OFF PUMP CORONARY ARTERY SURGERY AND INTRAOPERATIVE SAFETY–EXPERIENCE AT AFIC/NIHD, RAWALPINDI

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Background: Coronary Artery Bypass Grafting (CABG) with cardiopulmonary bypass (CPB) on one hand allows controlled haemodynamics with superior graft quality while on the other hand carries inherent risks of CPB which has renewed interest in Off-pump coronary artery bypass (OPCAB). Haemodynamic instability and intraoperative dysrythmias are major procedural complications of OPCAB, threatening conversion to emergency on-pump surgery. The purpose of this study was to compare intraoperative dysrythmias and inotropic use for haemodynamic stabilization during OPCAB surgery against conventional CABG. **Methods:** Consecutive CABG cases operated between 1st June 2003 and 31st May 2006 were included while conversions were excluded. Primary end points were analyzed using chi square and t test and values described in percentages, means and probability (*p* value). **Results:** Six hundred and eighty-four cases were divided in group-A (on-pump, n=574) and B (OPCAB, n=97). Conversion rate was 11.8%. Intraoperative dysrythmias (A, 3.5%, B, 15%, $p<0.0001$) and use of inotropic support was higher in group-B (A, 15.3%, B, 30.3%, $p<0.0001$). Actual mortality in group-B was higher than the predictive value (A, 3.8%, B, 3.6%, Predictive value 3–5% and 0–3% respectively). **Conclusions:** OPCAB leads to higher frequency of dysrythmias and inotropic use intraoperatively, highlighting lower procedural safety over conventional CABG.

Key words: OPCAB, intraoperative dysrythmias, inotropic use

INTRODUCTION

Coronary artery bypass grafting (CABG) with cardiopulmonary bypass (CPB) is a standard procedure for treatment of coronary artery disease. This technique provides controlled haemodynamics, bloodless and motionless surgical field intra-operatively, allowing the surgeon to bypass multiple coronary arteries with greater precision and control.[1] CPB is a major invasive intervention with inherent risks and increased awareness has renewed interest in off pump coronary artery bypass grafting(OPCAB).[2]

During OPCAB, anastomoses are performed on beating heart using stabilization devices[3] and intracoronary shunts.[4]During last 10 years OPCAB is being offered as established and safe alternative to conventional CABG.[5,6] Although this method is intellectually appealing, there are still major concerns regarding intraoperative complications.[7] Anatomic distortion during positioning causes haemodynamic instability and reduction in stroke volume[8,9] necessitating additional supportive measures.[10–12] Intraoperative dysrythmias during positioning are a major complication during OPCAB and various techniques for their reduction are under research.[13] Atrial fibrillation can arise from compression of right ventricle during grafting of right sided vessels. Ventricular dysrythmias (Figure-1), especially polyphasic ventricular tachycardia (PVT) or polyphasic ventricular fibrillation are short cycle length and lead to loss of systemic perfusion pressures and ischemic injury. Ventricular dysrythmias can be induced using transient ischemia followed by re-perfusion.[14,15] Hypothermia, inotropic agents and coronary spasm due to hypomagnesaemia are other triggering factors.[16] Intraoperative dysrythmias, haemodynamic collapse, and anastomotic bleeding are leading factors for conversion of OPCAB to emergency on-pump surgery carrying even higher mortality.[17,18] Therefore the role of OPCAB still remains controversial in clinical application.

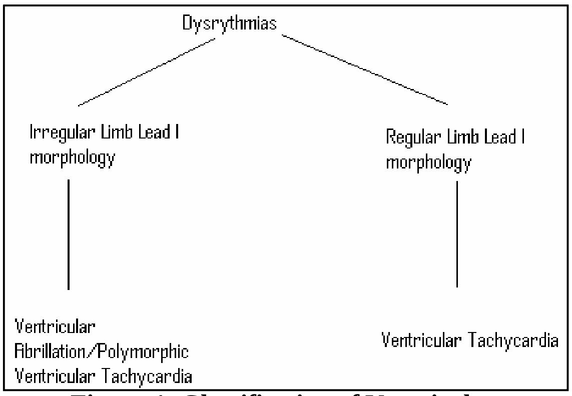

Figure-1: Classification of Ventricular Dysrythmias

At AFIC/NIHD we perform about 700–800 coronary artery bypass surgeries. OPCAB makes 23.4% coronary workload of our surgical team. This study was carried out after standardization of OPCAB technique according to international protocol (King`s College Hospital, London, UK) in 2003.

MATERIAL AND METHODS

It is case-review comparative analysis of on-pump and OPCAB cases. All consecutive CABG cases performed by single surgical team at AFIC/NIHD

Rawalpindi during the time period between 1st June 2003 and 31st May 2006, were included and divided in 2 groups; group-A on-pump cases and group-B OPCAB cases. OPCAB cases converted to on-pump surgery were excluded. Parsonnet scoring was used for standardization of risk (Table-1). Primary End Points were, Intraoperative dysrythmias (persistent brady- or tachyarrhythmias during surgery, causing significant hypotension and necessitating intervention like pacing, defibrillation, chemical cardioversion), use of inotropes (necessity of starting inotropic agents for haemodynamic stability during surgery) and in-hospital mortality (death within 30 days during hospital stay).

Table-1: Parsonnet scoring system

Demographic variables	Definitions	Score
Gender	Female	1
Morbid Obesity	BMI >35	3
Diabetes	History of diabetes (excluding gestational diabetes)	3
Hypertension	History of BP >140/90 on 2 occasions or low if on medicines	3
LV Dysfunction (EF%)	Good (G) >50%, Fair (F)=30–49%, Poor (P) <30%	G=0, F=2, P=4
Age	1= 70–74, 2= 75–79, 3= >80	1=7, 2=12, 3=20
Re-operation	1= Second , 2= Third or more	1=5, 2=10
IABP	Prior to surgery	2
LV Aneurysm	Aneuresmectomy	5
Recent failed intervention	1= operated with in 24 hrs, 2= operated after 24 hour	1=10, 2=5
Renal	Dialysis-dependence	10
Catastrophic states	Acute VSD, Acute MR, ARF, Cardiogenic Shock	10-50
Rare circumstances	Paraplegia, CHD in adults, Pacemaker depd, sev Asthma	2-10
Mitral-valve Surgery	1= Systolic PAP<60, 2= Systolic PAP >60	1=5, 2=8
Aortic-valve (AV) Surgery	1= PG across AV <120, 2= PG across AV >120	1=5, 2=7
CABG+Valve Surgery		2

(BMI=body-mass index, Hx=history, LV=left ventricle, EF=Ejection fraction, IABP=Intra-aortic balloon pump, VSD=ventricular septal defect, MR=Mitral regurgitation, ARF=acute renal failure, CHD=congenital heart disease, PAP=pulmonary artery pressure, PG=pressure gradient)

A-Surgery:

Single surgical team performed all operations through midline sternotomy approach in all cases. Left internal mammary artery (LIMA) and long sephenous vein were harvested simultaneously. Heparinization was done before ligating the distal end of LIMA.

Conventional on-pump surgery: Cardiopulmonary bypass was established by Aorto-Right Atrial Cannulation (Sarns-24Fr-aortic-cannula, 2-staged-36/51Fr-Venous-return catheter, Terumo, USA) and mild hypothermia (32–34 ^{0}C) with single aortic cross-clamp. Myocardial protection was achieved by antegrade transfusion of 10 ml Howards-cardioplegia injection/500ml warm blood using aortic root cannula (Sarns Cardioplegia/Vent catheter, 12G, Terumo, USA), and 100 ml of this preoaration was repeated after every distal anastomosis for 20 minutes. Aortic root was vented for decompressing the heart. Epicardial coronary arteries were stabilized using two 3/0 Prolene stay sutures and arteriotomy was performed with 15 size surgical blade. All the distal anastomosis were performed using 7/0 Prolen (Ethicon Prolene-8 mm, CC-needle, Johnson & Johnson, USA) and aortic cross-clamp was removed. Patient re-warmed to 37 ^{0}C central and weaned off bypass after completing the top ends with 6/0 Prolene (Ethicon Prolene-13 mm, Visi-black, Johnson & Johnson, USA) using single aortic side-clamp. Anticoagulation was reversed with protamine sulphate, just prior to removal of aortic cannula.

OPCAB surgery: OPCAB was standardized in all the cases. Temperature was maintained by regulating theatre temperature and humidity. Heparin was given in half dose to achieve ACT above 300. After midline sternotomy and harvesting LIMA, two strong stay sutures of vicryl 01 (Ethicon coated-Vicryl Plus, 40 mm, Johnson & Johnson, USA) were taken on the left posterior pericardium. Cardiac wall motion stabilization was achieved by placing a suction device, i.e., OCTOPUS (Octopus-2 Tissue Stabilization System, Medtronics, USA) on either side of the recipient coronary artery. Arteriotomy was performed using 15 size surgical blades and intracoronary shunt (size 1.5 mm, 1.75 mm, 2.0 mm, 2.5mm. CHASE MEDICAL, TX, USA) of appropriate size was introduced into the coronary artery for distal myocardial perfusion. Shunt was removed just prior to completion of anastomosis. For clear visualization of coronary vessel wall, a dual action device was used as blower having separate in-built channel for sprinkling saline in the form of a mist (Blower/Mister, ACCUMIST, Medtronics, USA). After every distal anastomosis heart was placed in natural anatomic position and proximal anastomosis was performed. Sequence of anastomosis was Left Anterior Descending Artery, Posterior Descending Artery, Diagonal Artery and then Obtuse marginal Artery, also proposed by Browaski.[19]

B-Anesthesia and Intraoperative Monitoring:
Preoperative visit to the cardiac anesthetic was done and OPCAB cases were always seen by specialist anaesthetist and monitored in Operation theatre as well. Single arterial line (20G×2 inch Safelet-Cath, Nipro, Japan) for perioperative blood pressure monitoring was placed in left radial artery. Central venous triple lumen catheter placed using right Jugular approach. Throughout the procedure heart rate, ECG, invasive and non-invasive blood pressure, central venous pressures, urine output and temperature were monitored. Heparin was given in loading dose of 300 IU/Kg body weight to achieve ACT >450 before ligation of distal end of LIMA.

Conventional on-pump surgery: As soon as CPB was established monitoring was taken over by perfusionist regulating flow rates and haemodynamics. Arterial blood gases and ACT were done half hourly and heparin repeated as necessary. After weaning off CPB, haemodynamic stabilization was achieved with volume replacement and if needed dobutamine was started and dose titrated. The anticoagulation was reversed with protamine sulphate, just prior to removal of aortic cannula in a dose of 3 mg/Kg body weight.

OPCAB surgery: During OPCAB, nitroglycerine infusion for ischemic prophylaxis and volume loading were instituted at the beginning of the case. Anticoagulation was produced using 150 IU/Kg of heparin in order to maintain an ACT >300 seconds.

Patient was monitored by the anaesthetist throughout the procedure. Anticoagulation was reversed with protamine sulphate in a dose of 1.5 mg/Kg body weight after completion of last proximal anastomosis. In the event of intraoperative dysrythmias, internal cardioversion was done before antiarrthymics were instituted and maintenance was achieved with infusion amiodarone 300 mg/100 ml normal saline, titrated to achieve heart rate between 80–100/minute. Volume replacement was used for haemodynamic stabilization followed by dobutamine infusion as first line inotropic agent where indicated and adrenaline as second line agent.

A bypass circuit was routinely available within operative suite in the event that conversion to cardiopulmonary support was indicated.

C-Statistical Analysis:
Demographic and outcome variables were obtained from departmental data sheets on SPSS version 12 for Windows®. Multivariable analysis was done and frequency tables were obtained using SPSS. Values were described in percentages and mean values ± standard deviation. Using Excel (Microsoft Excel® 2003) Chi-square and *t*-test was applied for significance analysis, describing results in probability values (*p* value) inferred at ≤0.05.

RESULTS

Total number of cases operated was 684. They were divided in group-A (on pump n=574) and group-B (OPCAB n=97). One hundred and ten patients were started as OPCAB surgery and 97 were successfully operated with 13 conversions to emergency on pump CABG. Conversion rate was 11.8 %.

Demographic and Pre Operative Status
Mean age at operation was higher for group-A being 53±9.1 against 51±9.39 in group-B. Emergency coronary surgery was performed on 12.7% cases of group-A (n=73) while all the cases of group-B were operated electively. Most of the patients had stable angina (A, 83.8%, B, 90%) with preserved left ventricular function (mean Ejection Fraction 0.50). Co-morbid conditions like hypertension, diabetes mellitus, unstable angina and poor LV function (Ejection Fraction ≤0.30) were more frequently operated in group-A ($p<0.05$) and rest were comparable (Table-2).

Table-2: Preoperative Profile.

Pre operative profile	Group A	Group B	*p* value
Age Year (Mean±SD)	53±9.1	51±9.4	0.001
Females n (%)	50 (8.7)	3 (3.1)	0.05
Hypertension	231 (40.2)	30 (30.9)	0.04
Diabetes mellitus	153 (26.7)	7 (7.2)	0.001
COPD	8 (1.4)	4 (4.1)	0.06
Renal disease	18 (3.1)	3 (3.1)	0.96
Unstable Angina	88 (15.3)	6 (6.2)	0.01
NYHA III/IV	35 (6.1)	9 (9.3)	0.41
Ejection Fraction≤30%	26 (4.5)	0	0.03

(n=number of patients, std dev=standard deviation, COPD=Chronic obstructive airway disease, NYHA=New York heart association)

Significance analysis shows group A, at higher risk due to high frequency of hypertension, diabetes, unstable angina, poor LV function. Angiographic data showed Triple vessel coronary artery disease in both groups (A, 78%, B, 60.6%) but group-A had higher percentage of associated left main stem disease (A, 10.5%, B, 1%) (Figure-2).

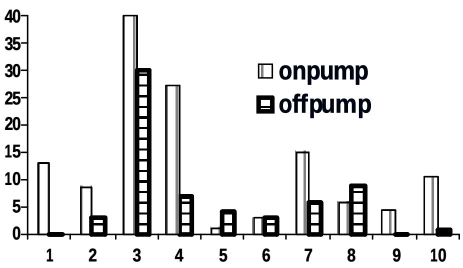

Figure-2: Population characteristics.
1=Emergency, 2=Females, 3=Hypertension, 4=Diabetes, 5=COPD, 6=Renal Disease, 7=Unstable Angina, 8=NYHA III/IV 9=EF<30%, 10=LMS disease

Intra Operative Status
CPB time was 84±26.9 minutes and cross clamp time was 47±15 min. Group-A received 3.02±0.70 while

group-B received 2.45±0.66 grafts on an average (*p*>0.01).

Intraoperative dysrythmias were observed in both groups. In group-A, 3.5% cases developed arrhythmias out of which 2.6% were ventricular tachyarrythmias (PVT/VF) and 0.9% heart block (type I, II, or III) requiring epicardial ventricular pacing. In group-B, 15.1% patients developed intraoperative dysrythmias being ventricular tachyarrythmias (PVT/VF) in 12.1% and heart block in 3% (*p*< 0.0001) (Figure-3).

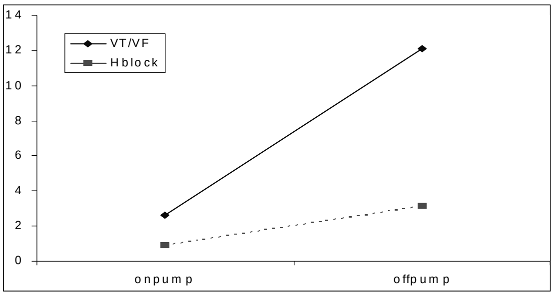

Figure-3: Intraoperative dysrythmias were more during OPCAB, tachy-arrhythmias (solid line) and brady-arrythmias (dotted line). (Y axis=percentage)

Use of inotropic agents for haemodynamic stabilization was significantly higher in group-B (A, 15.7% B, 30.3%, *p*<0.0001). In group-A and B respectively, 84.3% and 67.7% cases were shifted to intensive care without inotropic support. Graphic plotting clearly establishes that in group-A total grafts above 3, and in group-B total grafts above 2 needed inotropic support (Figure-4). A direct relation exists between the number of grafts (>3 on-pump, >2 OPCAB), and the use of inotropic support (dark rhomboids), independent of age (SPSS scatter diagram, y axis=age in years).

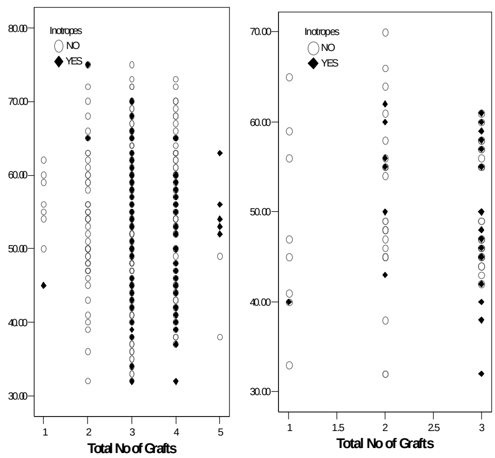

Figure-4: Inotropic support. (See text for description)

<u>Risk Assessment and Mortality</u>

Mean Parsonnet score for group-A was 3.0±2.07, and for B, 1.8±1.9 (*p*>0.01). Actual mortality was 3.8% for group-A and 3.6% for group-B (*p*>0.01). Predictive mortality was calculated to be 3–5% for group-A and 0–3% for group-B according to Parsonnet score. Actual mortality in group-B was higher than the predictive value (3.6%, 0.3% respectively).

DISCUSSION

This study was carried out mainly to address the ongoing controversy regarding safety of OPCAB over conventional CABG, so that it can be offered as a primary surgical approach for coronary revascularization. Most importantly patient seeking information about the safety of the procedure has to be provided with an ethically justified comparison done at the institute. OPCAB though claims superior early and long term outcomes in observational studies, but randomized control trials report otherwise. In the face of lacking evidence about role of OPCAB, its clinical application remains controversial and not universally accepted.[2]

This study shows the demographic profile and frequency of co-morbid conditions (Table-2) in our standard population presenting for CABG surgery. All the observed components are recognized risk factors effecting outcome during and after CABG surgery. Group-A was found to be at more risk, because of high frequency of females (8.7%, *p*=0.05), hypertension (40.2%, *p*=0.04), diabetes (26.7%, *p*=0.001), unstable angina (15.3%, *p*=0.01) and poor left ventricular function with ejection fraction ≤0.03 (4.5%, *p*=0.03).

The mortality in both groups was not statistically significant (A, 3.8%, B, 3.6%, *p*>0.01) and is supported by many randomized control trials. Observational studies so far have claimed huge mortality benefit in OPCAB which has not been proven by many randomized controlled trial done so far.[2]

The reported atrial fibrillation during surgery[7,8] was not observed in our experience. Our conversion rate of 11.8% was towards higher side of the reported range of 2.3–13%,[17,18] mainly due to higher frequency of intraoperative arrhythmias of ventricular origin (15%, *p*<0.001) causing haemodynamic instability or imminent cardiac arrest. OPCAB cases developed ventricular dysrythmias during positioning of the heart for grafting. Internal cardioversion was found to be superior in controlling dysrythmias and chemical agents like intravenous amiodarone was used as a maintenance agent.

Use of inotropic support, was higher during OPCAB, for stabilization of haemodynamic status.[10–12] Our data also shows a direct relation ship of inotropic support to number of grafts in both groups. Higher clamp time is a predictor of myocardial injury and grafts ≥4, have higher chances of myocardial damage.[20] In our study during OPCAB, when the total number of grafts exceeded 2, patient frequently needed inotropic support, indicating that manipulation of the heart for positioning with associated haemodynamic instability and dysrythmias, may be subjecting the patient to same risk of myocardial damage, as does higher clamping time.

The state of the facts is that, in our study mortality is higher in low risk OPCAB cases of standard population, indicating that by performing OPCAB we are definitely exposing our patients to increased risk of intraoperative dysrythmias, haemodynamic instability and conversion with its own associated higher mortality and morbidity. Intraoperative risks identified by our study, questions the very safety of this procedure. The safety of OPCAB will continue to be subjected to critical scrutiny before it can be offered as a primary standard for surgical revascularization.

CONCLUSIONS

OPCAB leads to higher frequency of intraoperative dysrythmias and haemodynamic instability necessitating higher use of inotropic support for stabilization. The actual mortality of OPCAB is higher than its predictive value, highlighting lower procedural safety over conventional CABG surgery.

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