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Original Article

Comparison of Early Mortality and Morbidity of Off Pump vs On Pump Coronary Artery Bypass Graft Surgery in High-Risk Patients

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ABSTRACT

Objective: To compare the early mortality and morbidity of high-risk patients following off-pump and on-pump Coronary Artery Bypass Grafting (CABG).

Study Design: Analytical Cross-sectional study.

Place and Duration of Study: Tertiary Care Cardiac Center, Rawalpindi Pakistan, from Oct 2022 to Mar 2023.

Methodology: Two hundred and forty-three patients undergoing on-pump CABG(ONCAB) or off-pump CABG(OPCAB) with an Ejection Fraction (EF) of <35%, history of stroke, Glomerular Filtration Rate (GFR) <60 ml/min/1.73m^2 or a serum creatinine level >1.5 mg/dl, and Chronic Obstructive Pulmonary Disease (COPD) were included using consecutive sampling. Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23:00. Descriptive statistics were used to calculate Mean±SD for continuous variables like (age, EF and duration of hospital stay). Frequencies and percentages were calculated for categorical variables like (gender and post-op outcomes). Chi-square & t-test were used to make comparison between both groups, *p*-value <0.05 was considered significant. Top of Form.

Results: Out of two hundred and forty-three (n=243) patients, 193(79.4%) males and 50(20.6%) females with mean age 49.04±7.75 years underwent ONCAB 150(61.9%) and OPCAB 93(38.1%). ONCAB had slightly higher rates of Myocardial Infarction (5.3%) and Stroke (6%) compared to OPCAB (1.1% for both), *p*-values of 0.08 and 0.06, respectively. Respiratory complications were more common in ONCAB, with 9.3% requiring re-intubation, compared to 2.2% in the OPCAB group (p=0.02). ONCAB also had a slightly longer hospital stay (7.1±1.4 days) compared to OPCAB (6.7±1.6 days) (p=0.03). Additionally, ONCAB had higher rates of re-exploration for bleeding (8%), Acute Kidney Injury (AKI) (8.7%), and mortality (6.7%) compared to OPCAB (1.1% for all) (p<0.05).

Conclusion: OPCAB showed lower rates of complications, indicates the potential superiority of OPCAB over ONCAB.

Keywords: Cardiopulmonary Bypass (CPB), Coronary Artery Bypass Graft, Left Ventricular Dysfunction, Myocardial Infarction, Off Pump, On Pump.

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INTRODUCTION

The standard revascularization strategy for patients with multiple vessel coronary artery disease includes bypass surgery.[1] According to evidence from multiple studies, individuals with complex vascular diseases who have CABG rather than Primary Percutaneous Coronary Intervention (PPCI) have a higher chance of survival. Bypass surgery is the most common procedure worldwide, which accounts for 200,000 isolated cases annually in the US and a typical prevalence rate of 62/100,000 people in western Europe.[2]

CABG carries increased risk of morbidity and mortality in patients with co-morbidities such as low ejection fraction, deranged Renal Function Tests (RFTs), Transient Ischemic Attack (TIA) and Chronic Obstructive Pulmonary Disease (COPD) patients.[3] Systemic inflammatory responses mediated by cytokines complements coagulation cascade and bradykinin / kininogen pathways have been reported as be the main culprits.[4,5] These physiological disturbances following Cardiopulmonary Bypass (CPB) lead to cardiac arrest. Multiple research investigations showed that; Off-Pump CABG reduces total systemic inflammatory response, which leads to enhanced organ function before and after surgery, which is particularly crucial for high-risk patients.[6,7]

However, it is known that Cardiopulmonary Bypass (CPB) has its own risks; primarily the initiation of systemic inflammatory response of unstable degree contributing to organ dysfunction.[8] Literature showed that OPCAB was associated with lower risk of in-

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hospital mortality and morbidity whereas other studies reported similar in-hospital outcomes in both OPCAB and ONCAB.[9] Another study supports benefit of off-pump CABG in high-risk patients as well as those with poor Left Ventricular Function (LVF).[10]

The comparison of off-pump and on-pump (CABG) in high-risk patients is crucial because it addresses the optimal surgical approach for a complex and vulnerable population, impacting patient outcomes, healthcare resource utilization, and the ethical and economic considerations surrounding cardiac surgery in these individuals.[9,10] Limited data is available on post-op outcomes (morbidity and mortality) between OPCAB vs ONCAB procedures to addresses the optimal surgical approach in our population. Our study aimed to compare the mortality and morbidity of coronary artery bypass operation performed on and off pump in high-risk patients.

METHODOLOGY

This analytical Cross-sectional study was conducted at Tertiary Care Cardiac Center, Rawalpindi Pakistan, from October 2022 to March 2023. Patients were included in the study by using non-probability consecutive sampling technique. Study was conducted after taking approval from Institutional Ethical Review Board under letter no. (IERB letter # 9/2/R&D/2022/217).

Sample size of n=173 was calculated using WHO sample size calculator by taking 12.9% prevalence of isolated CABG patients[1] at 95% Confidence Interval (CI) and 5% margin of error. However, we collected data prospectively from 243 patients.

Inclusion Criteria: All patients with age 18 years or more who underwent isolated CABG with EF <35%, history of stroke/Transient Ischemic Attack (TIA), GFR <60ml/min/1.73-m2 or creatinine <1.5mg/dl and COPD or deranged Pulmonary Function Tests (PFTs).

Exclusion Criteria: Patients who underwent emergency CABG, already on dialysis, patients with cardiogenic shock, heavily calcified aorta, or re-operative coronary artery surgery.

All the patients who met the inclusion criteria and who underwent isolated CABG (Off-pump and on-pump) were selected and divided into two groups based the use of CPB machine, ONCAB (group-I) and OPCAB (group-II) patients. Per-operative and post-operative complications such as incidence of myocardial infarction, stroke, respiratory failure requiring re-intubation, duration of hospital stay, re-exploration for bleeding, acute kidney injury (AKI), and mortality were obtained from a computerized database. Additional parameters such as age, hypertension, smoking status etc. related to the current study were acquired from patient charts.

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23:00. Descriptive statistics were used to calculate Mean±SD for continuous variables like (age, EF and duration of hospital stay). Frequencies and percentages were calculated for categorical variables like (gender and post-op complications). Chi square & t-test were used to make comparison between both groups, p-value <0.05 was considered significant by taking 95% CI and 5% margin of error.

RESULTS

Out of two hundred and forty-three (n=243) patients, 93(38.1%) underwent OPCAB and 150(61.9%) ONCAB surgery. Majority of study participants were males 193(79.4%) with mean age 49.04±7.75 years, 150(61.7%) were smokers and 212(87.2%) were hypertensive. As far as Coronary Artery Disease (CAD) status is concerned, TVCAD 203(83.5%) was found to be most prevalent, as shown in Table-I.

Table-I: Baseline Characteristics of Study Participants (n=243)

Variables		Frequency (%)
Gender	Male	193(79.4%)
	Female	50(20.6%)
Smoking status		150(61.7%)
Hypertension		212(87.2%)
Coronary Artery disease	SVCAD	9(3.7%)
	DVCAD	31(12.8%)
	TVCAD	203(83.5%)
Age (years) Mean±SD		49.04±7.75
Ejection Fraction (%) Mean±SD		27.51±4.30

**SVCAD=Single Vessel Coronary Artery Disease, DVCAD=Double Vessels Coronary Artery Disease, TVCAD=Triple Vessel Coronary Artery Disease*

Mean age in OPCAB group was 49.62±7.53 years. Majority of the patients who underwent OPCAB surgery had higher risk factors than ONCAB cases including hypertension 84(90.3%), hyperlipidemia 66(70.9%) and diabetes mellitus 46(49.4%) as shown in Table-II.

Table-II: Comparison of Preoperative Characteristics of Patients (n=243)

Co-morbids	Group I ONCAB (Total=150) Frequency (%)	Group II OPCAB (Total=93) Frequency (%)	*p*-value
Hypertension	128(85.3%)	84(90.3%)	0.35
Hyperlipidemia	104(69.3%)	66(70.9%)	0.90
Diabetes mellitus	74(49.3%)	46(49.4%)	<0.001
Age (years) Mean±SD	48.68±7.95	49.62±7.53	0.04

**OPCAB=Off-Pump Coronary Artery Bypass, ONCAB= On Pump Coronary Artery Bypass*

In the context of pre-operative risk analysis for a cohort of 243 study participants scheduled for either on-pump or off-pump CABG procedures, we observed significant variations in pre-operative risk factors between the two groups. Specifically, the data in Table-III revealed that 8.9% of patients in the ONCAB group had been diagnosed with COPD, while the OPCAB group displayed a slightly higher rate at 10.4%, indicating a marginal increase in the risk of COPD for the OPCAB group. Furthermore, peripheral vascular disease was found in 26.0% of ONCAB patients and in 34.4% of OPCAB patients, highlighting a notable discrepancy in the prevalence of this condition between the two groups. Additionally, the mean ejection fraction for the ONCAB group was 27.32±4.35, slightly higher than the OPCAB group's 25.54±3.33, signifying a difference in cardiac function that should be considered in the pre-operative risk assessment. These findings underscore the imperative need for a comprehensive pre-operative risk evaluation to tailor CABG procedures to individual patients based on their distinct risk profiles. Further, these findings demonstrated a statistically significant association of COPD, Peripheral Vascular Disease and EF between both groups (p<0.05)Top of Form.

Table-III: Comorbids of Study Participants (n=243)

Variables	Group I ONCAB (Total=150) Frequency (%)	Group II OPCAB (Total=93) Frequency (%)	*p*-value
COPD	64(8.9%)	46(10.4%)	0.04
Peripheral vascular disease	39(26.0%)	32(34.4%)	0.02
Ejection fraction (%) Mean±SD	27.32±4.35	25.54±3.33	0.03

**AKI= Acute Kidney Injury, COPD=Chronic Obstructive Pulmonary Disease*

As shown in Table-IV, myocardial infarction (ONCAB: 5.3% vs. OPCAB: 1.1%; p=0.08) and stroke (ONCAB: 6% vs. OPCAB: 1.1%; p=0.06) between the two groups didn't show statistically significant association although there was a clear trend towards improved outcomes with OPCAB. Particularly striking were the findings related to postoperative complications. The OPCAB group exhibited a significantly lower incidence of respiratory failure requiring re-intubation (ONCAB: 9.3% vs. OPCAB: 2.2%; p=0.02), re-exploration for bleeding (ONCAB: 8% vs. OPCAB: 1.1%; p=0.02), acute kidney injury (AKI) (ONCAB: 8.7% vs. OPCAB: 2.2%; p=0.04), and mortality (ONCAB: 6.7% vs. OPCAB: 1.1%; p=0.04). Additionally, patients who underwent OPCAB experienced a shorter hospital stay, with a mean of 6.7 days compared to 7.1 days for ONCAB (p=0.03), suggesting potential cost-saving and patient satisfaction benefits.

Table-IV: Intra and Postoperative Outcomes in Study Participants (n=243)

Variables	Group I ONCAB (n=150) Frequency (%)	Group II OPCAB (n=93) Frequency (%)	*p*-value
Myocardial Infarction	8(5.3%)	1(1.1%)	0.08
Stroke	9(6.0%)	1(1.1%)	0.06
Respiratory failure requiring re-intubation	14(9.3%)	2(2.2%)	0.02
Re-exploration for bleeding	12(8.0%)	1(1.1%)	0.02
AKI	13(8.7%)	2(2.2%)	0.04
Mortality	10(6.7%)	1(1.1%)	0.04
Hospital stay (days) Mean±SD	7.14±1.43	6.72±1.64	0.03

**ONCAB: On-Pump Coronary Artery Bypass Grafting; OPCAB: Off-Pump Coronary Artery Bypass Grafting*

DISCUSSION

The current study represents a comprehensive investigation into the comparative outcomes of two distinct coronary artery bypass grafting (CABG) techniques: on-pump (ONCAB) and off-pump (OPCAB), focusing specifically on patients with severe Left Ventricular Dysfunction (LVD).

The study findings underscore the significant advantages of OPCAB, particularly in reducing short-term adverse events and early mortality. These findings are consistent with a growing body of literature, which has progressively endorsed OPCAB as a valuable strategy for mitigating both intraoperative and postoperative complications, particularly in high-risk patient populations.[11-14] The study's results unveiled intriguing insights into the outcomes of on-pump (ONCAB) and off-pump (OPCAB) coronary artery bypass grafting (CABG) procedures.

Puskas JD *et al.,* conducted a study with n=12,992 patients in order to compare outcomes between off-pump coronary artery bypass (OPCAB) and on-pump coronary artery bypass (ONCAB) in patients with left ventricular dysfunction (LVD). 1161 patients who had an LVEF ≤35% were included. Of these, 442(38.1%) patients underwent OPCAB and 719(61.9%) underwent ONCAB procedures. Despite higher rates of incomplete revascularization in OPCAB, there was no significant difference in 30-day mortality. OPCAB showed potential benefits, such as better myocardial protection lower perioperative blood transfusion rates, less re-intubations (ONCAB: 12.8% vs OPCAB: 10.5%; p=0.34) and less number of hospital stay days (OPCAB mean hospital stay 11 days compared to 12 days for ONCAB (p=0.02).[15] Our study showed similar result in

OPCAB group shown a significantly lower re-intubation (ONCAB: 9.3% vs. OPCAB: 2.2%; p=0.02), re-exploration for bleeding (ONCAB: 8% vs. OPCAB: 1.1%; p=0.02) and mortality (ONCAB: 6.7% vs. OPCAB: 1.1%; p=0.04). Patients who underwent OPCAB experienced a shorter hospital stay, with a mean of 6.7 days compared to 7.1 days for ONCAB (p=0.03). This is achieved by avoiding regional ischemia, a key factor in the reduction of perioperative cardiac enzyme release, often observed following cardiopulmonary bypass and aortic clamping. Surgeon expertise emerges as a pivotal element in this context.[15,16]

A study by Garatti and colleagues further corroborates the merits of the off-pump technique (OPCAB), specifically in patients with LVD undergoing myocardial revascularization. This is substantiated by a meta-analysis involving 1512 patients with LVD undergoing either on-pump or off-pump CABG. The results of this meta-analysis suggest patients with reduced EF (<30%) undergoing CABG have higher operative mortality and reduced long-term survival compared with patients with preserved EF.[17] Our study showed similar result the mean ejection fraction for the ONCAB group was 27.32±4.35, slightly higher than the OPCAB group's 25.5±3.3. Further, these findings demonstrated a statistically significant association of EF between both groups (p=0.03).This enhancement in operative outcome is certainly multifactorial and probably related to improvements in myocardial protection strategies and perioperative management of related comorbidity.[17,18]

Several observational studies have consistently reported favorable outcomes for OPCAB, demonstrating a lower incidence of early in-hospital post-operative mortality, especially in patients with compromised left ventricular function.[19-21] These collective findings underscore the potential advantages of OPCAB, particularly for high-risk patients with severe LVD, while highlighting the crucial role of surgeon expertise in the decision-making process.

LIMITATIONS OF STUDY

The present study had several limitations: limited sample size and being a single centered study. The findings may not be applicable in general because of differences in practice patterns.

CONCLUSION

This study provides evidence that OPCAB may offer certain advantages over ONCAB in terms of postoperative outcomes, including reduced rates of respiratory complications, bleeding, AKI, and mortality. These findings could have significant implications for cardiac surgery practices, but further research is needed to confirm these trends and better understand the clinical significance of the differences observed. The choice between ONCAB and OPCAB should be made on a case-to-case basis, considering individual patient factors and risks.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript:

AN & NA: Concept, study design, drafting the manuscript, approval of the final version to be published.

SH & FS: Concept, data acquisition, critical review, approval of the final version to be published.

AS: Data acquisition, data analysis, data interpretation, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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