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Evaluation Of Pulmonary Functions Of Off-Pump Coronary Artery Bypass Graft Patients

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Abstract

Background: *Cardiopulmonary bypass has been implicated in causing poor pulmonary gas exchange postoperatively in patients undergoing coronary artery bypass graft (CABG). This nonrandomized prospective study was conducted to determine whether patients undergoing off-pump CABG and thereby avoiding cardiopulmonary bypass will have improved pulmonary functions postoperatively.*

Method: *Sixty patients undergoing elective CABG in the National Institute of Cardiovascular Diseases (NICVD), Dhaka between July 2005 and June 2006 were consecutively selected in the study. Sample was divided into two groups: Group A- off-pump CABG and Group-B on-pump CABG. The test statistics used to analyze the data were descriptive statistics as Chi-square (×2) and Student's t-test.*

Results: *Preoperative arterial blood gas (ABG) analysis showed no significant difference. ABG immediately at ICU on FiO2 1 revealed significantly better gas exchange in off-pump group (PaO2: 296.5±32.4 torr vs 234.8±10.7 torr, p<0.001; D(A-a)O2: 378.5±27.3 torr vs 439.2±10.3 torr, p<0.001; PaCO2: 38.5±3.8 torr vs 40.1±1.8 torr, p=0.045). ABG on 3rd postoperative day revealed no significant difference between the two groups. Ventilation time in off-pump group was significantly less than in on-pump group (10.5±2.8 hours vs 14.8±3.7 hours, p<0.001). For ICU stay, there was no significant difference. Postoperative spirometry at 3 month and pulmonary complications within 3 months were not different between groups.*

Conclusion: *off-pump CABG group yielded better gas exchange and earlier extubation than on-pump CABG group.*

Keywords: *Pulmonary function, CABG, arterial blood gas (ABG), FIO2 1(fraction of inspired oxygen of 1).*

Introduction

Disease of the coronary arteries is almost always due to atheroma and its complications, particularly thrombosis[1]. The cause of atherosclerosis is now clear. Atherosclerosis is a cholesterol related problem. The higher blood total cholesterol level (especially LDL), the greater is the risk for developing symptomatic coronary artery disease (CAD), fatal CAD, and atherosclerotic plaques.

Management of CAD can be discussed under the headings: Medical management (conservative), Intervention cardiology (angioplasty, stenting), and Surgical management. Coronary artery bypass graft

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(CABG) can be performed either under cardiopulmonary bypass (CPB) or by using off-pump technique. In NICVD we were performing CABG by applying both of these techniques. Pulmonary function test may decrease significantly after myocardial revascularization using CPB. Impairment of pulmonary function after CABG was one of the most common complications in the early postoperative period[2]. Sternotomy, pleurotomy with opening of the pleural space, harvest of internal mammary artery (IMA) and pain may lead to deterioration of postoperative pulmonary function. Additionally, CPB may cause pathomorphologic and functional pulmonary changes called "Post-perfusion Syndrome"[3]. Coronary revascularization procedure was done through median sternotomy incision, and for this, impairment of pulmonary function was one of the most significant postoperative complications of CABG[4]. For revascularization, emphasis was given over internal mammary artery (IMA) graft. The mediastinum and thoracic cavity were traumatized more with IMA than with reverse saphenous vein graft (RSVG) procedure. Indeed, some reports have found that IMA patients have worse pulmonary functions than the RSVG patients in the postoperative period[5]. Besides the effects of sternotomy and harvesting of IMA, CPB has been the most significant factor of respiratory dysfunction[6]. CPB increases lung vascular permeability and can result in ARDS[2,7] and reduction in lung compliance and gas exchange[8-9]. Systemic inflammation as well as imbalance of oxidant/antioxidant status[10-11-12] induced by CPB has been implicated in producing these pathophysiologic abnormalities. As a result, it can be predicted that postoperative pulmonary functions in off-pump CABG patients should be better than patients operated with on-pump CABG technique. So, the aim of the study was to compare pulmonary function tests and arterial blood gases postoperatively between on-pump and off-pump CABG patients.

Patients and methods

In a prospective, nonrandomized comparative study we studied 60 patients who underwent elective coronary artery bypass graft surgery (off-pump and on-pump). The study was conducted in the department of Cardiac Surgery, National Institute of Cardiovascular Diseases (NICVD), Dhaka between July 2005 and June 2006. Study population were divided into Group A (n=30, undergone off-pump CABG) and Group B (n=30, undergone on-pump CABG). Exclusion criteria was associated valvular diseases, associated congenital cardiac anomaly, urgent CABG and re-exploration, associated other systemic dysfunction (e.g. liver, renal, pulmonary dysfunction), redo CABG, LV Ejection Fraction <30%. The protocol of the study was also accepted by the Academic Council, NICVD, Dhaka. Patients were also explained the purpose and importance of the study and also likely consequence. The study was conducted by signed informed consent of the participants. At first detail medical history were taken from each patient in preformed data sheet including age, sex, risk factors of CAD, symptoms including NYHA class and relevant preoperative investigations e.g. coronary angiogram (to see extent of disease), spirometry, arterial blood gas (ABG) analysis were recorded. Postoperatively, mechanical ventilation time (in hours), ICU stay (in hours), ABG variables immediately on arrival at ICU and on 3rd postoperative day were recorded. All patients were followed up at 3 month postoperatively with spirometry and for any pulmonary complication. All these were recorded in data sheet & a master chart was prepared. Data analysis was done by statistical program for social science (SPSS) software. Results were presented in tables, figures and diagrams. Data were verified by student't' test and chi-square test. A probability 'p' value ($p<0.05$) was considered as statistically significant.

Results

Out of 60 patients of CABG, 30 were in off-pump and the rest 30 were in on-pump group. The following derived from data analysis are furnished below.

Age (yrs)	Group		p-value
	Off - pump	On - pump	
	(n=30)	(n=30)	
<40	5 (16.7)*	3 (10.0)	
40 - 50	3 (10.0)	3 (10.0)	0.426
50 - 60	8 (26.7)	7 (23.3)	
≥ 60	14 (46.7)	17 (56.7)	
Mean ± SD	49.5	50.3	
Range	32 - 70	32-65	

Chi-squared (×2) Test was done to analyze the data; level of significance was 0.05.

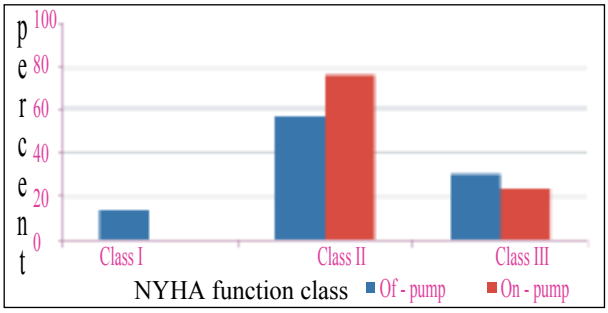
Table I Age distribution between groups

Sex	Group		p-value
	Off- pump (n=30)	On - pump (n=30)	
Male	25 (83.3) *	27 (90.0)	
			0.665
Female	5 (16.7)	3 (10.0)	

* Figures in the parenthesis denote corresponding %.

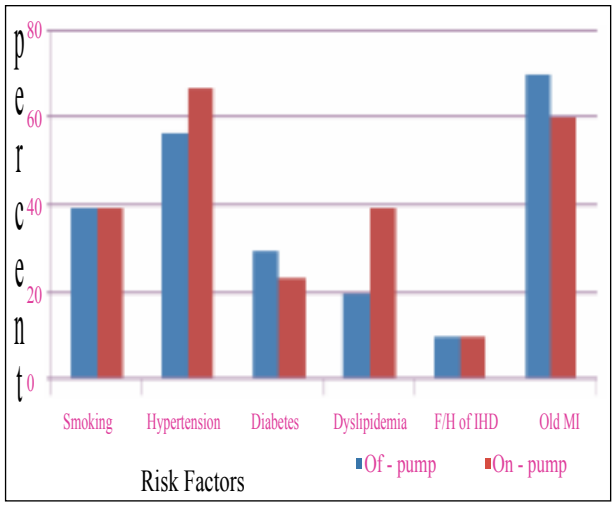
Table II Distribution of patients by sex

Level of significance was 0.5



Bar chart shows

Figure 1: Preoperative NYHA functional class



Bar chart shows

Figure 2: Comparison of risk factors

Extent of disease	Group	
	Off - pump (n=30)	On - pump (n=30)
SVD	00	2(6.7)
DVD	8(26.7)	8(26.7)
TVD	19(63.3)	17(56.7)
LM	3(10.0)	3(10.0)

* Figures in the parenthesis denote corresponding %.

Table III Extent of disease by coronary angiogram

Bar chart shows

Figure 3: Distribution of grafts

Figure 4: Distribution of individual grafts

Preoperative Lung Function Test	Group		p-value
	Off - pump (n=30)	On - pump (n=30)	
FVC (L)	2.68 ±0.55	2.93 ± 0.74	0.153
FEV 1(L)	2.20 ± 0.53	2.45 ± 0.65	0.106
FEV 1/FVC	0.82 ± 0.10	0.85 ± 0.18	0.436

Student's t-test was done to analyze the data; level of significance was 0.05.

Table IV Preoperative lung function by spirometry

Preoperative ABG variables	Group		p-value
	Off-pump (n=30)	On-pump (n=30)	
PaO 2 torr	134.43 ±5.84	132.87 ±12.77	0.544
D(A-a)O 2 torr	53.90 ±7.42	51.0 ±9.49	0.192
PaCO2 torr	40.23 ±2.62	40.03 ±1.71	0.728
pH	7.42	7.43	0.124

Student's t-test was done to analyze the data; level of significance was 0.05.

Table V Preoperative arterial blood gas analysis

Postoperative outcome	Group		p-value
	Off-pump (n=30)	On-pump (n=30)	
Ventilation time (hours)	10.5 ± 2.8	14.8 ±3.7	<0.001
ICU stay (hours)	46.27 ±3.7	47.77 ±2.5	0.071

Student's t-test was done to analyze the data; level of significance was 0.05.

Table VI Ventilation time and ICU stay

Postoperative ABG variables	Group		p-value
	Off-pump (n=30)	On-pump (n=30)	
ICU PaO 2 (torr)	296±32.4	234±10.7	<0.001
3rd POD PaO 2 (torr)	78.5±3.3	77.3±2.1	0.133
ICU D(A-a)O2 (torr)	378.5±27.3	439.2±10.3	<0.001
3rd POD D(A-a)O2 (torr)	63.9±4.5	62.4±5.1	0.231
ICU PaCO 2 (torr)	38.5±3.8	40.1±1.8	0.045 S
3rd POD PaCO 2 (torr)	43.2±2.5	43.6±2.2	0.549
ICU PH	7.36±0.55	7.46±0.03	0.312
3rd POD pH	7.38±0.55	7.41±0.02	0.325

Student's t-test was done to analyse the data; level of significance was 0.05; S= significant.

Table VII Postoperative arterial blood gas (ABG) analysis

Postoperative Lung Function Test	Group		p-value
	Off - pump (n=30)	On-pump (n=30)	
FVC after 3 month (L)	2.27 ±0.51	2.47±0.56	0.164
FFEV1 after 3 month (L)	1.81 ±0.46	2.04 ±0.47	0.055
FEV1/FVC	0.80 ±0.11	0.84 ±0.14	0.24 9

Student's t-test was done to analyse the data; level of significance was 0.05.

Table VIII Postoperative lung function (by spirometry) at 3 month (n=60)

Variables	Group Off-pump (n=30)	Group On-pump (n=30)
Death within 3 months	0	0
Complication: pleural effusion	1	1

Table IX Pulmonary complication within 3 months

Table demonstrates that there was no difference in pulmonary complication between two groups.

Discussion

This study was carried out in NICVD to evaluate pulmonary functions after off-pump coronary artery bypass graft surgery, a routinely performed surgery in this institute. This is a nonrandomized prospective comparative study done in NICVD during the period of July 2005 to June 2006. Sample size was 60 and

sample was purposely determined. Data were collected by an interview schedule and check list. Data were entered into a computer and data file was constructed. Data were analyzed by SPSS programme and tested by Student's 't' test and chi-square test.

The patients were divided into 2 groups- Group A: off-pump CABG and Group B: on-pump CABG.

Table-I shows age distribution of the patients ranged from 32-70 years in off-pump group and 32-65 years in on-pump group, with mean age 49.5 and 50.3 years respectively. Vargas et al (1997)[4] found mean age to be 58 years while Westerdal et al (2003)[13] found higher age (66 years) of the patients undergoing CABG.

Table-II shows distribution of patients by sex. A male predominance was observed in both groups with 83.3% male in off-pump group and 90% male in on-pump group. P value was not significant.

Figure-1 shows preoperative functional class of patients. Approximately 57% of the off-pump group belonged to NYHA class-II, followed by 30% NYHA class-III and 13.3% NYHA class-I. In on-pump group, about 77% were classified as NYHA class-II, 23.3% as NYHA class-III and none belonged to class-I. So, majority of the patients of both groups belonged to NYHA class-II & III, which closely resembles the findings of Westerdahl et al (2003)[13].

Figure-2 represents the incidence of risk factors; both the groups were also comparable to each other. In the off-pump group, 70% of the patients had old MI, 56.7% hypertension, 40% smoking, 30% DM, 20% dyslipidemia and 10% had family history of ischemic heart disease. In on-pump group, 66.7% had hypertension, 60% old MI, 40% smoking, another 40% dyslipidemia, 23.3% DM and 10% family history of IHD. The study of Vargas (1997)[4] revealed smoking and hypertension were the more prevalent risk factors.

Table-III represents extent of disease by coronary angiogram. Analysis of distribution of extent of disease between groups demonstrates that 19(63.3%) of off-pump and 17(56.7%) on-pump had TVD (triple vessel disease) followed by DVD in 8(26.7%) cases of each group and LM 3(10%) in each group. The off-pump did not have any SVD, while 2(6.7%) cases of on-pump had SVD.

Significant stenosis of left main (LM) was found in 3 each cases of off-pump and an-pump group, that of LAD (left anterior descending) 29 and 27 respectively, D1 5 and LCX (left circumflex) 19 and 17, OM1 3 and 5, OM2 1 and 5, RI (ramus intermedius) 2 and 1, RCA (right coronary artery) 27 And 21, and PDA 10 and 0 respectively.

Regarding distribution of number of grafts between two groups, Figure-3 shows 56.7% of off-pump group required 2 grafts, 30% 3 grafts, 6.7% 4 grafts and another 6.7% 1 graft. In on-pump group, 70% needed 3 grafts and 23.3% 2 grafts; one graft and 4 grafts each was 3.3%.

In Table-IV, preoperative spirometry revealed that FVC and FEV1 were not significant in off-pump were not significant in off-pump group compared to their on-pump counterpart. Study done by Gerald WS et al (2005) 14 supports this result.

In Table-VI, Ventilation time and ICU stay between off-pump and on-pump CABG surgery were recorded. The ventilation time was observed to be significantly less in off-pump than on-pump group (10.5±2.8 vs 14.8±3.7 hours, $p<0.001$). The ICU stay, however, was not found to be significantly different between groups ($p=0.537$). This finding closely resembles the findings of Gerald WS et al (2005)[14]. But finding of significance of ventilation time in off-pump group is not supported by the study of Gary SK et al (2000)[15].

Arterial blood gas (ABG) was analyzed preoperatively, at ICU and on 3rd postoperative day. Preoperative values, presented in Table-V, were found not significant in off-pump vs on-pump groups.

In Table-VII, values recorded at ICU reveal that PaO2 and D(A-a)O2 were significantly better in off-pump group compared to those on-pump group (296(±32.4) trr vs 234(±10.7), trr, $p<0.001$ and 378.5±27.3 torr vs 439.2(±10.3) $p<0.001$ respectively). On the other hand, ICU PaCO2 was observed to be significantly less in off-pump group than on-pump group (38.5±3.8 torr vs 40.1±1.8 torr, $p=0.045$). The groups were not found to be different with respect to other ABG variables. Significance of values of the ABG analysis of 3rd postoperative day was not found. These findings resemble with studies of Gerald WS et al (2005)[14] and Gary SK et al (2000)[15]. On-pump group had poorer gas exchange immediately postoperatively, and their extubation was delayed by ABG-based protocol even though they had no signs of pulmonary edema and a smaller decrease in compliance. The explanation for these observations may lie in some aspect of CPB

including release of inflammatory mediators or possible failure of replenishment of surfactant. Tschernko et al (2002)[16] demonstrated that immediate postoperative oxygenation and shunt fractions were better in the off-pump group. Gerald WS et al (2005)[14] also echoed having similar findings. On the other hand, Cimen S et al (2003)[17] found no significant differences between off-pump and on-pump groups in gas exchange, spirometry and time of extubation.

Patients were followed up 3 month after operation. Follow up examination included physical examination, any pulmonary complication and spirometry. Postoperative outcome measured in terms of lung function test (presented in Table-VIII) showed that none of the variables of lung function test was any different between groups (FVC 2.27±0.51 L vs 2.47±0.56 L, p=0.164; FEV1 1.81±0.46 L vs 2.04±0.47 L, p=0.055; FEV1/FVC 0.80±0.11 vs 0.84±0.14, p=0.294). These findings were supported by study of Gerald WS et al (2005)[14].

Regarding pulmonary complication, 1 patient from each group had pleural effusion (Table IX).

Study limitation

1. Sample size was only 60 sixty and number of female patient was very few in comparison to male patients. More number of patients, more female patients and more multicentre studies at national level required for a definitive conclusion.

Conclusion

Off-pump CABG is a safe procedure that avoids the potential risks of CPB. It may also be concluded that off-pump CABG group yielded better gas exchange and earlier extubation.

Recommendation

We recommended that off-pump CABG should be considered better than on-pump CABG for gas exchange and earlier extubation. But patients going to be surgically revascularized should not be altered to off-pump surgery merely with the hope of improving respiratory functions with off-pump technique.

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