *et al*. Off pump versus on pump coronary artery bypass surgery in high risk patients (Euro Score ≥6). Thoracic Cardiovasc Surg 2007;55;13–8.
12. Aranki SF, Shaw DP, Adam DH, Rizzo RJ, Couper GS, VanderVliet M. Predictors of atrial fibrillation after coronary artery surgery. Current trend and impact on hospital resources. Circulation 1996;94:390–7.
13. Yau TM, Ikonomidis JS, Weisel RD, Mickle DA, Hayashida N, Ivanov J, *et al*. Which techniques of cardioplegia prevent Ischemia? Ann Thoracic Surg 1993;56;1020–8.
14. Bouchard D, Cartier R. off pump revascularization of multi vessel coronary artery disease has a decreased myocardial infarction rate Eur J Cardiothoracic Surgery 1998;14:S20–4.
15. Koh TW, Carr White GS, De Souze AC, Ferdinand FD, Hooper J, Kemp M, *et al*. Intraoperative cardiac Troponin release and lactic acid metabolism during Coronary artery surgery: Comparison of beating heart with coronary artery surgery on conventional bypass. Heart 1999;81;495–500.

16. Saatvedt K, Flane AE, Sellevold O, Novdstrand K. Is atrial fibrillation caused by extra corporeal circulation? Ann Thorac Surg 1999;68:93–3.
17. Piren ZA, Wayshal AB, Lancey R, Hung SC. Arrhythmias and conduction disturbances after coronary artery bypass graft surgery: Epidemiology, management and prognosis. Am Heart J 1995;129:799–808.
18. Maisel WH, Rawn JD, Stevenson WG. Atrial fibrillation after Cardiac Surgery. Ann Intern Med 2001;13J:1061–73.
19. Widimsky P, Straka Z, Stros P, Jirasek K, Dvorak J, Votava J, *et al*. One year coronary bypass graft patency a randomized comparison between off pump and on pump surgery angiographic results of the PRAGUE-4 trial. Circulation 2004;110:3418–23.
20. Karolak W, Hirsh G, Buth R, Legare JF. Medium term out come of coronary artery bypass graft surgery on pump versus off pump: Results from a randomized controlled trial. Am Heart J 2007;153:689–95.
21. Buffalo E, Gerola LR. Coronary artery bypass grafting without cardio-pulmonary bypass through sternotomy and minimally invasive procedure. Int J Cardiol 1997;62(Suppl 1):589–93.
22. Puskas JD, Williams WH, Mahoney EM, Huber PR, Block PC, Duke PG, *et al*. Off pump versus conventional coronary artery bypass grafting: early and 1 year graft patency, Cast and quality of life outcome: a randomized trial. JAMA 2004;291:1841–9.
23. Puskas JD, Kilgo PD, Lattouf OM. Thourani VH, Cooper WA, Vassiliades TA, *et al*. Off pump coronary bypass provides reduced mortality and morbidity and equivalent 10-years Survival. Am Thorac Surg 2008;86:1139–46.
24. Van Dij KD, Nierich AP, Jansen EWL, Nathoe HM, Suyker WJ, Diephuis JC, *et al*. Early outcome after off pump versus on pump coronary by pass surgery. Results from a randomized study. Circulation 2001;104:1761–6.
25. Al Ruzzeh S, Nakamura K, Athanasiou T, Modine T, George S, Yacoub M, *et al*. Does off pump coronary artery bypass (OPCAB) surgery improves the outcome in high risk patients? A comparative study of 1398 high risk patients. Eur J Cardiothorac Surg 2003;23:50–5.
26. Cleveland JC, Shroyer AL, Chen AT, Peterson E, Grover FL. Off pump coronary artery dypass grafting decreases risk adjusted mortality and morbidity. Ann Thorac Surg 2001;72:1282–8.
27. Mack MJ, Brown PP, Kugelmass AD, Battaglia SL, Tarkington LG, Simon AW, *et al.* Current status and outcome of coronary revascularization 1999 to 2002: 148, 396 Surgical and percutaneous procedures. Am Thorac Surg 2004;77:761–6.
28. Czerny M, Baumer H, Kilo J. Zuckermann A, Grubhofer G, Chevtchik O. Complete revascularization in coronary artery bypass grafting with and without cardio pulmonary bypass. Ann Thorac Surg 2001;71:165–9.
29. Angelini DG, Taylor FC, Reeves BC, Ascione R. Early and mid term outcome after on pump and off pump surgery in beating heart against cardioplegic arrest studies (BHACAS, 1 and 2): a pooled analysis of randomized control trial. Lancet 2002;359:1194–9.
30. Zamvar V, William D, Hall J, Payne N, Cann C, Young K, *et al.* Assesment of neurocognitive impairment after off pump and on pump techniques for coronary artery bypass graft surgery: a prospective randomized controlled trial. BMJ 2002;325:1268.
31. Legare JF, Buth KJ, King S, Wood J, Sullivan JA, Hancock Friesen C, *et al*. Coronary bypass surgery performed off pump may not result in lower in hospital morbidity than coronary artery bypass grafting performed on pump. Circulation 2004;109:887–92.
32. Van Belleghem Y, Caes F, Van Overbeke H, Moerman A, Van Nooten G. Off pump coronary surgery: Surgical strategy for high risk patient. Cardio Vasc Surg 2003;11:75–9.

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