ORIGINAL ARTICLE

STROKE AFTER CORONARY ARTERY BYPASS SURGERY WITH AND WITHOUT CARDIOPULMONARY BYPASS

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Background: Stroke is a devastating complication of coronary artery bypass grafting (CABG). This study was carried out with the aim that the development of off pump coronary artery surgery decreases the incidence/adverse outcome due to extra corporeal circulation. **Methods:** The data utilized in this study was extracted from a randomized controlled trial that 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:** 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. Renal failure occurred in 21% patients of group-A as compared to 10% of group-B while Acute Myocardial Infarction occurred in significantly higher number of patients in group-B (11%) as compared to group-A (2%). Off pump was associated with significant decrease in rate of stroke 1.5% as compared to on pump 3.5%. similarly there was decreased in the risk of deaths after stroke 0% as compared to on pump 1.5% mortality after stroke. In group A 6(3.5%) patients developed stroke where as in group-B 2 (1.5%) patients developed stroke out of these 6 patients there were 2 mortalities after stroke in group-A while in group-B there was no mortality after stroke within 30 days postoperatively. **Conclusion:** Off pump CABG is associated with significantly decreased rate of stroke in comparison with the on-pump CABG.

Keyword: Coronary artery bypass grafting, Cardiopulmonary bypass, cerebrovascular accident, stroke

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INTRODUCTION

Stroke is a devastating complication of coronary artery bypass grafting (CABG). The incidence of stroke after CABG has been reported to be 2–3%. The causes of stroke during peri-operative period are embolism, hypoper-fusion, hypoxia, bleeding and metabolic abnormalities. The burden of the disease is associated with increased morbidity and mortality rate and increased cost to the health care system through prolonged in hospital stay and outpatient rehabilitation.[1,2] Coronary artery bypass surgery with cardiopulmonary bypass is a standard procedure for treatment of coronary artery disease. 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. There are some advantages of off pump compared to conventional on pump coronary artery surgery. 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.[3–5]

It was observed in earlier experiences 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. Stroke after coronary artery surgery causes significant increase in mortality. Due to the economic and medical impact of neurological complication, their prevention has become a major focus of bypass surgery. Previous studies have shown stroke rate between 1.3–3.4% this rate varies depending on the type of operation and preoperative co-morbid factors. There is significant evidence that off pump coronary artery bypass grafting is associated with better outcome compared with on pump coronary artery bypass grafting, specifically with a lower incidence of stroke and mortality. Stroke risk is increased three folds in patients with post-operative atrial Fibrillation. Patient selection plays an important role in success of off pump coronary artery bypass (OPCAB). Patients 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 outcome.[6,7] Despite the continuous modification of operative procedure and improvement in intra and post-operative care stroke remains a common and devastating complication of coronary artery bypass grafting. This study was designed to determine the outcome by comparing off pump and on pump coronary artery bypass grafting, with reference to frequency, severity and death related incidence of stroke at a single institution.

MATERIAL AND METHODS

The data utilized in this study was extracted from a randomized control trial that was conducted from

January 2006 to March 2007 at the Punjab Institute of Cardiology.

This is a single institution and single surgeon study. Only the first 30 days postoperative outcome was evaluated. Patients were randomized in two Groups-A and B. Group-A, included 100 patients in whom on pump coronary artery bypass surgery was done. In Group-B off pump coronary artery bypass surgery was carried out in 100 patients. All patients were assessed preoperatively by using Euro Score for standardizing the risk and expected outcome. Inclusion criteria for the patients were elective coronary artery bypass 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 last one month, history of supra-ventricular tachycardia, atrial fibrillation, renal, respiratory impairment, previous stroke, transient ischemic attacks and coagulopathy. Operative techniques for on pump and off pump were adopted as standard. Vessel size >1.5 mm, quality were considered for satisfactory anastomosis. Keys to optimization of intra-operative patient haemodynamic 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 (MVO_2, 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 was used for reversal after completion of procedure.

The first post-operative neurological examination was performed in the intensive care unit before extubation by cardiac surgeon, senior anaesthetist intensivist. On neurological examination the follow-up functions were checked and compared with preoperative status. Pupillary reflex, orientation about time, place, and person, speech, memory function, motor function by checking power and movement, symmetry of movement feet leg, hand, arm, and facial muscles were accessed. The major outcome variable was stroke which is defined as visible/ evident temporary or permanent new neurological defect during the same hospital stay. The neurological deficit was confirmed by CT scan of the brain and clinically by a senior neurologist unaware of the study status. We did not collect data about the severity of calcification of the aorta which was incidental finding and might have influenced the results.

The data was analysed using PASW 18.0 and STATA 8.2, Mean±SD was calculated for quantitative variables and frequencies and percentages 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

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 and hypertension status of patients in group-A and group-B. The other baseline parameters such as diabetes, positive family history of IHD, hyperlipidemic, renal failure, Hepatitis-B, Hepatitis C, Intra-aortic Balloon Pump (IABP) were compared and results didn't show any statistically significant difference among two groups. While more vessels were endartrectomised in group-A 29% as compared to group-B 16% (p=0.027) as shown in table-1.

The preoperative laboratory investigations were compared in both the groups. 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, showing no significant difference in both groups. Similarly mean ESR platelet count, mean haematocrit the mean levels of blood urea, creatinine, bilirubin, prothrombin time, International Normalised Ratio (INR) Activated Partial Thromboplastin Time (APTT), serum cholesterol, triglycerides and cardiac enzymes showed no significant different levels in both groups (Table-2).

Table-3 shows comparison of grafts application in terms of site in both groups. LAD was grafted in 100% patients of both groups. In group-A D1 was grafted in 29 (29%) patients whereas in group-B it was grafted in 35 (35%). D2 was grafted in 4 (4%) patients in group-A, and in group-B it was grafted in 3 (3%) patients. In group-A OM1 was grafted in 60 (60%) patients whereas in group-B it was grafted in 43 (43%) patients. There was no statistically significant difference in respect of application of grafts in both groups. Similarly no significant association was observed in the number of grafts applied on OM2 in group-A and group-B (12% vs 9% p=0.4889), on CX in group-A and group-B (7% vs 10% p=0.4469), on RI in group-A and group-B (12% vs 18% p=0.234), on PDA in group-A and group-B (19% vs 18% p=0.8555) and on RCA group-A and group-B (51% vs 50% p=0.8875) respectively.

Table-3 shows that 24 (24%) single vessels were endartrectomised in group-A and 14 (14%) were endartrectomized in group-B. Similarly 4 (4%) double vessel endartrectomies were performed in group-A and 2 (2%) were performed in group-B. Triple vessel endartrectomy was performed in 1(1%) patient in group-A and none of the patients in Group B had triple vessel endartrectomy.

In table-3 number of post-operative graft application is compared in both groups. No significant difference was observed in terms of grafts applied in both groups as the mean number of grafts applied in group-A were 2.99±0.882 and in group-B were 2.96±0.942, p=0.234.

Table-4 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.

Renal failure occurred in 21% patients of group-A as compared to 10% of Group-B while Acute Myocardial Infarction occurred in significantly higher number of patients in group-B (11%) as compared to group-A (2%). In group-A 33 (33%) patients developed arrhythmias whereas in group-B 22 (22%) patients had arrhythmias p=0.3467 with no significant difference in both groups in mortality and morbidity (p >0.05).

In both groups, no significant association was observed between low output syndrome, respiratory infections, wound infections, Intra-aortic balloon pump and mortality as shown in table-4.

Mean Euro score was 3.0±2.07 in group-A and 1.8±1.9 in group-B. Overall mortality occurred in 5 patients, mortality in group-A, was higher 3 (1.673%) than group-B 2 (0.75%) (p=0.3332). Mortality occurred due to arrhythmias. In Group-A, 1 patients died due to atrial fibrillation (AF), 1 due to Bradycardia and 1 because of heart block. In group-B, 1 patient died due to ventricular tachycardia (VT) and the other due to supraventricular tachycardia (SVT).

We observed that off pump was associated with significance decreased in rate of stroke 1.5% as compared to on pump 3.5% similarly there was decreased in the risk of deaths after stroke 0% as compared to on pump 1.5% mortality after stroke odds ratio 0.157, 95% confidence interval 0.035 to 0.711 p-value 0.016 for the risk postoperative stroke. In group A 6 (3.5%) patients developed stroke where as in group-B, 2 (1.5%) patients developed stroke out of these 6 patients there were 2 mortalities after stroke in group-A while in group-B there was no mortality after stroke within 30 days post-operatively.

Patient with postoperative course who were complicated by stroke remained in ICU for more than 7 days and in the hospital for more than 25 days. Predictors of poor outcome were delayed emergence from anaesthesia, increase serum creatinine postoperatively, prolonged CPB, use of IABP preoperatively and presence of infarct on brain imaging.

Encephalopathy was characterized by confusion, delirium, seizures, coma, prolonged alteration in mental status and agitation. Incidence of encephalopathy following cardiac surgery in our study was around 5 to 10% patient 5 with encephalopathy remained hospitalized for more than 20 days these patient required constant supervision by family member in the home setting and assistance with activities of daily living. 7.5% for patient who developed encephalopathy after CPB. Post-operative depression psychosis as consequence of cardiac surgery had been observed in about 7–10% of our patient out of them 5% of patient who were depressed before surgery. The best predictor of post-operative depression was pre-operative depression. Patient who were depressed after cardiac surgery were having longer stay then non depressed patient. Incidence of cognitive decline (memory loss) was noted in quite few cases. But the cognitive function improved gradually within few months.

Table-1: Demographics of the study population

Variables	Group I ON-PUMP (n=100)	Group II OFF-PUMP (n=100)	*p*-value
Age mean years	53.51±9.96	51.59±10.30	0.765
Height mean Cm	167.9±9.57	168.97±6.49	0.512
Weight mean Kgs	71.80±12.6	74.90±12.13	0.070
Heart rate mean per minute	81.19±9.98	78.70±8.39	0.052
Systolic Blood Pressure mean mm Hg	119.20±13.8	121.70±12.85	0.941
Diastolic Blood Pressure mean Hg	77.42±9.13	75.87±8.32	0.209
Respiratory Rate per minute	20.46±2.21	20.16±2.49	0.470
Hypertension	54 (54%)	53 (53%)	0.8873
Diabetes Mellitus	38 (38%)	42 (42%)	0.5637
Family History	34 (34%)	39 (39%)	0.4637
Hyperlipidemia	18 (18%)	10 (10%)	0.1030
Smoking	42 (42%)	33 (33%)	0.1887
Renal Failure	0 (0%)	1 (1%)	---
Hepatitis B	1 (1%)	3 (3%)	0.3124
Hepatitis C	2 (2%)	4 (4%)	0.4071
Endartrectomy	29 (29%)	16 (16%)	0.0277
IABP	3 (3%)	4 (4%)	0.3476

Table-2: Pre-operative laboratory investigations of the study patients.

LABORATORY INVESTIGATIONS	Group-1 ON-PUMP (n=100)	Group-2 OFF-PUMP (n=100)	*p*-value
Haemoglobin in mean gm/dl	13.23±1.67	12.34±1.80	0.773
Erythrocyte Sedimentation Rate mean/hour	19.51±12.70	19.36±12.89	0.930
Platelets mean	221.62±69.97	223.66±68.94	0.845
Haematocrit mean percentage	38.31±5.38	38.19±4.65	0.887
Urea mean mg/dl	31.11±14.41	28.24±10.28	0.098
Creatinine mean mg/dl	1.06±0.64	1.07±0.73	0.878
Bilirubin mean mg/dl	0.64±.227	0.63±.25	0.826
Prothrombin Time mean sec	13.63±2.28	13.45±1.202	0.513
International Normalised Ratio mean	1.08±.11	1.07±0.09	0.522
Activated Partial Thromboplastin Time mean	38.81±10.53	39.36±14.90	0.761
Cholesterol mean mg/dl	155.6±35.431	151.87±39.4	0.654
Triglyceride mean mg/dl	169.3±131.97	174.49±132.05	0.435

Table-3: Application of Per-operative Grafts in both groups.

Variables	Group-1 ON-PUMP (n=100)	Group-2 OFF-PUMP (n=100)	*p*-Value
LAD	100 (100%)	100(100%)	---
D1	29 (29%)	35 (35%)	0.3631
D2	4 (4%)	3 (3%)	0.7004
OM1	60 (60%)	43 (43%)	0.3181
OM2	12 (12%)	9 (9%)	0.4889
CX	7 (7%)	10 (10%)	0.4469
RI	12 (12%)	18 (18%)	0.2348
PLV	1 (1%)	1 (1%)	---
PDA	19 (19%)	18 (18%)	0.8555
RCA	51 (51%)	50 (50%)	0.8875
Endarterectomy			
Single Vessel	24 (24%)	14 (14%)	
Double Vessel	4 (4%)	2 (2%)	
Triple Vessel	1 (1%)	0	
Post-o-grafts	2.99±0.882	2.96±0.942	0.234

CX= Circumflex artery; D1= First diagonal; D2= Second diagonal; LAD= Left anterior descending artery; OM1= First obtuse marginal; OM2= Second obtuse marginal; PDA= Posterior descending artery; PLV= Posterior left ventricular; RCA= Right coronary artery RI= Ramus Intermediate

Table-4: Post-operative outcome

Outcome Variables	Group-1 ON-PUMP (n=100)	Group-2 OFF-PUMP (n=100)	*p*-Value
ICU Stay mean days	5.32±2.15	4.47±1.83	0.051
Mean hours Ventilated	10.69±8.53	8.12±5.23	0.070
Hospital stay mean days	13.43±7.11	11.69±6.01	0.074
Drain mean mls	526.24±265.73	558.61±242.60	0.468
Conversion to On-pump	1 (1%)	0	---
Neurological	6 (6%)	2 (2%)	---
Arrhythmias	33 (33%)	22 (22%)	0.0815
Low Output Syndrome	2 (2%)	1 (1%)	0.3467
Respiratory	9 (9%)	13 (13%)	0.3660
Wound Infection	3 (3%)	4 (4%)	0.3465
IABP	6 (6%)	2 (2%)	0.1489
Renal Failure	21 (21%)	10 (10%)	0.0316*
Mortality	3 (3%)	2 (3%)	0.3465
AMI	2 (2%)	11 (11%)	0.0098*

AMI=Acute myocardial infarction; ICU=Intensive care unit; IABP=Intra-aortic balloon pump

DISCUSSION

Several studies have compared the surgical results of conventional CABG and OPCAB in institutions with experienced cardiac surgeons in OPCAB have better operative outcome including the incidence of stroke, maintaining the long term outcome comparable to those of on pump CABG. A recent study reported a 58% reduction in the incidence of stroke and an 84% decrease in the risk of death after stroke after OPCAB as compared to that after on pump CABG.[8,9] But in our study the actual incidence of stroke was as low as 0.5%. Sedrakyan *et al* reported a meta-analysis of 41 randomized clinical trials comparing surgical outcomes between OPCAB and on pump CABG. They demonstrated that peri-operative stroke was reduced by 50% using the OPCAB technique as compared to conventional CABG, though the incidence of stroke was not completely eliminated. Peel *et al* evaluated the onset of stroke in a group of cardiac surgery patients undergoing On-pump CABG

versus OPCAB. Majority of stroke associated with OPCAB occurred after an initially uncomplicated neurological recovery following cardiac surgery.[10,11] Median time for the onset of stroke after OPCAB was 4 days and 2 days after on pump CABG. On-pump CABG was associated with a higher risk of stroke (odds ratio) 5.3; a 95% confidence interval (CI) 2.6-10.9; (p<0.01) as compared to OPCAB. Nishiyama *et a*l found that incidence of stroke after OPCAB (1.0%) was lower than that of on pump CABG (2.5%) (p=0.0043) and that most of stroke (90%) in OPCAB occurred after first awakening from surgery without a neurological deficit (delayed stroke), while almost half of the strokes after on pump CABG were early strokes.[12–14]

In our study there was no occurrence of early stroke. The prognosis of stroke depends on the type of stroke. A higher mortality rate has been reported for early stroke as compared to that of delayed stroke. In majority stroke occurs within the first 48 hours after surgery, although delayed stroke may occur usually within 30 days postoperatively. Advanced age is shown to be an independent risk factor for stroke in CABG, mainly among octogenarians. The risk increases with a 10 year increment in age. Co morbid conditions such as hypertension diabetes chronic renal insufficiency peripheral vascular disease, prior history of TIA or stroke presence of bruit, moderate to severe carotid artery stenosis, significant atheroma in the ascending aortic arch are shown to be independent predictors of post CABG stroke.[15,16] A prior history of TIA or stroke is identified as an independent determinant of stroke in patients who have CABG in large observational studies, with the age of the patient, history of carotid occlusive disease, and other pre-existing conditions playing an additional risk factor. Like MI, unstable angina before surgery was associated with increased risk of stroke. Duration of bypass is associated with higher intra operative risk of stroke. Coronary artery surgery study a multicentre randomized controlled study of medical therapy versus CABG group shows that duration of bypass surgery of more 200 minutes was associated with 4.5 fold increase in risk of stroke in high risk patient. In a large review of CABG surgery over 10 years OPCAB was associated with an overall reduction in stroke rate of 0.76%. Similar data was obtained by Engelman in a collective review of more than 35000 patients. Other published studies comparing OPCAB and conventional surgery do not show a major difference in the incidence of stroke.[17,18] Atrial fibrillation after bypass surgery is associated with a three to four fold increased risk of postoperative stroke with significant prolongation of hospital stay and 30 day morbidity and mortality.

Neuropsychiatric abnormalities are one of the common complications of CPB. A permanent Neurological deficit/stroke occurs in 4–6% of the patient undergoing cardiac surgery. But in our study it was around 3.5% which is similar to other reported studies in literature. Any neurological deficit which persists for more than 30 minutes is regarded as stroke. The causes of stroke are multifactorial. But the advanced age is the most important predictor of perioperative stroke. Prior stroke or cardiovascular disease is a strong predictor of recumbent stroke. Patient with history of hypertension and those with elevated systolic blood pressure above 120 were found to be at an increased risk for perioperative stroke. Total time spent on CPB was another predictor of stroke. The longer the time the higher the probability for stroke. Postoperative atrial fibrillation was associated with stroke on univariate analysis p<0.001.

CONCLUSION

Stroke after CABG is a serious morbid complication with high mortality rate. Off pump CABG is associated with significantly decreased rate of stroke in comparison with the on-pump CABG.

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